US Army Corps
of Engineers
Portland District

BONNEVILLE DECISION DOCUMENT

Juvenile Fish Passage Recommendation

December 2002

BONNEVILLE DECISION DOCUMENT
JUVENILE FISH PASSAGE RECOMMENDATION

EXECUTIVE SUMMARY

Bonneville Dam has an existing screened bypass system at both powerhouses. Based on past studies these systems do not meet regional standards for guidance away from the turbines. In addition, past studies have also shown that survival of fish passing through the bypass systems is lower than desired. Finally, spill at Bonneville is limited due to increased adult fallback from high spill and due to levels of dissolved gas produced by high-levels of voluntary spill.

A five-year plan for fishery improvements at Bonneville Dam was developed in 1997 by a subgroup of the System Configuration Team (SCT). The plan identified implementation of survival improvements to the existing bypass system, evaluation of potential measures to improve fish guidance efficiency (FGE), and evaluation of surface bypass alternatives at Bonneville Second Powerhouse (B2). At the First Powerhouse (B1), the plan identified the evaluation of extended length screens, which would be coupled with survival improvements to the existing bypass system versus a stand-alone surface bypass system. The plan identified a decision between these two alternatives at B1 following prototype testing.

Implementation decisions at each powerhouse need to be made with an understanding of fish passage at the entire project and in conjunction with alternative selection at the other powerhouse. For this reason, a subgroup of the SCT was formed to assist the US Army Corps of Engineers (COE) to reach agreement on the appropriate measures to be implemented, the relative priority of the measures and operational issues such as powerhouse priority and appropriate level of voluntary spill to improve juvenile survival.

Using a framework based on the December 2000 Biological Opinion (BIOP) which provides performance standards for survival improvements throughout the Federal Hydropower system that must be met to avoid jeopardy to be continued of listed species; and the Northwest Planning Power Council's Fish and Wildlife Program criteria, this Decision Document was prepared to address various proposed structural alternatives. Throughout development of the document, a model called SIMPAS developed by National Marine Fisheries Service (NMFS) was used to evaluate the various combinations of alternatives and the assumptions made by this group where risk and uncertainty of the survival data had to be assigned and used as input to the model.

The following recommendations will be forwarded to SCT for yearly regional prioritization and implementation funding:

(1) B2 will be the priority powerhouse.

(2) Implement the B2 Corner Collector as soon as possible.

(3) Continue to evaluate methods to improve B2 FGE and implement if results are favorable.

(4) Defer decision on B1 until critical information is available (B1 Sluiceway Efficiency and Survival, B1 DSM Spring Survival and Adult Fallback with high spill). Improvement is needed at B1, but it is unclear what the appropriate fix should be given B2 priority and level of uncertainty regarding the available biological information.

(5) With the deferral of B1 decision, the performance standard for B1 as laid out in the December 2000 BIOP will also be deferred.

The subgroup also agreed that a decision regarding the appropriate measure to improve survival at Bonneville First Powerhouse (B1) is not needed at this time but improvements are needed at B1. Although it is unclear what the appropriate fix should be given B2 priority and level of uncertainty regarding available biological information, additional biological evaluation is needed to assist in determining the best B1 solution. With B2 as a priority, B1 will not likely operate much in the summer and only partially in the spring for average water years. The sub-group agreed that additional biological studies should be conducted to better understand B1 sluiceway efficiency and survival, B1 DSM survival in the spring, new turbine unit survival (MGR), and better understand the affects of different levels of spill on fall back of adults through the spillway. Other biological research will be conducted during the delay, which should provide insight into biological concerns associated with delayed/multiple bypass mortality associated with bypass systems.

With B2 as the priority powerhouse, and implementation of B2 Corner Collector over the next few years, funds will not be available for B1 implementation. This allows time to address the biological uncertainties to lower the level of risk and explore lower cost options at B1 that might make sense given it's not the priority powerhouse.

In addition, multiple bypass mortality data will be gathered to gain better understanding of this potential problem. This data will verify/modify the inputs used in SIMPAS, which in turn will provide the information needed to make a final decision with regards to the appropriate fix for B1. This will include updating SIMPAS inputs, rerunning SIMPAS, summarizing the results and having a meeting with the SCT subgroup annually (FY 02 biological data, FY 03 biological data and FY 04 biological data). At the end of FY 04 it is anticipated that a decision for B1 can be made. The plan is to prepare an addendum to the Decision Document developed by the COE and the SCT subgroup. When the addendum is developed additional information on water quality and spill volume should be available and will be incorporated into the addendum.

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INTRODUCTION

1-1 PURPOSE OF THE DECISION DOCUMENT

The purpose of the Bonneville Decision Document is to determine the appropriate measures that should be implemented to improve juvenile survival at Bonneville Dam. A subgroup of the System Configuration Team (SCT) was formed to assist the COE in preparation of the document. Our goal was to determine the appropriate measures to be implemented, the relative priority of the measures, and operational issues such as powerhouse priority and appropriate level of voluntary spill to improve juvenile survival. Implementation of actions at Bonneville are initiated in response to the December 2000 National Marine Fisheries Service Biological Opinion (BIOP) for the Federal Columbia River Power System (FCRPS).

The SCT subgroup recognized and determined that decisions at Bonneville needed to be made in light of all potential actions to improve survival, and should not just address each powerhouse independently. Measures selected for implementation will be placed in the regional prioritization process to determine the appropriate time for installation. This prioritization will be based on the measures' ability to improve juvenile survival relative to all the measures in the Columbia River Fish Mitigation Project at the eight COE Dams in the Lower Columbia and Snake River hydropower system.

1-2 BACKGROUND

Bonneville Dam has existing screened bypass systems at both powerhouses. Based on past studies, these systems do not meet regional standards for guidance of juvenile fish away from the turbines. Also, past studies have also shown that juvenile survival of fish passing through the bypass systems is lower than desired. In addition, spill at Bonneville is limited due to increased adult fallback from high spill and due to levels of dissolved gas produced by high levels of voluntary spill.

A five-year plan for fishery improvements at Bonneville Dam was developed in 1997 by a subgroup of the SCT. The plan identified implementation of survival improvements to the existing bypass system and evaluation of surface bypass alternatives and fish guidance efficiency (FGE) improvements at Bonneville Second Powerhouse (B2). At the First Powerhouse (B1), the plan identified prototype testing of extended length screens, coupled with survival improvements to the existing bypass system, and a stand alone surface bypass system. Following this testing, a decision between these two alternatives at B1 was planned. In addition, the plan also called for evaluation of adult fallback issues and system wide gas abatement and turbine survival studies.

Improvements to the existing bypass system at B2 were completed and operational in 1999 and 2000. Minor modifications to improve functionality of the system are continuing. A biological evaluation of B2 surface bypass was performed in 1998. The system was tested using the existing ice and trash chute as a corner collector to supplement the existing screened bypass system. Biological testing of increased flow into the gateslot and associated modifications at B2 to increase FGE was performed in 2001, and is again planned in 2002. A prototype surface bypass system (deep slot) was tested at the B1 between 1998 and 2000, and prototype extended length screens were tested at B1 in 1998 and 2000. The addition of flow deflectors in 5 bays in the spillway (plus replacement of one existing deflector) at elevation 7 was completed in April 2002. In addition, minimum gap runners are being installed at B1 through a separate major rehabilitation project. Installation of the new turbines is scheduled for completion in 2008.

1-3 FRAMEWORK FOR THE DECISION

The December 2000 Biological Opinion (BIOP) provides performance standards for survival improvements throughout the Federal hydropower system that must be met to avoid jeopardy to the continued existence of listed species. The BIOP states that:

"Action 66: The COE shall continue design development and construction of a Bonneville Second Powerhouse permanent corner collector at the existing sluice chute, pending results of high flow outfall investigations. The COE shall construct new facilities if, and as soon as, evaluations confirm the optimum design configuration and survival benefits."

"Action 97: By January 2002, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of an extended-length intake screen bypass system, a surface-collection bypass system, and hybrid alternatives at Bonneville 1st Powerhouse (B1). Through the annual planning process, COE (US Army Corps of Engineers) shall determine which of these configurations to implement.

"Two configuration alternatives are under evaluation for an improved bypass system at B1. One alternative completely upgrades the existing conventional bypass system by replacing the existing standard-length intake screens with extended length screens, upgrading the collection gallery, and relocating the outfall. The other alternative employs the developing surface attraction and collection technology in front of the powerhouse and passes juveniles in a collection channel to a new outfall site downstream. Intake screens and surface collection may be found to work best in tandem, suggesting a hybrid of the two systems may be a third alternative configuration. The decision on which alternative to implement may be made as early as January 2001, but no later than January 2002."

As mentioned above, implementation decisions at each powerhouse need to be made with an understanding of fish passage at the entire project and in conjunction with alternative selection at the other powerhouse. Table 1.1 lists the alternatives being incorporated into the Decision Document. All alternatives listed in Table 1.1 will have an associated planning, design and construction cost and schedule. The cost and schedules are at different levels of detail based on the amount of design study performed to date. Some of the cost estimates are based on detailed plans and specifications, while others are still in the conceptual stage. Impacts to operations and maintenance cost are incorporated. In addition, impact to power generation is presented.

The goal of any of the proposed juvenile fish passage actions is to increase the survival of juvenile salmon through Bonneville and is the key criteria used to make the decision. Other factors considered will be time to full implementation, design and construction cost, operations and maintenance cost, and impact to power production. In addition, the level of risk associated with the different alternatives will be incorporated into the screening process. Our goal is to identify and implement cost-effective improvements that maximize juvenile survival without impacting adult passage and meeting requirements of the Endangered Species Act, Clean Water Act, and other laws.

Since the Decision Document is addressing juvenile survival only, no adult fish passage improvements are evaluated. If the juvenile fish passage alternative affects adult fish passage, those concerns and issues will be highlighted and incorporated into the decision. For example, additional deflectors at Bonneville Spillway will increase the volume of flow, which can pass the spillway, while staying at or below the gas waiver (115 percent) at the downstream fixed monitor site at Camas/Washougal. The current daytime restriction of 75Kcfs is the result of adult fallback issues and additional deflectors may or may not increase daytime spill.

Table 1.1. Alternatives

Alternative	Schedule	Cost ($000)	Average Annual Cost ($000) Power impacts not incorporated	Status
Bonneville Fast Track				
Phase 1 - 6 new deflectors	FY02	$8,500	$556	Evaluated through spill level
Phase 2 - 13 modified deflectors	FY04	$10,350		Not evaluated.
B1 Surface Bypass/Deep Slot	10 to 12 years FY2012	$200,000 - $250,000	$9,170	Included
B1 Surface Bypass/ Shallow	FY06 – FY10	$125,000		Semi included
B1 Partial Deep Slot	FY06 (5)*	$110,000		Semi included
B1 JBS/ESBS	FY04 (3)*	$98,400	$5,738	Included
B1 JBS/STS	FY03 (2)*	$74,800	$4,628	Included
B2 Surface Bypass	FY04 (3)*	$55,200	$3,084	Included
B2 FGE	FY05 (4)*	$13,900	$795	Included
Adult Fallback	FY06			Included in Risk
MGRs				Included
No Screens and MGRs				Not evaluated.
Note: * Years were based on a start date of March 01. The number in parenthesis is the number of years after initiation.				

This Decision Document presents the necessary information for the region to make a decision regarding alternatives to be implemented at Bonneville. It does not address issues associated with funding requirements at the project in view of fish and wildlife spending limits or with priorities of other projects throughout the eight main stem dams under COE operation. The recommended alternatives at Bonneville will be added to the overall regional prioritization process to determine when, and if, each alternative will actually be implemented.

1-4 Biological Model Used to Estimate Survival Improvements

Fish survival estimates are made using SIMPAS, a spreadsheet model developed by National Marine Fisheries Service (NMFS) and used in the BIOP. SIMPAS as described in the BIOP:

"is a fish passage accounting model that apportions the run to various passage routes (turbines, fish bypass systems, sluiceway/surface bypass, spillway and/or transportation) based on empirical data and input assumptions for fish passage parameters. The model accounts for "successful fish passage" (survival) and "losses" (mortalities) through each of the alternative passage routes to estimate survival past each project. The model also accounts for the proportion of fish left to migrate inriver. The model also provides as output survival estimates at each project (dam plus pool) and throughout the system (from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam)."

Only the Bonneville portion of the SIMPAS model is being utilized for the Decision Document. Biological data supporting the various input estimates in SIMPAS are based on past studies and professional judgment. Based on the amount of data and the robustness of the biological studies used as the basis of the estimate, there are corresponding levels of risk or uncertainty associated with these estimates. SIMPAS results are presented and discussed in Chapter 7. The risk analysis is presented and discussed in Chapter 8.

A list of acronyms used in this document is in Appendix A.

SECTION 2

BACKGROUND

2-1 PROJECT AUTHORIZATION

The Bonneville Project began with the National Recovery Act, 30 September 1933 and was formally authorized by Congress in the Rivers and Harbor Act of 30 August 1935. Authority for the completion, maintenance, and operations of Bonneville Dam was provided in Public Law 329, 75th Congress, 20 August 1937. This act provided the authority for the construction of additional hydroelectric generation facilities (Bonneville Second Powerhouse) when requested by the Administrator of Bonneville Power Administration. Letters dated 21 January 1965 and 2 February 1965 from the Administrator developed the need for the construction of Bonneville Second Powerhouse. Construction started on the second powerhouse in 1974 with units 11 through 18 and two fishway units and was completed in 1982.

2-2 LOCATION

The Bonneville Project is located on the Columbia River, 42 miles east of Portland, Oregon at river mile 146, Figure 2.1. The Bonneville First Powerhouse and Navigation Lock are between the south shore in the state of Oregon and Bradford Island. The Spillway is between Bradford Island and Cascade Island. The Bonneville Second Powerhouse is between Cascade Island and the north shore in the state of Washington.

2-3 FISH PASSAGE

The 1934 Fish and Wildlife Coordination Act has traditionally been the most important legal authority for insuring protection and/or compensation for salmon and steelhead impacted by Federal water projects. The Mitchell Act of 1938 recognized the impossibility of identifying and requiring compensation for salmon and steelhead losses resulting from a wide array of land and water resource activities. It authorized appropriation of Federal tax revenues to restore and enhance the salmon and steelhead runs of the Columbia Basin

2-4 ENDANGERED SPECIES ACT

The Endangered Species Act (ESA)(16 USC 1531-1544), establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United State Fish and Wildlife Service (USFWS) and NMFS, as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitats. Through interagency consultations pursuant to section 7 the Biological Opinion (BIOP) four consistent actions were generated from the December 2000 BIOP:

1. The Federal agencies that operate, or market power from, the Federal Columbia River Power System (FCRPS), such as Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (COE), and the U.S. Bureau of Reclamation (BOR) reinitiated consultation with the NMFS and the USFWS to consider the effects of action related to FCRPS configuration, operations, and maintenance on species listed as threatened of endangered under ES

Figure 2.1. Bonneville

2. BOR is also consulting on the continued operation and maintenance of 19 of its projects in the Columbia River basin. While the configuration, operation, and maintenance of the FCRPS and the operation and maintenance of the BOR's 19 projects are separate agency actions, they are similar in the all have hydrologic effects on the flows in the mainstems of the Columbia and Snake rivers. However, the BIOP does not attempt to apportion the relative contribution of the FCRPS and BOR projects to the current status of the evolutionary significant units (ESUs).

3. NMFS is also consulting internally on its issuance of Section 10 permit for the COE' Juvenile Fish Transportation Program.

4. NMFS is also consulting internally on its issuance of Section 10 permits for certain research, monitoring, and evaluation actions essential to the implementation of the BIOP.

The action area encompasses the mainstem Columbia and Snake rivers from Chief Joseph Dam and Hells Canyon Dam down to and including the estuary and plume of the Columbia River. Some of the FCRPS dams and reservoirs are also operated for other purposes as authorized by Congress (e.g. navigation, irrigation, fish and wildlife, and recreation). These operations are inseparable from those for power generation and flood control.

The December 2000 FCRPS NMFS and USFWS BIOP generated through the implementation of ESA law considers all known operational effects of the Columbia Basin Projects, not just its contribution to the cumulative hydrologic impacts on streamflows in the Columbia River. This consultation also considers whether the effects of these actions are likely to jeopardize the continued existence of 12 listed species of Columbia Basin Project salmonids and cause the destruction or adverse modification of their designated critical habitat. The twelve species are as follows:

Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*)
Snake River fall chinook salmon (*O. tshawytscha*)
Upper Columbia River spring chinook salmon (*O. tshawytscha*)
Upper Willamette River chinook salmon (*O. tshawytscha*)
Lower Columbia River chinook salmon (*O. tshawytscha*)
Snake River steelhead (*O. mykiss*)
Upper Columbia River steelhead (*O. mykiss*)
Middle Columbia River steelhead (*O. mykiss*)
Upper Willamette River steelhead (*O. mykiss*)
Lower Columbia River steelhead (*O. mykiss*)
Columbia River chum salmon (*O. keta*)
Snake River Sockeye salmon (*O. nerka*)

2-5 Biological Opinion

Columbia River basin anadromous salmonids, especially those above Bonneville Dam, have been dramatically affected by the development and operation of the FCRPS. The eight dams in the migration corridor of the Snake and Columbia rivers alter natural smolt and adult migrations. There have been numerous changes in the operation and configuration of the FCRPS as a result of ESA consultations between Action Agencies (BPA, COE, and BOR) and the services (NMFS and USFWS). These changes have improved survival for the listed fish migrating thorough the Columbia River. Increased spill has been used as an interim measure along with flow and transportation improvements to improve the survival of all listed stocks as well as non-listed fish.

Using SIMPAS, it is possible to quantify the survival benefits accruing from various actions for each of the listed ESUs. For Snake River (SR) spring/summer chinook smolt migrating in-river, the estimated direct survival through the hydrosystem in 2000 is between 40% and 60%, compared with an estimated survival rate during the 1970s of 5% to 40%. The increase in survival rates is due to fish passage improvements, such as spill for juvenile passage, barging, bypass systems, etc. SR steelhead have probably received a similar benefit because their life histories and run timing are similar to that of the spring/summer chinook. It is reasonable to expect that the improvements in the operation and configuration of the FCRPS will benefit all listed Columbia Basin salmonids above Bonneville and the benefits will be greater the farther upriver the ESU. The improvements made at Bonneville are aimed at enhancing and improving all stocks that travel to and descend through Bonneville. Some of the listed stock ESU's only travel through Bonneville during their life cycle and may react or have a higher likelihood of being benefited by specific actions contributed by Bonneville.

The BIOP describes a set of specific, hydro actions that NMFS has determined, on the basis of scientific information, will achieve the FCRPS hydro performance standards. Most of the measures are aimed at improving passage through FCRPS dams and reservoirs by changing project operations and improving project configuration. The measures include the following:

1. Enhanced spill and spillway improvements to facilitate higher spill levels without exceeding harmful TDG limits or reducing TDG levels with existing spill levels

2. Improved flow management

3. Physical improvements to both juvenile and adult fish passage facilities

4. Increased use of barges and less reliance on trucks to transport summer migrants at collector projects

5. Continuation of spill at collector projects to maximize the survival rate of inriver migrants

As determined through the planning process, NMFS, along with the participating Action Agencies, may deem other combinations of measures sufficient to meet the performance standards described in the BIOP and avoid jeopardy of listed ESUs.

NMFS suggested, in the FCRPS biological opinion that the primary objective is "to increase survival of juvenile out migrants with two biological principles: 1) protecting biological diversity and 2) favoring fish passage solution that best fit natural behavioral patterns and river processes".

NMFS priorities for juvenile passage routes are:

1. Spillway passage,

2. Surface bypass passage,

3. Surface collection passage

4. Powerhouse intake screens and bypass systems, and

5. Turbine passage.

An annual, multiyear planning process to refine, implement, evaluate, and adjust ongoing efforts is critical to achieving the FCRPS hydro and offsite performance standards within the time frame covered in the BIOP. This will be accomplished through development and implementation of the 1- and 5- year plans to achieve both hydro performance standards and offsite mitigation performance standards. The plans will cover all operations, configuration, research, monitoring, and evaluation action. The Reasonable and Prudent Alternative (RPA), as defined in the BIOP, allows for revision of the specific measures throughout its term, as long as the Action Agencies make steady progress toward meeting performance standards and remain on track for full attainment of the hydro performance standards by 2010. The 2003 annual plan will contain a comprehensive assessment of the success of the actions agencies in obtaining the funding and authorizations and in further defining and implementing the actions called for in the RPA. NMFS will reinitiate consultation if there is a lack of adequate progress at that time or in subsequent reviews. The current RPA calls for annual progress reports; major progress evaluations in 2003, 2005, and 2008. Improvements made at Bonneville Dam and at all other projects will be used to make these critical progress evaluations.

2-6 Northwest Power Planning Council

The ISRP evaluated whether the Bonneville Dam Decision Document and recommended actions are consistent with the criteria set forth in Section 4(h)(10)(D) of the Pacific Northwest Electric Power Planning and Conservation Act and the criteria and strategies contained in the 2000 Columbia River Basin Fish and Wildlife Program (Council document 2000-19). In addition, the ISRP referred to the Biological Opinion of December 2000.

The Act requires the Independent Scientific Review Panel to determine whether projects proposed for funding:

1. Are based on sound science principles
2. Benefit fish and wildlife
3. Have clearly defined objectives and outcomes
4. Have provisions for monitoring and evaluation of results
5. Are consistent with the Council's program.

The 2000 Columbia River Basin Fish and Wildlife Program's section on hydrosystem passage and operations strategies specifies that the ISRP will apply the following principles in its review of "reimbursable" projects including those in the COE fish passage program (page 26 or www.nwcouncil.org/library/2000/2000-19/strategies.htm#d6; see also ISAB report at www.nwcouncil.org/library/isab/isab99-4.htm.)

2-7 Primary strategy

1. Provide conditions within the hydrosystem for adult and juvenile fish that most closely approximate the natural physical and biological conditions.

2. Provide adequate levels of survival to support fish population recovery based in sub-basin plans.

3. Support expression of life history diversity.

4. Assure that flow and spill operations are optimized to produce the greatest biological benefits with the least adverse effects on resident fish while assuring an adequate, efficient, economical and reliable power supply. (FWP p. 25, bracketed numbers added).

SECTION 3

STRUCTURAL ALTERNATIVES

3-1 GENERAL

Table 1.1 lists the structural alternatives that are evaluated in this document. Table 3.1 is a list of the alternatives and their combinations. The following is a brief summary of each alternative:

3-2 FLOW DEFLECTORS

As part of the Bonneville Fast Track Program there are two phases to the design and construction of the Flow Deflectors. Phase I deflectors involves installing deflectors on the 5 non-deflector bays and replacement of one existing deflector. The new deflectors are being installed at elevation 7 versus elevation 14 for the existing deflectors. Phase II involves the potential modification of the existing deflectors. The decision regarding potential implementation will be based on survival and Water Quality studies conducted after construction of Phase I. Phase II is not considered in this Decision Document since the additional Phase I deflectors will increase the spill volumes for juvenile fish passage. Phase I deflectors were installed in FY02. COE will be evaluating the benefits of Phase I deflectors in FY02 to determine if Phase II deflectors are necessary. Action 60 in BIOP discusses this structural alternative.

3-3 B1 SURFACE COLLECTION DEEPSLOT (5 AND 20 WIDE SLOT)

The Surface Collection System for B1 consists of a surface collection component, beginning at the entrance in the forebay upstream of the dam, and leading to a fully functional bypass discharging all water and collected fish safely to the tailrace downstream of the project. Prototype testing has been conducted to evaluate the potential for guiding fish in to a surface collector. Preliminary design and physical model studies have been conducted to provide insight into what a complete system would look like but additional prototype tests are required. The major components are: the surface collector which includes entrances, ramps to a collection channel; and the outfall which includes a transition channel from the collection channel to the outfall channel, the outfall channel and the outfall. In the Alternatives Report (HARZA, 2001) several alternative paths were proposed indicated by the cost range shown in Table 1.1. There is also significant uncertainty associated with the cost and schedule for this alternative. Actions 61 and 97 in BIOP discuss this structural alternative.

During the course of the Decision Process two other Surface Collection alternatives were identified, Partial Deepslot and Shallow Surface Collection.

3-4 B1 PARTIAL DEEPSLOT

A Joint Technical Staff Memorandum (CRITFC, USFWS, ODFW, WDFW, and IDFG) dated February 6th, 2001, recommended the evaluation of the Partial Deepslot. The Partial Deepslot option is composed of a Deepslot Collection Channel in front of units 1-3, vertical occlusion in front of units 4-6 and the existing screened bypass system in front of units 7-10. The collection channel in front of units 1-3 is one of the recommended prototypes in the Deepslot Alternatives report. A cost estimate for this alternative is developed in Appendix E and shown in Table 1.1. There is significant uncertainty associated with the cost and schedule for this alternative. Hybrid systems are discussed in Action 97 of the BIOP.

Table 3.1 Decision Document Alternatives and Their Combinations

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
Existing	X	X	X	X	X	X	X	X	X	X	X	X
B1 MGRs		X	X	X	X	X	X	X	X	X	X	X
Flow Deflectors												
B1 JBS			X	X					X			
B1 ESBS				X					X			
B1 Deepslot					X					X		
B1 Partial Deepslot											X	
B1 Shallow												X
B2 FGE Improvement						X		X	X	X	X	X
B2 Corner Collector							X	X	X	X	X	X
Cases 11 and 12 only applied to Spring Chinook												

3-5 B1 Shallow Surface Collection

NMFS recommended (memorandum dated March 30th, 2001) a conceptual design of the B1 Shallow Surface Collection system. This alternative consists of a collection channel with overflow weirs for fish passage into the channel, vertical occlusion of the units, a transition channel to the outfall channel, an outfall channel and an outfall. A cost estimate for this alternative is developed in Appendix E and shown in Table 1.1. There is significant uncertainty associated with the cost and schedule for this alternative. Hybrid systems are discussed in Action 97 of the BIOP.

3-6 B1 JBS Improvements

The Plans and Specs for the B1 JBS Improvements have been developed. The major components of this alternative are: modifications of the existing juvenile bypass system collection channel, ice and trash sluiceway, a JBS transportation channel, which leads to a new dewatering structure, an elevated transport flume and flume bridge which crosses the Columbia River from Bradford Island and connects to the B1 transport flume on the Washington shore (constructed at the same time as the B2 transport flume). Little risk is associated with the cost and schedule of this alternative. Actions 62 and 97 in BIOP discuss this structural alternative.

3-7 B1 Extended Length Bar Screens (ESBS)

To improve guidance at Bonneville 1st Powerhouse, prototype tests of ESBS have been conducted. If implemented, this would replace the existing submerged traveling screens (STS) with ESBS. Turning vane, streamlined trashracks and vertical barrier screen (VBS) porosity modifications are included. The schedule and costs presented in Table 1.1 assumes that no changes will be made to the existing ESBS bar spacing which would require additional prototype testing.

COE conducted model tests regarding different gatewell flow conditions that will occur as a result of changes with a new gantry crane at B1. The new B1 gantry crane (which will be designed so that 2 out of the 3 gate slots will be empty and one intake gate dogged off at 19 ft.) will have significant impact on the porosities determined for the 1998-99 FGE tests (19 ft. gate raise). Results of the modeling indicate significant departures especially in the top half of the VBS. It has been recommended to biologically evaluate these changes. Seven of the units are anticipated to have this configuration and three units will have all gates in. Specifics on which units have not been determined. Based on potential operational issues, ideally one configuration that can be used for all the gate slots would be desirable. These recommendations require that the porosity plate will have to be modeled, redesigned, prototyped and tested. Schedule to perform survival testing is tentatively scheduled for spring of FY04. This will delay the implementation of the B1 ESBS and have some impact on cost.

3-8 B2 Corner Collector

Prototype testing of the B2 Ice and Trash Sluiceway as a Surface Collector showed numerous juveniles entering the forebay passed through the existing ice and trash sluiceway entrance and passed downstream. This has been dubbed the Corner Collector and includes: the modification of the intake to elevation 52 to increase flow into the system, hydraulic improvements inside the existing chute, construction of a transportation channel to the tip of Cascade Island, an outfall, and a plunge pool. Design work is completed for this alternative and there is a small level of risk associated with the cost and schedule. Action 66 in the BIOP discusses this alternative.

3-9 B2 FGE Improvements

The B2 bypass system has a state of the art fish conveyance system coupled with relatively low fish guidance efficiency. Methods to improve FGE are currently being evaluated at units 15 and 17. If results show improvement in guidance, the modifications could be implemented at the other units. Cost and schedule information is based on the cost of modifications to unit 15 and there is some risk. Action 67 discusses this alternative.

SECTION 4

HYDROLOGY

4-1 RIVER FLOWS

River flows at Bonneville can vary significantly throughout the year and during the juvenile fish passage season. Figure 4.1 shows the hydrograph that represents the lower Columbia River for a period of October 1973 through September 1999 and is representative of the flows that will occur at Bonneville. Peak flows generally occur at the end of May or first part of June and drop off significantly by the end of June or start of July. The river flow and how the flow is distributed at the project has a major impact on which alternatives will be recommended in the Decision Document. Depending on which river flow and flow distributions are considered, there may not be flow at both powerhouses. In addition the juvenile fish are distributed to the spillway, B1 and B2 based on the flow distribution.

The river flows that are to be evaluated to represent the flows that spring and summer juvenile fish will encounter need to be determined. The BIOP uses representative flows for 1994 through 1999, see Table 4.1. The average mean daily flows and the 50% exceedance line show that the 300 Kcfs in the spring might be achieved for a couple of weeks around the 1st of June and after the 1st of July the river would typically be below 200 Kcfs.

Figure 2.1 shows the layout of Bonneville. From south to north the primary features are: Navigation Lock, Bonneville 1st Powerhouse, Spillway and Bonneville Second Powerhouse. The major flow paths (B1, Spillway and B2) are separated by islands and depending upon which powerhouse is running and the volume of spill, there may be little to no flow in the channel immediately in front of B1, Spillway or B2. Typically at any given time there is a priority powerhouse, which is fully loaded before the other powerhouse is bought on line. Flow distribution or operational rules, as described in the BIOP and the 2000 Fish Passage Plan, are:

Minimal powerhouse flow 30 Kcfs (either powerhouse).
Minimal egress flow in the spillway of 50 Kcfs.

4-2 ADDITIONAL LIMITATIONS OR GUIDELINES

Maximum flow at B1 is 120 Kcfs (operating within 1 percent).
Maximum flow at B2 is 144 Kcfs (operating within 1 percent).

4-3 POSSIBLE SPILLWAY FLOWS

75 Kcfs day and 120 Kcfs night (current operations)
150 Kcfs (24 hour gas cap limit with Phase I flow deflectors installed)
50 Kcfs (minimum spillway egress)
0 Kcfs

Figure 4.1. Hydrograph

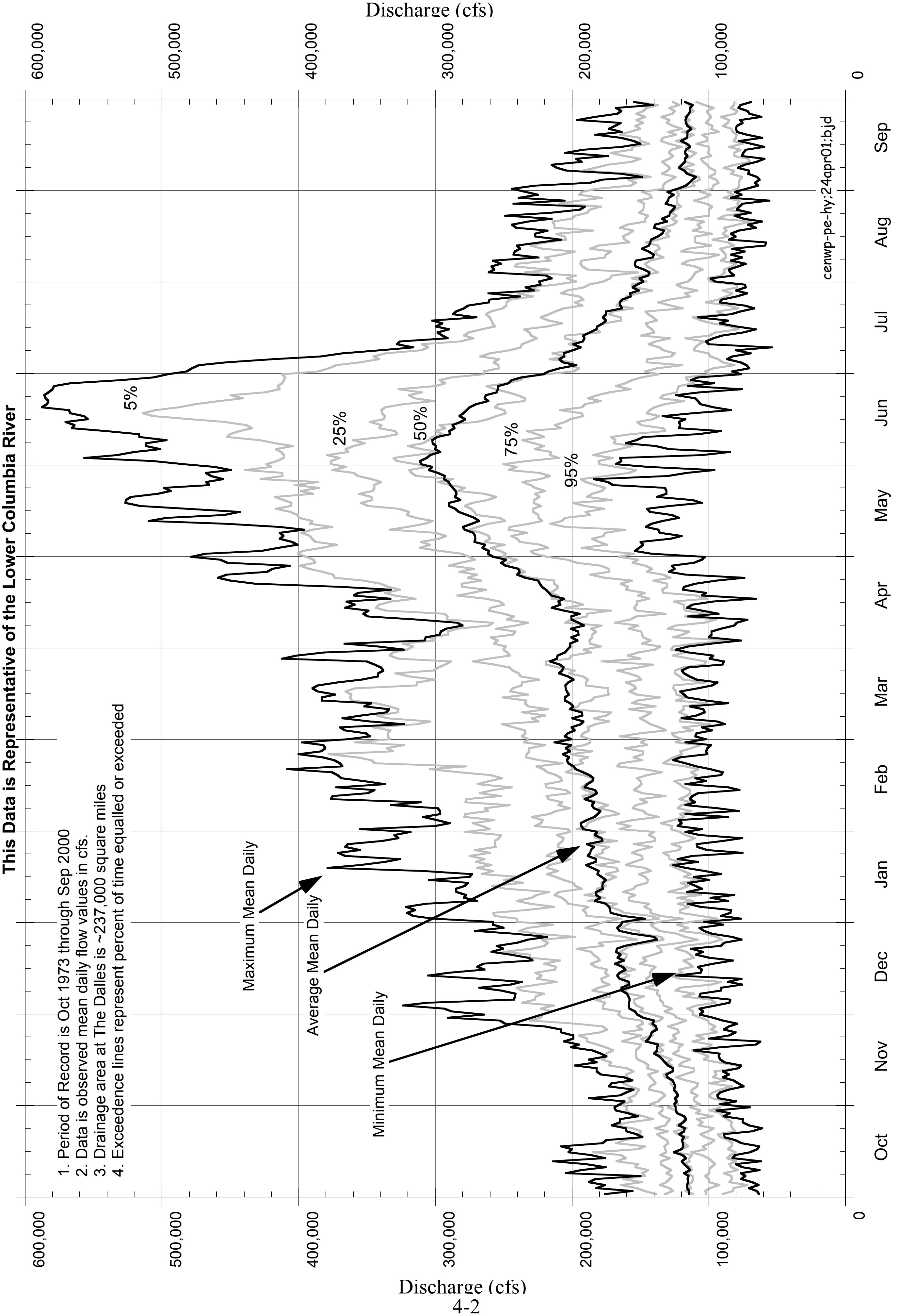


Table 4.1 Representative Flows

Representative Flows		
Year	Spring	Summer
1994	190	118
1995	253	165
1996	357	215
1997	463	237
1998	288	170
1999	302	233
Average	309	190

4-4 NO SPILL

On average would have full load at B2.
On average would have full load at B1 during May and June.
On average would have 75 Kcfs at B1 during April.
On average would have 40 Kcfs at B1 during July.
On average would have no flow at B1 during August.

4-5 75 KCFS SPILL

On average in April, May and June would have full load at B2.

On average in the month of August would have 60 Kcfs at B2.
On average in May and June B1 would be partially loaded at 60 Kcfs.

4-6 120 KCFS SPILL

On average would have full load at B2 during May and June.
On average would have 60 Kcfs or less at B2 in April, July or August.
On average would have 10 Kcfs at B1 in May and June.

4-7 150 KCFS SPILL

On average would not see a full load at B2.
On average would have 125 Kcfs at B2 during May and June.
On average would have 65 Kcfs at B2 in April.
On average would have 35 Kcfs at B2 in Jul and Aug.
On average would not have any flow at B1 during the spill season.

4-8 OPERATIONAL RULES

Table 4.2 summarizes the impact of the operational rules during the juvenile fish passage season. Maximum flow through each powerhouse is assumed to be 140 Kcfs to limit the number of tables and amount of evaluation. Assuming a B2 priority the following observations can be made.

For the three spill options shown (75, 120 or 150 Kcfs) May and June are the only months where full load would be achieved at the priority powerhouse. Data suggest that the priority powerhouse would operate at 60 Kcfs or less a significant amount of the time. For the 150 Kcfs spill option the priority powerhouse will operate at 30 Kcfs in July and August (powerhouse minimum). In addition, the non-priority powerhouse will only operate in the spring with any of the spill options.

The decision on which alternatives to implement at Bonneville will depend upon what operational rules are used to govern the project. Thus all of the spill options (0, 50, 75, 120 and 150 Kcfs) and both B1 and B2 priority will be evaluated for survival.

Table 4.2 Hydrograph Summary

Impact on Operation Rules At Bonneville for Different Spill Levels - Assuming a B2 Priority and 50 percent Exceedance						
Month	River Flow	Spills				
		0	50	75	125	150
	(Kcfs)					
B2						
April	215	140	140	140	90	65
May	275	140	140	140	140	125
June	280	140	140	140	140	130
July	180	140	130	105	55	30
Aug	135	135	85	60	30	30
B1						
April	215	75	25	0	0	0
May	275	135	85	60	10	0
June	280	140	90	65	15	0
July	180	40	0	0	0	0
Aug	135	0	0	0	0	0
Spill						
April	215	0	50	75	125	150
May	275	0	50	75	125	150
June	280	0	50	75	125	150
July	180	0	50	75	125	150
Aug	135	0	50	75	105	105

SECTION 5

DATA REQUIREMENTS

5-1 GENERAL

All reasonable and prudent alternatives are to be evaluated by the COE for Bonneville to improve juvenile fish passage survival. Several alternatives are currently under evaluation that would impact juvenile fish passage survival, see Table 1.1. Some of the alternatives are not mutually exclusive and the reasonable and prudent action is to identify the "best" combination of alternatives that improves juvenile fish passage survival at Bonneville. The recommendations for implementation at Bonneville will be incorporated into a system list for the Lower Columbia and Lower Snake Rivers projects to determine the priority for implementation. This Decision Document summarizes the information necessary to make a recommendation for Bonneville but does not deal with the funding of that recommendation. The following information was used to evaluate the alternatives:

1. Survival estimate for the individual alternatives and all reasonable combination of alternatives.

2. Risk associated with different routes of passage.

3. Expected implementation date (affects the 2005 and 2008 check point evaluations)

4. Expected annualized cost (includes planning, design and construction from March 01, O&M and power impacts)

The alternatives are compared for each species using a form of a benefit to cost ratio. Benefits will be associated with survival estimates take into account the risk associated with different routes of passage (discussed in Section 6). Cost will include planning, design and construction, increased O&M and impacts to power generation.

5-2 POWER GENERATION

Table 5.1 shows the average annual cost or benefit associated with the various alternatives being considered. The values are the difference between the proposed alternative and the base case. The base case is the configuration during the 2000 fish passage season at Bonneville and the operational guidelines established in the February 2000 Fish Passage Plan. The daytime spill was set at 75 Kcfs and the nighttime spill was set at 120 Kcfs.

The HYSSR model was used to determine flow volumes through the Bonneville Project. HYSSR provides monthly values using 60 historical water years, August 1928 through July 1978. Once the flow is determined the HALLO model computes the megawatt (MW) generated based on unit performance data. Minimal Gap Runners (MGRs)are currently being installed at B1 and were assumed at all ten B1 turbines. This is a reasonable assumption given that the power analysis starts in 2005 and goes to 2046. No unit outages were assumed but since the evaluation is the change between the various alternatives, this is acceptable.

Results from the John Day Drawdown study done in February 2000 were used to provide the economic cost of the power production. Henwood Energy Services, Inc. of Sacramento, California computed the value of the hydropower by computing the cost of the alternative power required to replace it

Appendix D is a report prepared by the Hydroelectric Analysis Center computing the power cost and benefits.

5-3 Operation and Maintenance

Table 5.2 shows the expected impact to the O&M budget at Bonneville given the different structural alternatives. All of the alternatives (including changing the spill volume) have minimum impact to O&M except for B1 Deep Slot and the B2 Corner Collector. In both cases an additional cost of $200,000 a year is estimated.

Table 5.1 Power Cost or Benefits

Annual Power Cost/Benefits From Existing Conditions 75/120 Spill (Kcfs)		
Structural Modifications	B1 Priority	B2 Priority
B1 Surface Collection -14.2 million	B1 0 Spill + 28.6 million	B2 0 Spill +28.5 million
B1 JBS/ESBS - 56 thousand.	B1 50 Spill +14.0 million	B2 50 Spill +13.9 million
B2 FGE improvement 0	B1 75 Spill +5.5 million	B2 75 Spill + 5.3 million
B2 Corner Collector 0	B1 120 Spill - 10.6 million	B2 120 Spill -10.9 million
B1 Remove STS + 0.5 million	B1 150 Spill - 19.5 million	B2 150 Spill - 19.7 million

Table 5.2. Operations and Maintenance

Delta Operations and Maintenance From Existing Conditions 75/120 Spill		
0 = No change		10 = Maximum Change
Structural Modifications	B1 Priority	B2 Priority
B1 Surface Collection 4	B1 0 Spill 4	B2 0 Spill 4
B1 JBS/ESBS 8	B1 50 Spill 3	B2 50 Spill 3
B2 FGE improvement 2	B1 75 Spill 2	B2 75 Spill 2
B2 Corner Collector 1	B1 120 Spill 1	B2 120 Spill 1
	B1 150 Spill 2	B2 150 Spill 2

SECTION 6

BIOLOGICAL INFORMATION

6-1 GENERAL

The Portland District Army Corps of Engineers has been tasked by the current NMFS biological opinion to measure the survival of adult and juvenile anadromous fish past Bonneville Dam (current passage routes, Fish Passage Efficiency (FPE), Fish Guidance Efficiency (FGE), routes of passage).

a. Routes of Passage/FPE/ Project Survival. Bonneville Dam has three (3) primary routes of passage for juvenile fish and one (1) for adults. The three most prominent routes for juveniles are the spillway, powerhouse juvenile bypass systems, and turbines. The primary routes for adults are the four main fish ladders at the first and second powerhouses as well as the ladders associated with the spillway.

b. Estimation of Project FPE and Survival. Estimation of Project FPE and survival requires accurate estimates of the proportion of juvenile salmon that pass through every major passage route. The region has accepted and supported the COE efforts to measure survival, behavior, FGE and FPE by these tools:

Radio Telemetry
Hydroacoustics
Direct Survival Tools (i.e., HI-Z Turbine Tag)
Passive Integrated Transponder Tags (PIT Tags)
Coded Wire Tags (CWT)

Discussed below are the historical research dealing with these specific routes of passage, improvements that have been made and the current research detailing improvements in technology and the COE has been able to gather more accurate passage survival data.

6-2 FISH GUIDANCE EFFICIENCY AND SURVIVAL

a. General. The 2000 FCRPS BIOP established the need to understand project specific survival and fish passage efficiency (FPE). Project **survival** is defined as the number of juveniles that survive as they pass through the project structures and immediate downstream impacts (including tailrace predation) divided by the total juveniles that pass the project. Project **FPE** is defined as the number of juveniles that pass through the project without going through a turbine unit divided by the total juveniles that pass the project. This includes bypass systems and the spillway. Fish guidance efficiency (**FGE**) at a powerhouse is defined as the number of juveniles passing the powerhouse via the bypass system divided by the total number of juveniles that pass the powerhouse. FPE and FGE are an indication of the effectiveness of measures to divert juveniles around the turbines, which are considered to have a higher mortality rate, compared to the bypass systems and spillway. These terms can be expressed by formulas as:

$$\textbf{Survival} = \frac{S_b+S_t+S_s}{Ft}$$

where: S_b = fish surviving passage through the powerhouse bypass system,

S_t = fish surviving passage through the turbines,

S_S = fish surviving passage around and through the spillway, and

F_t = total fish in the Bonneville forebay.

FGE = $\frac{B_p}{F_p}$

B^p = fish that bypass around the powerhouse turbines, and

F^p = total fish passing the powerhouse.

FPE = SPE + ((1-SPE) x FGE)

where: SPE = proportion of fish that go through the spillway,
(1-SPE) = proportion of fish passing the powerhouse, and
FGE = proportion of powerhouse destined fish that bypass around the powerhouse turbines.

Although FGE and FPE performance are considered important, for better understanding of routes of passage, survival is the standard that NMFS has endorsed for the BIOP. COE will utilize survival as the factor in determining appropriate measures to implement to meet BIOP performance standards.

b. B1 FGE Testing. Starting in 1981 Submerged Traveling Screens (STS) were tested at Bonneville's First Powerhouse at various angles to determine Fish Guidance Efficiency (FGE) (Krcma R. et al 1981). The study evaluated fish guidance performance according to the varying angles of the screens. FGE's in excess of 70 percent were obtained for all species with the STS operating at a 47-degree angle at elevation 44. FGE was the lowest for sub yearling chinook at 71.5 percent due primarily to loss through the gap (8.7 percent) at the top of the screen.

Test also indicated that 75-90 percent of the fingerling found in the area of the intake intercepted by the STSs (approx. 14ft below the ceiling intake). Fall chinook and sockeye appeared to be more deeply distributed than spring chinook, coho, and steelhead.

Testing was conducted again in 1988 in response to the new navigation lock. Guidance levels from 30 May to 5 June 1988 were considerably less than in 1981; 55 percent and 41 percent for coho and subyearling chinook, respectively. From 6 to 27 July, FGE for subyearling Chinook averaged 11 percent (Gessel et al. 1989). Tests on the effects of flow pattern changes on FGE were continued in 1989 and further expanded to include both the spring and summer outmigrations of yearling and subyearling salmon. From 9 to 14 May , FGE for yearling chinook averaged 42 percent. From 27 to 30 May, FGE for yearling and sub yearling chinook averaged 31 percent and 37 percent respectively; however, generally fewer that 100 fish were recaptured per test. From 12 to 24 July, FGE for Subyearlings averaged 5 percent (Gessel et al. 1990). These studies suggest that FGE drops for subyearlings later in the season.

Because of the relatively low FGE in 1988 and 89 additional tests were conducted in 1991 to determine the effect of raising the operating headgate in the slot and how this increased flow up the slot could effect screen guidance (Monk et al 1992). Tests in 1991 showed a subsequent increase on FGE for yearling chinook from 29.5 percent to 49.5 percent by raising the operating gate in unit 8, indicating that optimal flows into the gatewell did not exist with the operating gate stored in the lowered position. NMFS conducted additional studies at B1 in 1992 to compare FGE under the following conditions: a standard STS with a stored headgate; a standard STS with a raised headgate; and a lowered STS with a raised headgate. The results of the STS research done at other powerhouses on the Snake and Columbia Rivers suggested that lowering the STS more that 36 inches caused a large portion of the fish to go over the top of the screen and through the gap between the STS and the Vertical Barrier Screen (VBS) rather than up into the gatewell.

Test results in 1992 showed that lowering the STS 31.5 inches below the standard elevation in the gatewell did not improve FGE for yearling chinook at PH1. Contrary to results obtained in 1991 at PH1, a raised operating gate did not significantly improve FGE for yearling chinook. However, FGE was significantly increased for subyearlings, coho, and steelhead. And finally, a steady decline in FGE for yearling and subyearling salmon was noticed as the Spring migration progressed (Monk et al. 1992).

In 1998, NMFS conducted FGE studies at the First Powerhouse (Unit 8) on ESBSs with the operating gate removed. In spring studies, FGE for yearling chinook salmon ranged from 53 to 87 percent with a mean of 72 percent (SE = 1.9). For subyearling chinook salmon, steelhead, coho, and sockeye salmon, FGE averaged 67, 85, 80 and 51 percent, respectively. These were all substantial increases over any previous FGE values with a STS (since 1981). In summer studies, from 22 June-2 July and from 6-17 July, FGE for subyearling chinook salmon averaged 48 percent and 23 percent, respectively. These late July FGE values with ESBSs were 2-5 times that observed in 1988 and 1989 with STSs.

During the spring 1998 FGE studies, there was a significant difference in descaling percentages between yearling chinook salmon guided with the ESBS (9.6 percent) and those guided with the STS (8.2 percent). There was no significant differences in descaling between the two screen types for any other species, either during the spring or summer migration. Longer ESBS have increased flows and velocities up the gatewell slots and understanding potential for descaling is important.

A repeat test was conducted in the spring and summer of unit 8 at Bonneville PH1 in 2000. To further improve FGE by increasing flows into the gatewell, operating gates were raised in the A and C slots and the gate was removed in the B slot to accommodate the fyke net frame used in FGE testing. A total of 22 FGE tests were conducted from 24 April to 24 May. FGE for yearling chinook averaged 66 percent. For both steelhead and coho the mean FGE was 76 percent. For all three species, mean FGE in 2000 was 4 to 9 percent less than what was observed in 1998. In 18 tests conducted from 12 June to 7 July, FGE for subyearlings averaged 46 percent. As seen in 1998 at B1 and at other projects, there was a steady decline in FGE for subyearling chinook throughout the summer.

In 2000, DOE (Ploskey, G.) was tasked with comparing the biological fyke netting results generated by NMFS (Monk et al 2000), to hydroacoustic data collected by their agency. Results from both techniques showed that numbers of guided fish declined and the numbers of unguided fish increases from spring through summer, although daily variability was high for both methods. Hydroacustic estimates were lower that netting estimates in spring but similar to netting estimates in summer; nonetheless, they correlated. Hydroacustic counts of the unguided fish gradually increased for spring thought summer (P=0.0142), and netting estimated showed a similar rate of change, although daily variability was high for both methods. On average, hydroacoustic estimates of unguided fish were about 33 percent of netting estimates in spring and 50 percent of netting estimates in the summer. Values used for SIMPAS modeling for STS are as follows: spring chinook – 39 percent, steelhead – 41 percent and sub-yearling chinook 9 percent. Values for ESBS are: spring chinook – 72 percent, steelhead – 85 percent and sub-yearling chinook 35 percent.

6-3 PROTOTYPE SURFACE COLLECTOR

At Bonneville Dam First Powerhouse (B1), the Portland District of the U.S. Army Corps of Engineers (COE) evaluated two distinct smolt bypass approaches, surface flow bypass and extended-length submersible bar screens. In 2001 the COE scheduled a decision on which suite of smolt passage measures to emphasize for long-term smolt protection at B1.

The goal of the surface flow bypass program is to "*…develop and evaluate surface bypass and collection prototype concepts that will lead, if justified by prototype test results, to permanent systems for improving survival of juvenile salmon…*" (USACE 1995). In 1998, a prototype surface collector (PSC) was installed at Units 3-6 and was extensively studied (see Johnson and Giorgi 1999 for a review). In 1999, limited research occurred to prepare for tests in 2000. In 2000, the PSC was extended from Units 3-6 to also cover Units 1-2, because a noticeable number of smolts were observed in 1998 and 1999 to move obliquely from north to south across the forebay of the PSC. A thorough evaluation of the PSC was conducted in 2000 as part of the Anadromous Fish Evaluation Program (AFEP). The general objectives for surface bypass research at B1 in 2000 were to (1) confirm proof-of-concept for surface bypass at B1 that was established in 1998 (concept design was to validate if fish could be guided. The fish were not transported into a bypass channel.)(2) estimate PSC performance metrics; and (3) study behavioral processes and mechanisms that affect performance to aid future surface bypass designs.

The 2000 PSC evaluation emphasized PSC performance, i.e., efficiency, as well as forebay fish movements. It included the following biological research (AFEP study codes are given in parentheses):

- Fixed radio telemetry to determine species-specific PSC performance and movement patterns for yearling chinook salmon and steelhead (SBE-P-95-6);

- Acoustic telemetry to study three-dimensional movement patterns and PSC performance for yearling chinook salmon and steelhead (SBE-P-00-14);

- Fixed hydroacoustics to estimate fish passage rates and determine PSC performance for the run-at-large during spring and summer (SBE-P-98-8a);

- Multi- and split-beam hydroacoustics to assess fish movements near the PSC (SBE-P-98-8b);

- Computational fluid dynamics modeling to document forebay hydraulic conditions (no AFEP code);

- Numerical modeling to integrate hydraulic data from a computational fluid dynamics model with three-dimensional fish movement data (SBE-P-00-13).

The PSC was retrofitted to the upstream face of B1 at Units 1-6. Vertical slots in the PSC in front of middle (B) intakes at each unit were configured to have 5-ft or 20-ft wide openings. These widths were chosen to maximize differences in flows and velocities between the configurations to increase the likelihood of detecting differential smolt responses to PSC slot-width treatments. PSC entrances were 40-46 ft deep depending upon forebay level (PSC floor was at El. 30.5 ft). The mean velocity at the entrance ranged from 3.8 to 8.3 fps, depending on slot width. Flow through the entrances was 1,700 cfs for 5-ft slots and 3,300 cfs for 20-ft slots.

Fish passing via the PSC migrated through the structure into the turbine intake or sluice gate behind the PSC. The PSC was not designed to actually bypass fish around turbines during the test periods. The intent was to use the PSC to examine entrance hydraulics and to examine the efficacy of surface bypass at B1 before building a large-scale prototype or full production surface bypass facilities. Based on results from 1998-1999, the 20' slot width proved most efficient. Given the 1998-1999 results, it did not seem necessary to continue to compare 5-and 20-foot entrance widths in 2000. Thus, PSC entrance width was a constant 20 feet in 2000.

The B1 PSC evaluation in 2000 emphasized performance (i.e., efficiency) and fish movements (i.e., processes); the study did not have experimental treatments. The PSC and associated turbines and sluice gates were operated as constantly as possible. Relatively steady dam operations reduced environmental variability, thereby improving the conditions under which researchers investigated biological processes affecting PSC performance.

6-4 EVALUATION TOOLS

Radio telemetry was used to study the movement, distribution, and passage behavior of juvenile salmonids at Bonneville Dam in 2000 (Evans et al. 2001). In total, they radio-tagged and released 1,193 steelhead and 2,075 yearling chinook salmon in the Columbia River at the Hood River Bridge and well upstream. Aerial and underwater radio telemetry antennas were deployed to determine specific passage routes at the dam for each tagged fish. The primary purpose of the radio telemetry study was to provide species-specific data on PSC performance including discovery efficiency, entrance efficiency, collection efficiency, effectiveness, and residence time.

a. Performance Metrics. The following performance metrics were estimated for the PSC evaluation in 2000.

- PSC collection efficiency relative to Units 1-6 (CE_{1-6}) and individual areas (e.g., Units 1 and 2, CE_{1-2}).
- CE = PSC passage divided by PSC passage plus passage under the PSC

b. PSC Collection Efficiency. Collection efficiency is defined as PSC passage divided by PSC passage plus passage under the PSC. In spring 2000, collection efficiency was estimated on a species-specific basis for yearling migrant steelhead and chinook salmon using radio and acoustic telemetry and for the run-at-large using fixed-location hydroacoustics. During the hydroacoustic summer study, subyearling chinook salmon predominated the outmigration. (The study ended before shad became prevalent in the forebay.) Thus, the hydroacoustic results for summer can be ascribed to subyearlings. In this section, results are presented for each method separately. In the discussion the PSC collection efficiency data are collectively tabulated and compared.

Species-specific estimates of collection efficiency are important to decision-makers because different species may respond differently to smolt protection measures. Radio telemetry estimates of collection efficiency were 83 percent for steelhead and 79 percent for yearling chinook salmon. Acoustic telemetry estimates of collection efficiency were 88 percent for steelhead and 96 percent for yearling chinook salmon. For the purpose of the decision document, the COE believes the species-specific collection efficiency estimates from radio telemetry should be used, because the relatively large samples sizes for radio telemetry likely yielded more precise estimates than those from acoustic telemetry.

Collection efficiency was also estimated by PSC unit and by block (5-day) using hydroacoustics. It was highest (>80 percent) at Units 5 and 6, and was always greater than 60 percent. Lowest collection efficiencies were found at Units 3 and 4 in spring. uring the evaluation from April 20 to July 2, 2000, collection efficiency among blocks (5-day) was reasonably consistent.

c. Conclusions. Based on the Collective data presented:

- Monitoring and evaluation of the prototype surface collector at B1 in 2000 allowed for a thorough evaluation of PSC performance.

- The surface bypass concept as applied at B1 was found to be an efficient way to collect smolts and minimize turbine passage.

Table 6.1 presents collection efficiency estimates based on hydroacoustics (HA) and radio (RT) and acoustic (AT) telemetry at B1 in 2000. Sample sizes are given in parentheses. Hydroacoustic data were obtained from Ploskey et al. (2000). Radio telemetry data were obtained from Evans et al. (2001). Acoustic telemetry data were obtained from Faber et al. (2001).

Table 6-1. Collection Efficiency Estimates

Population	Season	Collection Efficiency		
		HA	RT	AT
ST	Spring	----	83 percent (214 of 258)	88 percent (70 of 80)
CH1	Spring	----	79 percent (246 of 312)	96 percent (22 of 23)
Run-at-Large	Spring	83 percent[A]	----	----
CH0	Summer	84 percent[A]	----	----

[A]Adjusted for passage into the sluiceway behind the PSC entrances which was not sampled by hydroacoustics.

1. PSC collection efficiency estimates from independent methods (hydroacoustics, radio telemetry, acoustic telemetry) comported reasonably well.

2. The best available data for collection efficiency are from the 2000 evaluation. For the purposes of planning and analysis, the following values are recommended:

- Steelhead 86 percent
- Yearling chinook salmon 89 percent
- Subyearling chinook salmon 84 percent

3. Collection efficiency was similar between spring and summer, i.e., it did not decrease in summer as is the case with other smolt bypass approaches.

4. Collection efficiency for the B1 PSC as higher than that for the SBC at Lower Granite Dam, and comparable to that for the Wells Dam surface bypass.

5. Extending the PSC to Units 1-2 in 2000 was worthwhile because the surface bypass entrances at Units 1-2 passed a substantial proportion of total PSC fish passage (23-28 percent).

6. According to radio telemetry data from 2000, the PSC would have increased fish passage efficiency at Bonneville Dam 18 percent for steelhead and 10 percent for chinook salmon compared to FPE without it had it been a functional bypass system.

7. The PSC was twice as effective (percent fish divided by percent water) as spill at passing fish at Bonneville Dam in 2000.

There are uncertainties with development of a permanent surface bypass at B1, but it is likely that they can be satisfactorily resolved with additional research and development.

6-5 B1 SLUICEWAY

Sluiceway passage efficiency tests were carried out in 1981 as part of the NMFS research component to study the FGE at the First Powerhouse (Krcma et al. 1992). The evaluation was tailored around determining sluiceway passage by determining how many juveniles used the sluiceway by setting up a test design to separate out sluiceway passage and turbine. The test design was as follows:

$$\textbf{SPE} = \frac{\text{Sluiceway Passage}}{\text{Sluice passage +turbine passage X 100}}$$

To estimate the numbers of fish using the sluiceway NMFS estimated the numbers of juveniles passing through turbines with the sluiceway opened and closed. Then they took measurements of fish passing through the sluiceway by direct net capture. They were then able to use the above formula to calculate an estimate of fish using the sluiceway when operating. A large variation in numbers of fall chinook from day to day occurred. This was primarily due to hatchery fish, liberated within Bonneville pool, passing the project within a few days after release. Variations in the estimated numbers of sluice passage were also found to be due to how fish were distributed as they approached the powerhouse changes as a result of a open or closed sluiceway. It was found that on days that the sluiceway was closed the fish had a higher chance to delay and not pass through the top part of the intake. Just because the fish were surface oriented didn't mean that when the sluiceway was closed they would be guided better by the STS which directs fish in the top on third of the intake. It was evident from further data collection that the fish would delay and just pass at night. Sluiceway passage efficiency ranged over the study from12.5 percent for fall chinook salmon to 58.9 percent for steelhead. For all species combined, the sluiceway guided and estimated 24 percent of the fish passing the powerhouse.

In 2001, USGS used radio-tagged yearling chinook to test passage behavior at Bonneville Dam (Evans, el at. 2001). At B1 in 2001, the greatest percentage (76 percent) of fish that traveled past the first powerhouse did so by passing through the shallow, weir-type entrances of the sluiceway followed by the deeper unguided (13 percent) and guided (11 percent) routes of passage. Because of the low water year the bulk of the flow for 01 traveled either through the spillway or B2 which is first in the operating priorities for powerhouses at BON. Approximately 6 percent of the total river flow was past via the first powerhouse for spring and summer combined. Sluiceway survival is unknown and it appears that sluiceway guidance is affected by the level of flow through the powerhouse. Additional information is needed to address this area.

6-6 SPILLWAY PASSAGE

a. <u>Spill Passage Efficiency and Effectiveness</u>. Spill efficiency and spill effectiveness need to be properly defined to understand their components and how they are used to evaluate fish behavior as it relates to fluid dynamics.

- Spill Passage Efficiency-- the proportion of fish that pass through the spillway.
- Spill Passage Effectiveness-- spill passage efficiency divided by the proportion of total discharge spilled.

Throughout the 1990's, hydroacoustic techniques were used to monitor fish passage at Bonneville Dam's spillway. In addition FPE studies were conducted in 2000 and 2001. Information collected during these evaluations determined that migrating juvenile salmonids readily pass the spillway at varying discharges during periods of voluntary and involuntary spill times. Through these evaluations it has been estimated that spill efficiency to be 0.44 and 0.40 in spring and 0.49 and 0.60 in the summer respectively, and spill effectiveness to be 1.36 and 0.84 in spring and 1.03 and 1.83 in summer respectively. These data points above were used in the SIMPAS model to accurately estimate fish passage survival according to varying spill levels. This means that at various times of the year the ratio of fish passing the spillway is higher than a 1:1 ratio that has been accepted regionally for Bonneville's spillway. Ploskey et.al in his 2001 and 2000 Hydroacustic evaluation reports of passage through Bonneville Dam shows continued support of these findings. In general he found that the trend lines for project fish passage efficiency (FPE) and spill efficiency vs. spill level had *very slight* positive slopes, suggesting that higher spill levels may be associated with slightly higher spill passage. The spill levels evaluated in 2000 were between 75K to 130K and only spill at 50K in 2001 due to drought conditions in the region. Ploskey reports that there was a positive correlation found between higher spill volumes and the reduction of spill effectiveness at higher spill levels. Therefore, as increasing volumes of water are discharged at the spillway the effectiveness of the spill is reduced (ie, additional fish pass with higher spill volumes, but a lesser percentage increase of juveniles is observed). It was also documented that individual spillbay levels at larger openings did not translate into higher fish passage.

Included is an estimate of spillway effectiveness used in SIMPAS. The equation used for these estimates can be found in Ploskey 2000 and are derived from 2000 research data. To further clarify the distinction between fish passage efficiency and fish passage effectiveness see below. The effectiveness for a B2 priority for the summer flows is bumped up 7.5 percent from the B1 priority for the summer flows.

Spill Effectiveness Spring = -0.0017*(spill) + 1.5255
Spill Effectiveness Summer = -0.0091*(spill) + 1.8766

In addition to hydroacoustic measurements by DOE in 2000 and 2001, DOE also measured spillway effectiveness and spillway efficiency by radio-tagging yearling and sub yearling chinook.

b. <u>2000-01 Data for Yearling and Subyearling Chinook Using Radio Tracking</u>. Spillway efficiency for yearling chinook in spring 2000 was 44 percent and in 2001 was 16 percent overall, 30 percent during 37 percent spill, and 1 percent during 2 percent spill in summer.

The proportion of fish that passed through spill relative to the proportion of discharge spilled (spillway effectiveness; SF) was 1.3 for yearling chinook in 2000.

6-7 ADULT FALLBACK

Biological studies in the 1970's and early 1980's identified potential problems with adult fallback through the spillway at Bonneville Dam. Results suggest that adult fallback rates were a concern at moderate to high spill rates, especially for adult fish passing the Bradford Island fishway. Recent studies on adult fallback have further quantified the affects of adult fallback and suggest that fallback events do increase the potential for reduced escapement. Currently, spill at Bonneville is regulated for gas management as well as reducing the incidents of adult fish falling back through the spillway by limiting spill during the day time when possible. Actions and recommendations associated with higher levels of spill carry the risk of impacting migrating adults by introducing them to fallback conditions that might not exist at lower levels of spill. Current recommendations for Bonneville are to make improvements to the spillway to allow for higher levels of spill with the gas cap waivers and to reduce gas levels at low spill. A separate program is underway to develop alternatives to resolve adult fallback if necessary. Six new deflectors were installed at Bonneville in FY2002. These new deflectors are in response to the need to reduce gas entrainment at these bays during voluntary and involuntary spill. As the region progresses forward in reducing gas levels at Bonneville as well as implementing higher spill levels, an effort to continuously monitor and quantify the impacts as it pertains to increased fallback is needed.

6-8 BONNEVILLE FALLBACK EVALUATION

A randomized block tests was conducted to evaluate effects of high and low spill on fallback rates of adult salmon and steelhead at Bonneville Dam in 2000. Periods of low spill (50-75K) were alternated with periods of high spill (80-145K) during which the proportion of Chinook salmon and steelhead that fell back were compared. Overall, 1,624 salmon and steelhead passed through the two fish ladders, of which 180 fish (11.1 percent) fell back at Bonneville Dam, and of those, 1,449 fish and 168 fallbacks were used in the analysis. These tests were conducted prior to having additional flow deflectors installed at the spillway in 2002, which should increase spill and still remain within the gas cap. It is important to understand if higher spill increases fallback rates for the project. Adult fallback used in this analysis reflect adult radio tagged fish that fallback past the project within 24 hours of exiting the fishway.

*Percent fallback for the Project low spill treatment = 6.2 percent
*Percent fallback for the Project high spill treatment = 9.3 percent
*Percent fallback for Bradford Island low spill treatment = 10.2 percent
*Percent fallback for Bradford Island high spill treatment = 15.8 percent

*Fish that passed the dam using exiting the Bradford Island fishway averaged 14.9 percent fallback during low spill and 20.6 percent during high spill.

6-9 POWERHOUSE PRIORITY

Recent changes and upgrades to Bonneville Dam's Powerhouse's has recently made it possible to run each powerhouse independently of each other. Historically, PH1 was the priority powerhouse with PH2 only being loaded once all units at PH1 were brought on-line. In 2000, an inter-tie between the two powerhouses was completed. Upon completion, PH2 can now be operated independently of PH1 as well as feed project station service needs. Since the COE obtained this ability in 2000 and supportive biological survival data showed a substantial increase in survival and improved guidance at PH2 it was regionally decided to switch powerhouse operating priority and place PH2 in the lead.

Since the inception of this new operating priority, several theories or passage hypothesis have been generated concerning how the effects of certain powerhouse operations reflect on increased guidance and spill efficiency of the spillway. It is theorized that if you have the bulk of your flow going through B2 (B2 priority) and the spillway that due to channel hydraulics associated with smoother flow patterns into PH2 and the spillway that you will get better SE then if you changed powerhouse priority to PH1 and the spillway. Because of the river bathometry (SP) and the shape of the entrance channel above Bradford Island leading into the Bonneville powerhouse 1 forebay, it is felt that fish tend to track closer to the center of the spillway channel and less towards PH1. Due to the change in priority in 2000 and the drought year in 2001 the COE has been unable to gain firm biological data to support this theory. The 2002 water year appears to be more normal and should allow for some spring and early summer operation of PH1. Spring Radio Telemetry data will aid in bolstering this theory by providing route specific tracking data of juveniles as they approach the project. Once the RT data can be combined with hydroacoustic data the COE will have a much better idea of how powerhouse operation and priority influences SE and SF.

6-10 BONNEVILLE SECOND POWERHOUSE

Biological data were collected using a variety of methods, including direct capture fyke netting and gatewell dipping, hydroacoustics, and radio telemetry. Hydraulic data have been collected by both field measurements and model techniques. Results of the experimental periods from 1983 to 1989, and the post-construction evaluation are included below.

During the experimental period (1983-1989) a large number of short term duration tests were performed on a variety of measured designs to enhance FGE. Lowering the STS 0.8 meters, streamlining the main unit trashracks to the incoming flow lines, and installing Turbine Intake Extensions (TIEs) were the most effective measures tested. Together, these improvements increased FGE under experimental test conditions (partial powerhouse and partial TIEs) to approximately 70 percent for spring migrants. Other measures tested included a raised operating gate (ROG), blocked trashracks, and a trashrack deflector. None of these measures improved FGE. This suggested the hydraulic environment above the screen, that is the flow field leading from the trashracks up into the gatewell slot, was limiting further FGE improvements.

Because of their apparent success, a full compliment of TIEs, streamlined trashracks, and lowered STSs were installed and tested starting in 1993. Results from the 93-94 FGE evaluations produced lower than expected FGE results. Spring migrant FGE was approximately 50 percent, compared to 70 percent during the 1980s testing. The performance of various measures tested from 1983 to 1994 was found to be highly variable. Results varied with year, season, species, intake slot, and unit and powerhouse operation. The number of fish entering and being guided by the non-TIE intake slots was higher under four and six than eight-unit operation. This suggested that powerhouse load (number of units on) has an effect on the strength of the lateral flows directed toward each corner of the powerhouse, and that TIEs produce a varying effect on intake distribution that decreases from four to six unit operation, and disappears with eight units. With these findings NMFS concluded that two hydraulic conditions must be addressed to further improve FGE: 1) the flow field above the STS and into the gatewell slot is restricted and needs to be increased, and 2) the bulk flow moving laterally across both the north and south ends of the powerhouse in the near forebay needs to be redirected into the intake. It was also determined by limited hydroacoustic evaluations that vertical distributions of fish were found to be similar to other projects, and fish are distributed in the upper portions of the water column, moving down and lateral near the trashracks.

Hydroacoustic evaluations conducted in 1998 with the southern most TIEs removed indicated that the sluice chute located in the corner south of unit 11 is a highly effective route of passage (see B2 Corner Collector section for data). Combined FPE for the chute and units 11-13 was 90 percent for both spring and summer. In contrast, when the chute was closed FGE of the STSs in units 11-13 averaged 55 percent and 30 percent during spring and summer, respectively. Based on this data, SIMPAS B2 Corner Collector guidance estimates are spring chinook – 46 percent, steelhead – 62 percent and subyearling – 47 percent.

NMFS concluded that FGE is limited by a constrained hydraulic environment above the STSs. In addition, the near forebay hydraulic environment greatly complicates the sensory cues presented to the fish. NMFS also recommended that subsequent hydraulic evaluations need to be examined to look at the complex interactions between bulk forebay flow and the flat face and intake structures for clues on how to improve FGE.

In response to these findings the COE started research in 1998 to collaborate and support the construction of two new fish passage improvement projects at B2. The first of the two was a modification to the current gatewell intake structure to direct more flow up into the gatewell slot. This included a new VBS design, a gap closure device and a turning vain. With these improvements in place the hydraulic capacity up the gatewell slot went from 270cfs to 480cfs. Also, the STS top gap flows were reduced from 215cfs to 90cfs. With this increase flow the COE expected to improve guidance up the gatewell slot by directing more flow up into the gatewell area. Research was conducted in 2001 to measure the FGE improvements in modified main unit 15.

Improvements were measured by using three different research-measuring tools in the 2001 field season. These tools were: 1) Fyke netting, 2) Hydroacoustics, and 3) Radio tags. Spring FGE using fyke netting (NMFS) resulted in 71 percent for yearling chinook, 88 percent for steelhead, and 82 percent for Coho. These numbers were the highest FGE values measured at PH2 since testing began in the early 1980's. Summer FGE for sub yearling chinook averaged 57 percent, similarly hydroacoustics (DOE) which measures all species passage found a spring guidance of 72 percent for spring and 50 percent for summer. RT (USGS) showed a much lower FGE in spring compared to Fyke tests and hydroacoustics with a 38 percent FGE in the spring and 34 percent in the summer. When comparing 01 Fyke net information to the hydroacoustics for that same year a close correlation is apparent between the two data sets. RT shows a great disparity between the two other data sets with as much as 32 percent FGE difference between RT and hydroacoustics data for that same time period (spring). This was probably due to low sample sizes in comparison to the other techniques.

In 2002, the COE has modified another PH2 Unit (17) to test if for FGE improvements. Results will be compared to the unit 15 data collecting in 01 and a decision made on whether further intake modifications to additional PH2 units will advantageous.

6-11 B2 Corner Collector (B2CC)

a. Biological Rationale. The biological rationale for development of the B2CC is based on data on forebay collection efficiency, observations of increased entrance flows in a physical model of the B2 forebay, and regional expertise to bioengineer a smolt bypass and outfall at Bonneville Dam. Forebay collection efficiency for the B2 sluice chute during 1998 baseline tests was 44 percent for all radio-tagged fish combined. Also, Hydroacoustic estimates for 1998 showed that the combined passage efficiency for B2 increased dramatically when the prototype corner collector was operating. This was remarkable for the small amount of flow (~2,550 cfs), but not surprising given the relative success of sluiceway-type smolt bypasses at other dams, e.g., B1, The Dalles, and Ice Harbor. Based on visual assessments made during physical model studies, it was apparent that the zone of influence of a B2 CC could be enlarged significantly by doubling the flow into the corner collector. It is reasonable to assume that this increased flow will result in further increases in forebay collection efficiency for the B2 CC. Since the B2 CC will be the first high flow bypass system designed specifically for juvenile fish passage using predetermined guidelines, it will have a solid, scientific foundation. In conclusion, the biological rationale for the B2 CC is convincing.

b. B2CC Passage Efficiency. The B2 sluice chute was tested as a prototype corner collector (B2CC) in 1998, in addition to baseline studies in 1996 and 1997. In the baseline studies, research regarding fish passage at the sluice chute was inconclusive because turbulence created by the turbine intake extensions (TIEs) precluded accurate estimation of passage rates with hydroacoustics. Radio telemetry work was not performed in 1996 and 1997 at the B2CC. However, researchers in 1996 and 1997 did visually observe appreciable numbers of smolts going over the sluice chute weir. In 1998, the TIEs at Units 11-14 were removed and the B2CC was opened and closed according to a randomized block experimental design. The objective was to determine if passage through non-turbine routes (B2CC and intake screen system) was greater with the sluice chute on than with it off. Recall the sluice gate was at El. 61 ft and the TIEs at

Units 11-14 were removed. Sluice chute flow was about 2,550 ft^3/s. The B2CC and B2 intakes were monitored and evaluated using fixed radio telemetry and fixed hydroacoustics. The 1998 study was the only valid evaluation of the collection efficiency of the sluice chute.

The radio telemetry study in 1998 by Hensleigh et al. (1998) showed that 73 percent of the radio-tagged steelhead and 47 percent of the radio-tagged yearling chinook salmon that passed B2 were detected within 10 feet of the B2CC entrance. The sluice chute was closed most of summer 1998 because of the desire to maximize detection of PIT tagged fish in the B2 juvenile bypass system for other studies, so few B2CC efficiency data on subyearlings could be collected. Overall, B2CC efficiency (B2CCE) for radio-tagged fish relative to passage at the entire B2 powerhouse was impressive; 52 percent for steelhead and 36 percent for yearling chinook salmon. Given the relatively small proportion of flow entering the B2CC (~2 percent), effectiveness (B2CCE/percent flow) of the B2CC was about 26 for steelhead and 18 for yearling chinook salmon. Effectiveness this high has not been observed at any other surface bypass in the region (see Dauble et al. 1999 for a review).

Based on radio telemetry data, comparing combined bypass efficiency ($CBE_{11\text{-}18}$ = (B2CC+guided)/total at Units 11-18) with the B2CC open and closed showed the positive effect of the B2CC. $CBE_{11\text{-}18}$ was higher for steelhead with the B2CC open than with it closed (73 percent open vs. 50 percent closed). The same trend held for yearling chinook salmon (50 percent open vs. 30 percent closed). Clearly, operating the B2CC resulted in more fish passing B2 through non-turbine routes than with it closed. The B2CC did not "rob" fish that would otherwise have been guided by the intake screens because $CB2CCE_{11\text{-}18}$ was so much higher with the B2CC open than closed. In fact, the data indicated that the B2CC passed many fish that would otherwise have gone through B2 turbines. Ideally it would be advantageous to have conducted evaluations over several years providing additional observations. This was not possible. Absent that, two different tools were employed in 1998, telemetry and hydroacoustics. Results from the hydroacoustics study corroborated the telemetry results.

Table 6.2. Results From Monitoring Radio-Tagged Fish Passage at the B2CC and Intake Screen System at B2 in 1998.

Parameter	Steelhead		Yearling Chinook		Total	
PCC entrance	open	closed	open	closed	open	closed
$CBE_{11\text{-}18}$	0.73	0.50	0.50	0.30	0.62	0.39

Ploskey et al. (1998) monitored fish passage into the B2CC and Intakes 11B, 12B, and 13B, using fixed beam hydroacoustics. The trend in combined bypass efficiency for the B2CC and Units 11-13 for the run-at-large was consistent with that observed for radio tagged fish; $CBE_{11\text{-}13}$ was significantly higher with the B2CC open than closed B2CC efficiency relative to Units 11-13 was 83 percent in spring and 81 percent in summer. B2CC effectiveness (percent fish/ percent flow at Units 11-13) was 5.8 in spring and 4.6 in summer. When extrapolated to the entire powerhouse, effectiveness was approximately 12-16. These values for B2CC effectiveness relative to the entire powerhouse are high when compared to other regional surface bypasses (Dauble et al. 1999).

Table 6.3. Combined Bypass Efficiency for the PCC and Screens at Units 11-13 for When the B2CC was Open and Closed in Spring and Summer 1998.

(Based on hydroacoustic data from Ploskey 1998.)

	Spring	Summer
PCC Open	0.90	0.90
PCC Closed	0.55	0.30

Fish passage in the conveyance channel and outfall for the B2CC were not monitored and evaluated in 1998. The focus of research was on the entrance/collection component of the B2CC. Overall, the 1998 results from radio telemetry and fixed hydroacoustics comport well. The data indicate strong potential for the B2CC to successfully collect smolts.

6-12 IMPROVEMENTS TO TOTAL PROJECT SURVIVAL AND FISH PASSAGE EFFICIENCY

Potential improvements to total project survival and fish passage efficiency (FPE) were computed using the SIMPAS model, as applied for the Bonneville Decision Document (Portland District 2001). SIMPAS is a computer spreadsheet model developed by NMFS, which apportions smolts through various passage routes at the dam and applies survival probabilities to each route. Two scenarios, with and without B2 CC were modeled, allowing B2 CC effects to be computed by subtraction:

Scenario A = existing + B1 MGR (minimum gap runners) with and without the B2 CC operating.

Scenario B = existing + B1 MGR + B2 FGE (fish guidance efficiency), with and without the B2 CC operating.

Some concern exist for Juvenile bypass release sites corresponding to the B2CC. Considerable effort has occurred in response including development of new guidelines for high flow outfalls (i.e. B2CC). In addition studies were undertaken to determine mechanistic effects as juveniles re-enter the river. NMFS criteria as well as Johnson et al. (1999) have redeveloped criteria as applied to high flow outfalls. Guidelines were divided into two general categories: location and design. Emphasis is placed on receiving water types and characteristics as well as designs that improve survival by providing good entrance conditions. Additional emphasis is also placed on not adversely effecting adult migration, while providing the best possible juvenile egress conditions.

6-13 SURVIVAL AT BONNEVILLE

a. <u>Direct versus Indirect</u>. By virtue of its position as the lowermost dam, more juvenile salmon must pass Bonneville Dam than any other hydroelectric project on the Columbia River. During the summers of 1987 through 1990 and 1992, Coded Wire Tag (CWT) up river bright (URB) juvenile fall chinook were released simultaneously through a turbine and the bypass systems at Bonneville Dam Second Powerhouse. Additional releases were made 1) into the tailrace at the downstream edge of the turbine boil, 2) about 2km downstream from the dam, and 3) through the spillway. However none of these release sites were used all 4 years. Each year about 2 million fish were released for a study total of about 9 million fish. CWT fish were released and recaptured in the Columbia River estuary (at Jones Beach), 157 km downstream of

Bonneville. Recovery percentages from seining were used to estimate short-term comparative passage survival for fish groups sent through various passage routes. Estimates of long-term relative survival were based on recoveries of tagged adult fish from the fisheries and from hatchery returns.

The most striking finding of the Bonneville Survival Study was that differences in estuarine recoveries of juvenile salmon from turbine and bypass release groups suggested lower survival associated with the bypass system. In the first two years (87-88), recoveries of bypassed release groups were significantly less than recoveries of turbine-released groups; mean differences were 10.8 and 13.6 percent. In 1989 and 1990, recoveries of bypass-released groups were also less (though not significantly) than recoveries of turbine-released groups (mean differences were 3.3 and 2.5 percent respectively). The difference between the first two and the following two years of study may have been associated with lower river flow and resulting lower tailwater elevation during the first two years.

At the B2 outfall pipe the lower tailwater elevation caused greater water velocity within the 0.9m diameter bypass discharge conduit and increased the turbulence and shear forces at the conduit terminus. Comparisons of recovery differences between bypass and other release groups were also made, but included far fewer years of comparisons (see table above). Based on three years of releases, the recoveries of bypass released fish groups averaged 8.3 percent less than recoveries of tailrace-released groups. From two years of releases, recoveries of bypass-released groups averaged 17.4 percent less than recoveries of downstream-released groups. Based on data from a single year (1989), bypass-released groups averaged 16.6 percent less than spillway-released groups. This latter comparison is noteworthy because the spillway has long been believed to provide the safest passage and the bypass was assumed to be equivalent. It should be noted that the spillway release conducted in 1989 was a very controlled experiment (50K total spill, with 6700cfs through bay being tested). Spill at Bonneville at or below 50K is known to create poor egress conditions and increase chances for predation. Because NMFS tested at these lower spill limits, it is suspect that survival estimates reported are not representative of the overall seasonal survival that is truly occurring with the current COE spill program.

Table 6.4 shows the differences in relative survival between fish passing through the bypass systems and other passage routes at Bonneville Dam based upon juvenile recovery data from estuarine sampling

The low survival of the control released fish recorded in the B1 and B2 survival studies in 1988-89 and 1992 are suspect as well. Normally, control fish are released in an area that is suspected to have the least amount of predation and a anticipated high survival rate so treatment effects can be measured against the control fish. In the above control release cases it is now known that these control releases made close to the shore line (rip-rap areas), just below the Hamilton Island boat launch were not a good choice because these areas in particular were later found to retain excellent structure and sanctuary habitat for Northern Pikeminnow. In studies conducted by Thomas Poe in 1990 and 1991, he reports that significant amounts of predators (pikeminnows in particular) were known to use the shoreline areas around Hamilton Island as geologic relief. Pikeminnows and other predators were found to be able to use this rocky shoreline structure to stay out of the stronger currents, reduce energy expenditures, and dart in and out of the current while hunting prey.

This decreased survival through the B2 bypass system may have been a consequence of either physical damage occurring during passage through the system increased predation after egress from the discharge conduit or both. This important information provided the rationale for upgrading the First and Second Powerhouse bypass systems.

Table 6.4. Differences in Relative Survival.

Release Site/ Treatment	Bypass Recoveries	Percent difference of bypass recoveries from indicated treatment
SECOND POWERHOUSE BYPASS		
	Survival Averages 1987-92	
Turbine:	Release at ceiling and mid-depth of the turbine intake. Passage through the turbine and through the Second Powerhouse tailrace.	**7.6 percent** greater survival compared to the Treatment Released Fish
Tailrace:	Released at the downstream side of the turbine discharge boil. Passage through the Second Powerhouse tailrace.	**8.3 percent** greater survival compared to the Treatment Released Fish
Spillway:	Released 0.5m above spillway crest. Passage over the spillway, through stilling basin and spillway tailrace.	**16.6 percent** greater survival compared to the Treatment Released Fish
Downstream:	Released downstream from dam and tailraces at a swifter-water site.	**17.4 percent** greater survival compared to the Treatment Released Fish
FIRST POWERHOUSE BYPASS		
Turbine:	Release at ceiling and mid-depth of the turbine intake. Passage through the turbine and through the First Powerhouse tailrace.	**11.8 percent** greater survival compared to the Treatment Released Fish
Downstream:	Released downstream from dam and tailraces at a swifter-water site.	**28.3 percent** greater survival compared to the Treatment Released Fish
* Statistically significant at P=0.95		

b. Direct Survival Studies.

(1) Juvenile Fish Survival Passing Spillway Flow Deflectors. Johnson and Dawley (1974) evaluated the effect of spillway flow deflectors at the Bonneville Dam with a total spill of 180 kcfs. They found no significant difference in survival between test groups of fish passing over spillway bays with or without flow deflectors. In 1995, the COE contracted with Normandeau and Associates to evaluate the potential effects of spillway flow deflectors on fish condition and survival at Bonneville Dam. Direct effects were measured using the HI-Z Turb'N Tag-recapture technique (balloon tag). Survival probabilities and condition at 1 h and 48 h after release were estimated for fish passing thorough a non-deflectored (Bay 2) and one with a deflector at Elevation 14' (Bay 4) at a spill discharge of 12,000 cfs. Estimated survival after 48 hour treatment holding were 99 percent for both treatment groups.

(2) Calculated Survival Probabilities. Even though the calculated survival probabilities were identical for both treatments some evidence of differences in injury type was observed through out the test. Four of the 280 spillbay 2 (no deflector) treatment fish (1.4 percent) suffered eye injuries while only 1 of 280 (0.4 percent) at spillbay four (flow deflector) showed this type of injury. However, relative to controls the overall injury rate was low (1.3 percent) in both treatment groups and few injuries was lethal over the 48 h period. Most of the observed injuries (bruises, injured eyes, small scrapes and cuts) appeared to be due to physical contact with a spillbay and Tainter gate structure and other components. Obvious effects of pressure (e.g., expanded air bladder, entrapped gas bubbles, etc.) or shear (e.g., decapitation) were absent. The estimated 48 hour fish survival probabilities of 1.0 percent in both experiments suggest that the spillbay configuration (with or without deflectors) at the hydraulic conditions tests has no effect on survival of juvenile chinook salmon. The survival probabilities are slightly higher than reported in many other spillway investigations around the region.

6-14 BONNEVILLE DAM SPILLWAY FLOW DEFLECTOR CONSTRUCTION AND BIOLOGICAL TESTING 2002

In its continued efforts to minimize gas supersaturation and improve passage conditions and fish survival at its hydroelectric dams, U. S. Army Corps of Engineers (the COE), Portland District, have made structural modifications to spillbays at the Bonneville Dam on the lower Columbia River. These involved modifying an existing flow deflector (14'msl) and lowering it 7 ft deeper than previously constructed. The new flow deflector is at an elevation of 7-ft msl versus the old one at 14 feet msl. In addition to modifying one of the existing deflectors, (5) five new deflectors were installed in bays that previously did not have any flow deflectors installed. Through model studies, the COE has chosen a new flow deflector design and elevation and desires to conduct field studies to ascertain gas abatement qualities and the biological effects (survival/condition) of both the new and existing flow deflectors, at different submergence levels and flow discharge rates, on passed juvenile salmon.

Additional Hi-Z tag studies are planned for 2002 to determine salmon survival and condition after passage through spillbays at the Bonneville Dam with a shallow (elevation 14 ft msl) and deep (elevation 7 ft msl) flow deflector. The goals and objectives for the study are to seek direct survival information during a period of high tailwater (>23 ft msl) and low tailwater (<14 ft msl) on condition/survival of juvenile chinook salmon upon passage through spillbays equipped with a shallow (14 ft msl) and deep (7 ft msl) flow deflector at Bonneville Dam on the lower Columbia River. The COE desires to measure the survival over the modified spillbays at Bonneville. The hope is that the new deflectors that will effectively decrease gas supersaturation and simultaneously have minimal or no impact on passed fish.

In summary, spill research shows high survival through the spillway with 98 percent or higher recorded and was used in the SIMPAS model. Several unknowns still exist such as high spill survival, biological performance of the newly installed flow deflectors, adult fallback, and gas associated with higher spill. Continued evaluation and research in 2002 and 2003 will hopefully answer several of these questions.

6-15 Indirect Survival USGS

In 1999 the COE completed a new juvenile bypass system, conveyance pipe and smolt sampling facility for the Second Powerhouse. In 1999 and 2000 the USGS evaluated the condition and behavior of juvenile chinook salmon and steelhead that passed through the new JBS. The objectives of the study were to determine: (1) the physiological effects on smolts traveling through the pipe, (2) the effects of passage through the pipe on tailrace egress behavior and, (3) how velocities in the tailrace influence behavior.

In both the 1999 and 2000 studies no evidence of direct mortality caused by travel time through the new conveyance pipe. These findings concur with a physical injury and descaling study conducted by Gilbreath (See NMFS Post construction Evaluation 2000 results below). Overall, fish moved quickly through the pipe in both 1999 and 2000. Travel time between the forebay and the outfall area through the PH2 JB was found to be longer in both years then traveling through non-JBS routes.

Median travel time and behavior through the tailrace area below the outfall was similar for upriver fish that passed through the JBS and non-JBS routes for both research years. USGS detected no significant travel times differences in travel time for both yearling and subyearling chinook released into the JBS compared to stressed and unstressed fish released near the outfall. Less than 4 percent of all the fish released into the JBS in 99 and 2000 took more than 90 minutes to travel between the outfall area and the first exit receiving station 8km downriver. Also, both in 1999 and 2000 less than 1 percent of the fish exiting the outfall were believed to be consumed by predators by radio tracking evidence.

Plasma cortisol and lactate are well-known stress indicators of physiological stress (Mesa 1994). Passage through the pipe and capture or recapture elicited an increase in plasma cortisol and lactate concentrations in the juvenile salmonids that were tested. Increases were most pronounced in fish obtained from a hatchery and to a lesser degree in run-of-the river fish. Sampling over time showed that although mean cortisol levels and lactate concentrations increased immediately after passage, cortisol levels peaked 3 hours after capture and then decreased to near basal levels within six hours. Lactate in hatchery fish and river-run fish peaked immediately after recapture then returned to basal levels within 3 hours. Lactate levels were higher in hatchery steelhead when compared to hatchery subyearlings and river-run subyearlings. These higher lactate levels were thought to be due to hatchery steelhead resisting transport through the pipe, possibly to the point of fatigue. However, quick recovery time from the stress of passage through the pipe and handling indicated that the fatigue was more acute than chronic and that fish were recovering. (See table 6.5.)

Table 6.5. Travel Times for PIT and RT Fish Releases 1999-2000 USGS.

Year	Species	Median Time Through JBS to outfall	Median Time Powerhouse and Spillway to outfall	Median Time Outfall site to downstream receiver site
1999	Year. Chinook	79 min	36 min	36 min
1999	Steelhead	74 min	33 min	33 min
1999	Sub Chinook			34 min
2000	Year. Chinook	121 min[1]	30 min	Travel times same as 1999 data.
2000	Steelhead	81 min [2]	30 min	
2000	Sub Chinook			

1 Delays in Chinook may have been caused by fish holding in the channel about the conveyance pipe.

2 For steelhead, the majority of the time was spent in the conveyance pipe.

6-16 NMFS B2 Juvenile Fish Bypass Post Construction Evaluation Tests (1999-2000)

Chinook fry were also tested and had a high recovery rate. An average of 84.7 percent of fish released into the JBS channel at unit 11 and at the beginning of the conveyance pipe were recovered and in good shape. Equivalent recovery percentages for the two live fry releases indicated that fish were not being lost at the collection channel dewatering screens. Fry descaling was also found to be minimal.

The average descaling rate of all species released into the flume and JBS systems (2,698) was only 3.8 percent in 2000.

6-17 Survival Estimates using Radio Tag Recovery (USGS 2000-01)

In 2000 USGS evaluated survival past Bonneville Dam and the new Second Powerhouse Bypass system using Radio Tag (RT) technology. Survival estimates were generated for yearling chinook. A paired release model was used with survival through the system being compared to references releases below the outfall. USGS found that overall project survival was approximately 96.3 percent for all conditions. They also found no significant differences in passage survival as it relates to project operations (total project discharge and total turbine discharge).

6-18 Hi-Z Balloon Tag Study at First Powerhouse (MGR)

a. General. As part of the COE' Turbine Survival Program, survival probabilities were estimated for hatchery-reared chinook salmon, *Oncorhynchus tshawytscha* (average total length about 166 mm) passed through Units 5 (existing) and 6 (Minimum Gap Runner or MGR) at Bonneville Dam in November 1999 through January 2000. The new runner was designed to minimize the gap between the blade and hub as well as between the blade tip and the discharge ring. This design improves the turbine efficiency at most operating points and has the potential to improve fish survival. The primary objective of the study was to test the hypothesis whether the passage survival through the MGR unit equals or exceeds that of Unit 5. Secondary objectives were to determine (1) whether the peak turbine operating efficiency is correlated with turbine passage survival; (2) effectiveness of gap minimization; and (3) better identify injury mechanisms and in-turbine areas where fish injuries occur. The study was designed as a two by three by four factorial design (two turbines x three release locations x four power levels). Sufficient numbers of fish were to be released so that the resulting survival probabilities would be ≤±3 percent, 90 percent of the time.

The study objectives were accomplished by releasing fish through a specially designed induction system to pass fish near the blade tip, mid-blade, and hub regions in each turbine at four discrete power levels. The four power levels at Unit 5 were: power level 1, near the lower end of the 1 percent operating limit; power level 2, slightly below the peak operating efficiency; power level 3, beyond the peak operating efficiency; and power level 4, near the upper 1 percent operating limit. The same power levels were tested for the MGR unit but with different operating efficiencies and they were: power level 1, below the lower 1 percent operating limit; power level 2, slightly below the peak operating efficiency but within the 1 percent operating limit; power level 3, beyond the peak operating efficiency but within the 1 percent operating efficiency; and power level 4, beyond the upper 1 percent operating limit. The absolute efficiency of the MGR was greater than or equal to that of the existing unit at all test points.

Recapture rates (physical retrieval of alive and dead fish) were high and met the pre-specified expectation used for sample size calculations prior to initiating the study. Recapture rates of treatment fish mostly exceeded 95 percent (range 94.6 percent to 99.1 percent) and those of controls were greater than 97 percent (range 97.6 to 100.0 percent). Most fish were recaptured within 500 yd downstream of the powerhouse; recapture times for controls averaged less than 7 min in any sample block (range 5.1 to 6.6 min) while those for the treatment fish were higher (average range 7.2 to 15.4 min). Treatment fish were generally retrieved at greater distances from the powerhouse than the controls.

This study established that the fish passage survival through the new MGR Unit 6 is equal to or better than through an existing unit. This was most evident for blade tip released fish. Depending upon the power level, absolute survival of the blade tip released fish in Unit 6 was up to 3 percent higher than for those passing near the blade tip in the existing Unit 5. Survival probabilities of mid-blade released fish were similar in both units except at power level 1 in MGR Unit 6 where survival was 2.2 percent higher than in Unit 5 (97.1 versus 94.9 percent). Survival probabilities of hub released fish were mostly greater than 0.98 in both units.

The incidence of fish injury was lower for fish passing through the MGR Unit than through the existing Unit 5. Overall incidence of injury was reduced by approximately 40 percent in the MGR unit (2.5 percent for Unit 5 and 1.4 percent for MGR). Reduction in injury was evident for blade tip passed fish (existing runner fish had a 3.9 percent injury rate versus 1.9 percent for the MGR) and the mid-blade region (2.3 percent in Unit 5 versus 1.0 percent in MGR). Very few hub released fish were injured in either turbine (0.7 percent for Unit 5 and 1.0 percent for Unit 6).

Most injuries at both turbines were inflicted by shear and mechanical forces. Shear inflicted injuries were primarily characterized by partial decapitation, hemorrhaged or ruptured eye, and damaged gill or operculum. Mechanical injuries were primarily lacerations, severed body or external bruises.

b. Multiple Bypass Uncertainties. Questions have been raised by the COE as well as regional players as to the impacts and survival of fish that are subjected to a multiple bypass events. Recent studies have shown that juvenile fish react to these somewhat stressful events in different and varying ways both physically and chemically (et al, Congleton, J.) Research suggests that when a juvenile fish is subjected to a passage event whether through a juvenile bypass, spillway, or turbine it expresses this stress through chemical changes inside of the fish as well as behavioral differences. Additionally, salmonid smolts migrating from the Mid-Columbia River take approximately 1-3 weeks longer to traverse the hydro system then under the pre-dam natural freshet conditions. A prolonged migration, in concert with the energy costs associated with dam passage and poor feeding conditions in reservoirs, could deplete energy reserves needed by smolts to acclimation to the marine environment. Continued studies to determine the effects of initial (premigratory) fish condition, river flow, distance traveled, and exposure to dam bypass systems on the nutritional and physiological conditions of smolts are occurring through the COE Anadromous Fish Evaluation Program (AFEP). The SCT subgroup feels that many more years of specific behavioral and survival research dealing with multiple bypass effects have to be conducted before a sound and scientifically proven decision can address the uncertainty associated with multiple bypass events.

6-19 BIO DIVERSITY AND OTHER LIFE HISTORIES

During the course of our modeling efforts the regional team thought it very important to include how our decisions would effect other aquatic species that are not included in the SIMPAS model such as lamprey, steelhead kelts and fry. When generating these criteria the SCT subgroup felt it necessary to adjust our ratings based on the amount of known biological information on these species and how they may be impacted by our decisions.

a. Lamprey. In recent years a more critical focus has been placed on gaining knowledge on the life history of the pacific lamprey and why it has been declining in numbers around the Columbia Basin. The COE through (AFEP) has ranked lamprey studies as an important segment of our research program. Studies on both juvenile and adult lamprey passage as well as behavioral work have been conducted and continue to be conducted. Through these studies the COE hopes to make improvements to our facilities to aid in passage and to understand its tendencies when it comes to this animals preferred routes as well as modes of passage. Much is unknown specifically about the life cycle of the species and how it migrates through the system.

b. Steelhead Kelts. Unlike most Pacific salmon, steelhead may spawn more than once during their lifetime. In the Snake River, post-spawn steelhead (kelts) must first pass up to eight dams on their return to the ocean each spring (April-June) thousands of kelts are incidentally collected in juvenile bypass systems at mainstem COE dams. These kelts are returned to the river to resume their downstream migration. Through COE studies passage data has been collected that indicates that kelts prefer to use routes through the spillway first followed by turbines and then juvenile bypass systems. FY 2000 Passage data collected by Allen Evans of the Columbia River Intertribal Fish Commission (CRITFC) shows poor survivability of kelt originating from about Lower Granite Dam to below Bonneville Dam. Approximately 3.3 percent of tagged fish (7/212) reached the Bonneville tailrace with a median travel time of 655 hours (31 days). Results suggest that very few kelts are able to successfully traverse the Columbia system without great loss to the migrating population. The COE continues to study kelt passage and make specific improvements at bypass facilities to improve passage for these fish.

c. Salmon Fry. Fry and the way the COE pass fry at COE facilities has recently come to the forefront with the testing of Extended Length Bar Screens (ESBS) at John Day Dam as well as the John Day Smolt sampling facility. Protective measures to limit impingement velocities against diversion screens as well as dewatering structures were developed in an effort to provide suitable protection the fry using these bypass systems. Approach velocities for fry have been set by the National Marine Fisheries service at no greater than .40 fps. Perforated and bar screen opening shall not exceed .09 inches and .06 inches respectively. The COE is now directed to design all of it’s new associated fish bypass systems to this criteria. COE in conjunction with the

NMFS is in the process of evaluating several of Bonneville Dam's Vertical Barrier Screens (VBS) as well as switch gates in the bypass flumes to evaluate how well fry pass these structures. Results will confirm whether not the design of the system is biologically meeting the performance standards set forth by NMFS as well as collecting a much needed data base of systems that have been shown to be fry friendly.

SECTION 7

SIMPAS

7-1 GENERAL

As stated in Section 1, the guidance and survival estimates are being determined by SIMPAS, a spreadsheet model developed by NMFS. A Fortran version of the Bonneville spreadsheet in SIMPAS was written to facilitate the large number of runs required to evaluate the different alternatives. Results were checked against the spreadsheet version of SIMPAS. SIMPAS assumes that the fish arriving at the project are distributed between the primary features (B1, Spillway and B2) and is described in Figure 7.1.

7-2 SIMPAS ACCOUNTING PROCESS

In its accounting process, SIMPAS normally diverts fish entering the forebay first to the spillway. The remainder are then divided up between surface bypass, screened bypass and turbines in that order depending on flow and passage efficiencies. Because of its unique configuration, fish distribution at Bonneville Dam may occur first towards the first powerhouse. To account for this, another flow based distribution strategy was used where fish were first diverted towards the first powerhouse, while the remaining were passed through the spillway and second powerhouse. Results for both distribution strategies were similar.

Estimates are computed for:

a. Three Species.

Spring Chinook
Steelhead
Fall Chinook

b. High, Medium, and Low Flows.

B1 Priority
B2 Priority

7-3 ALTERNATIVES LISTED IN TABLE 3.1

The guidance and survival estimates used in the 2000 BIOP are listed in Table 7.1. The SCT subgroup agreed to use the survival and guidance estimates in the BIOP for this analysis. However, the 2000 BIOP did not include guidance estimates for the B1 Surface Collector. Therefore, guidance estimates for the B1 surface bypass alternatives were developed for the Decision Document based on the biological testing results presented in Section 6. Table 7.2 shows the guidance and survival estimates used in this analysis. Guidance numbers for the B1 Surface Collector were derived from Johnson and Carlson, 2000. The guidance numbers for the Shallow Surface Collector were developed at a SCT subgroup meeting and are based on the subgroups judgement and previous blocked trashrack testing at B1. The Shallow Surface Collector has not been prototype tested and the guidance estimates have significant uncertainity. Guidance for the Partial Deepslot is dependent upon flow in the B1 forebay. If only units 1-6 were operating the guidance would be the same as the Deepslot alternative. But if flow exceeded the capacity of units 1-6 fish would be use both the Partial Deepslot and the existing JBS at units 7-10. The

Figure 7.1. Distribution of Fish at Bonneville

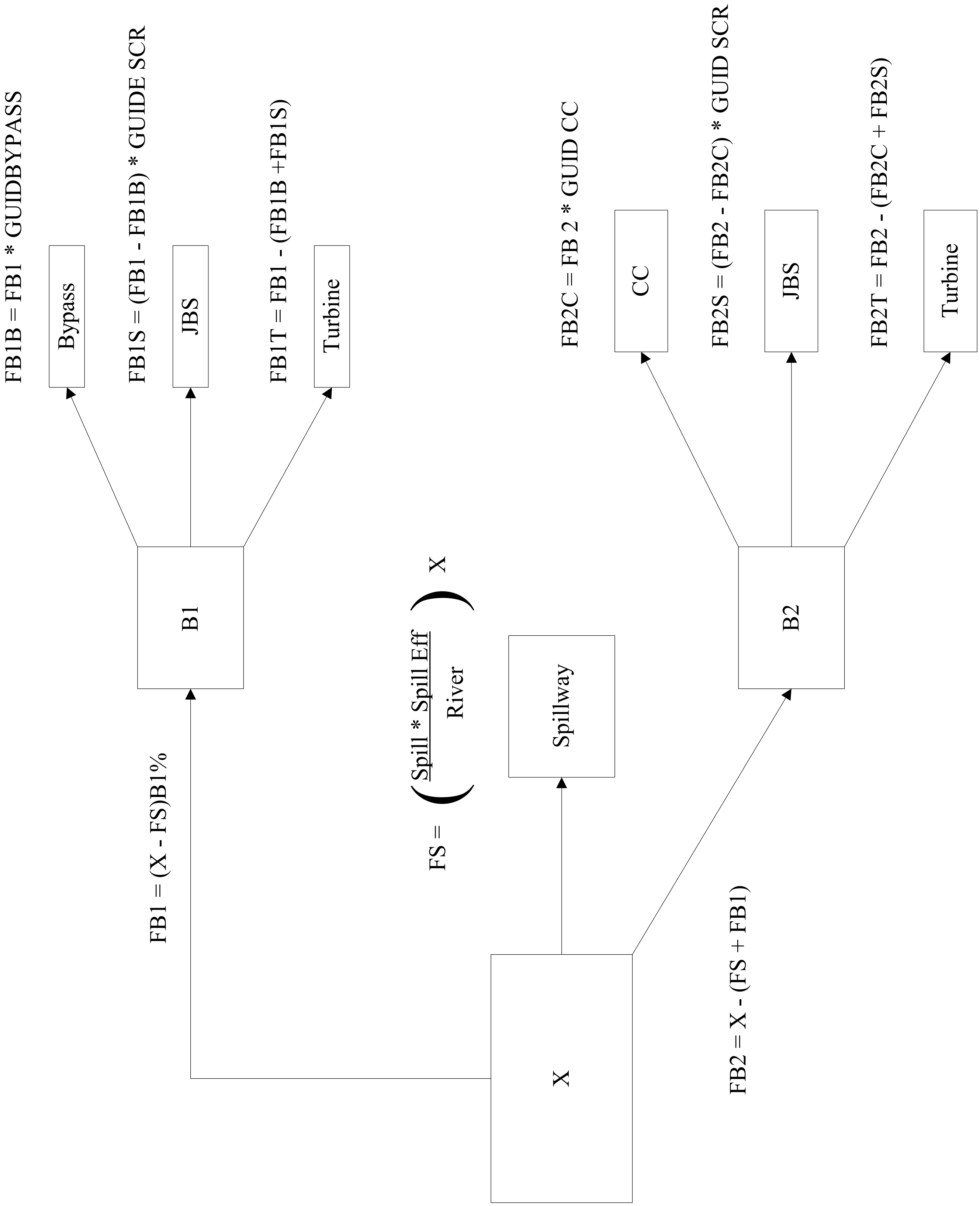


Table 7.1. 2000 BIOP Guidance and Survival

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse				
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.
Exisitng Spring Chinook	0.39	0.90	0.90	0.22	0.98	0.48	0.90	0.98	0.00	0.00
Exisitng Steelhead	0.41	0.90	0.90	0.22	0.98	0.48	0.90	0.98	0.00	0.00
Exisitng Fall Chinook	0.09	0.80	0.82	0.06	0.95	0.28	0.94	0.98	0.00	0.00
IMPROVEMENTS										
Spring Chinook										
B1 MGR		0.92								
B1 JBS	0.72		0.98							
B1 Deepslot Surface Collection	Not implemented in the Aggressive Case in 2000 BiOp									
B2 FGE Improvements						0.60		0.98		
B2 Corner Collector									0.46	0.98
Steelhead										
B1 MGR		0.92								
B1 JBS	0.85		0.98							
B1 Surface Collection	Not implemented in the Aggressive Case in 2000 BiOp									
B2 FGE Improvements						0.60		0.98		
B2 Corner Collector									0.62	0.98
Fall Chinook										
B1 MGR		0.92								
B1 JBS	0.35		0.98							
B1 Surface Collection	Not implemented in the Aggressive Case in 2000 BiOp									
B2 FGE Improvements						0.40		0.98		
B2 Corner Collector									0.47	0.98

Table 7.2. Decision Document Guidance and Survival

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse				
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.
Exisitng Spring Chinook	0.39	0.90	0.90	0.22	0.98	0.48	0.90	0.98	0.00	0.00
Exisitng Steelhead	0.41	0.90	0.90	0.22	0.98	0.48	0.90	0.98	0.00	0.00
Exisitng Fall Chinook	0.09	0.80	0.82	0.06	0.95	0.28	0.94	0.98	0.00	0.00
IMPROVEMENTS										
Spring Chinook										
B1 MGR		0.92								
B1 JBS	0.72		0.98							
B1 DeepslotSurface Collection				0.89	0.98					
B1 Partial Deepslot	0.39		0.90	0.89	0.98					
B1 Shallow Surface Collection				0.60	0.98					
B2 FGE Improvements						0.60		0.98		
B2 Corner Collector									0.46	0.98
Steelhead										
B1 MGR		0.92								
B1 JBS	0.85		0.98							
B1 Surface Collection				0.86	0.98					
B2 FGE Improvements						0.60		0.98		
B2 Corner Collector									0.62	0.98
Fall Chinook										
B1 MGR		0.92								
B1 JBS	0.35		0.98							
B1 Surface Collection				0.84	0.98					
B2 FGE Improvements						0.40		0.98		
B2 Corner Collector									0.47	0.98

The guidance numbers shown in Table 7.2 assume a full load at B1, but SIMPAS was run with various guidance depending on flow.

The flow conditions used in the Decision Document SIMPAS runs are based on the hydrograph, Figure 4.1. Table 7.3 shows the Monthly Representative Flows for the high, medium and low flow years. The high flow year represents 30% of the flows and is represented by the 15% exceedance value. The medium flow year represents 40% of the flows and is represented by the 50% exceedance value. The low flow year represents 30% of the flow and is represented by the 85% exceedance value. The weighted average flow values would be:

0.30*high flow + 0.4*medium flow + 0.3*low flow

For spring flows, the average of May and June values are used and summer flows are a weighted average of 80% of the July values and 20% of the August values. The average of May and June and the weighted average of July and August is based on the typical timing of the spring and summer runs.

7-4 SPILLWAY EFFECTIVENESS

Spillway effectiveness is estimated from the following equations, which were presented in Section 6:

Spill Effectiveness Spring = -0.0017*(spill) + 1.5255

Spill Effectiveness Summer = -0.0091*(spill) + 1.8766

The effectiveness for a B2 priority for the summer flows is bumped up 7.5% from the B1 priority for the summer flows. This determination was based on professional judgment due to B1 prioritization in 2000.

Appendix B has tables that present the guidance and survival estimates for all of the flows, including the weighted average. For ease of understanding and clarity only those configurations that provide the high guidance and survival estimates are summarized in Tables 7.4-7.6. Table 7.4 is for Spring Chinook, Table 7.5 is for Steelhead and Table 7.6 is for Fall Chinook. The Partial Deepslot and Shallow Surface Collection option were only evaluated for Spring Chinook. These alternatives were added to the discussion part way through our analysis when a B2 priority had already been determined. Therefore, Spring Chinook were only evaluated because B1 would only have flow during the spring run.

Guidance and survival estimates computed for each flow year are combined to give a weighted average. The weighted average is computed by:

0.30*high flow + 0.4*medium flow + 0.3*low flow

Table 7.3 Monthly Representative Flows

Month	High	Medium	Low
April	300	210	150
May	370	270	220
June	390	280	170
July	260	180	120
August	190	130	100
September	140	120	100
<u>Season</u>			
Spring	380	275	195
Summer	246	170	116

Table 7.4. Survival – Spring Chinook

Survival										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Spring and Summer Chinook										
Low Flow										
B2 CC&FGE	0.954	0.969	0.972	0.977	0.980	0.941	0.951	0.956	0.970	0.979
B2 CC&FGE B1 JBS/ESBS	0.964	0.969	0.972	0.977	0.980	0.965	0.971	0.974	0.978	0.980
B2 CC&FGE B1 SC	0.966	0.969	0.972	0.977	0.980	0.969	0.975	0.977	0.979	0.980
B2 CC&FGE B1 Partial	0.962	0.966	0.970	0.976	0.980	0.952	0.961	0.966	0.977	0.980
B2 CC&FGE B1 Shallow	0.953	0.966	0.970	0.976	0.980	0.948	0.957	0.963	0.973	0.957
Medium Flow										
B2 CC&FGE	0.958	0.958	0.963	0.973	0.975	0.953	0.953	0.956	0.961	0.964
B2 CC&FGE B1 JBS/ESBS	0.968	0.968	0.970	0.973	0.975	0.969	0.969	0.971	0.974	0.976
B2 CC&FGE B1 SC	0.970	0.970	0.971	0.973	0.975	0.971	0.971	0.973	0.976	0.978
B2 CC&FGE B1 Partial	0.965	0.965	0.969	0.971	0.973	0.960	0.960	0.963	0.968	0.971
B2 CC&FGE B1 Shallow	0.959	0.959	0.963	0.970	0.973	0.957	0.957	0.960	0.965	0.968
High Flow										
B2 CC&FGE	0.960	0.960	0.960	0.961	0.965	0.960	0.960	0.960	0.960	0.962
B2 CC&FGE B1 JBS/ESBS	0.971	0.971	0.971	0.971	0.972	0.971	0.971	0.971	0.971	0.973
B2 CC&FGE B1 SC	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.974
B2 CC&FGE B1 Partial	0.964	0.964	0.964	0.965	0.970	0.964	0.964	0.964	0.965	0.967
B2 CC&FGE B1 Shallow	0.962	0.962	0.962	0.963	0.966	0.962	0.962	0.962	0.963	0.965
Weighted Average										
B2 CC&FGE	0.957	0.962	0.965	0.970	0.973	0.952	0.955	0.957	0.964	0.968
B2 CC&FGE B1 JBS/ESBS	0.968	0.969	0.971	0.973	0.975	0.968	0.970	0.972	0.974	0.976
B2 CC&FGE B1 SC	0.969	0.971	0.972	0.974	0.976	0.971	0.973	0.974	0.976	0.977
B2 CC&FGE B1 Partial	0.964	0.965	0.968	0.970	0.974	0.959	0.962	0.964	0.970	0.972
B2 CC&FGE B1 Shallow	0.958	0.962	0.965	0.970	0.973	0.956	0.959	0.961	0.967	0.964

Survival										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Steelhead										
Low Flow										
B2 CC&FGE	0.957	0.972	0.974	0.978	0.980	0.942	0.951	0.956	0.970	0.979
B2 CC&FGE B1 JBS/ESBS	0.969	0.972	0.974	0.978	0.980	0.971	0.975	0.977	0.979	0.980
B2 CC&FGE B1 SC	0.969	0.972	0.974	0.978	0.980	0.970	0.974	0.976	0.978	0.980
Medium Flow										
B2 CC&FGE	0.960	0.960	0.965	0.975	0.976	0.955	0.955	0.957	0.961	0.964
B2 CC&FGE B1 JBS/ESBS	0.972	0.972	0.973	0.975	0.976	0.973	0.973	0.974	0.977	0.978
B2 CC&FGE B1 SC	0.972	0.972	0.973	0.975	0.976	0.973	0.973	0.974	0.976	0.977
High Flow										
B2 CC&FGE	0.962	0.962	0.962	0.962	0.966	0.962	0.962	0.962	0.962	0.963
B2 CC&FGE B1 JBS/ESBS	0.974	0.974	0.974	0.974	0.975	0.974	0.974	0.974	0.974	0.975
B2 CC&FGE B1 SC	0.974	0.974	0.974	0.974	0.975	0.974	0.974	0.974	0.974	0.975
Weighted Average										
B2 CC&FGE	0.960	0.964	0.967	0.972	0.974	0.953	0.956	0.958	0.964	0.968
B2 CC&FGE B1 JBS/ESBS	0.972	0.973	0.974	0.976	0.977	0.973	0.974	0.975	0.977	0.978
B2 CC&FGE B1 SC	0.972	0.973	0.974	0.975	0.977	0.972	0.973	0.975	0.976	0.977

Table 7.6. Survival – Fall Chinook

Conditions	B2/Q=0	B2/Q=50	B2/Q=75	B2/Q=120	B2/Q=150	B1/Q=0	B1/Q=50	B1/Q=75	B1/Q=120	B1/Q=150
Low Flow										
B2 CC&FGE	0.967	0.976	0.978	0.978	0.978	0.913	0.954	0.965	0.966	0.966
B2 CC&FGE B1 JBS/ESBS	0.967	0.976	0.978	0.978	0.978	0.942	0.965	0.971	0.972	0.972
B2 CC&FGE B1 SC	0.967	0.976	0.978	0.978	0.978	0.970	0.976	0.978	0.978	0.978
Medium Flow										
B2 CC&FGE	0.959	0.973	0.975	0.975	0.974	0.929	0.941	0.948	0.950	0.948
B2 CC&FGE B1 JBS/ESBS	0.963	0.973	0.975	0.975	0.974	0.949	0.958	0.962	0.963	0.961
B2 CC&FGE B1 SC	0.968	0.973	0.975	0.975	0.974	0.970	0.974	0.975	0.976	0.975
High Flow										
B2 CC&FGE	0.945	0.962	0.967	0.973	0.972	0.941	0.948	0.948	0.940	0.934
B2 CC&FGE B1 JBS/ESBS	0.957	0.967	0.970	0.973	0.972	0.955	0.960	0.960	0.957	0.954
B2 CC&FGE B1 SC	0.969	0.972	0.973	0.973	0.972	0.969	0.972	0.973	0.974	0.973
Weighted Average										
B2 CC&FGE	0.957	0.970	0.973	0.975	0.975	0.928	0.947	0.953	0.952	0.949
B2 CC&FGE B1 JBS/ESBS	0.963	0.972	0.974	0.975	0.975	0.948	0.961	0.964	0.964	0.962
B2 CC&FGE B1 SC	0.968	0.973	0.975	0.975	0.975	0.970	0.974	0.975	0.976	0.976

SECTION 8

RISK

8-1 GENERAL

The FPE and survival estimates assume that all routes are created equal through the project and for all operational scenarios, which is not necessarily true. There is different risk associated with each route of passage. The SCT subgroup participated in developing a method to define and evaluate the level of risk. Table 8.1 presents the results of our determination of the level of risk associated with the routes of passage. Four different components were rated in developing the composite risk score: ability to meet guidance expectations, ability to meet survival expectations, ability to protect other life histories and species and the ability to meet guidance and survival goals under all operations. Table 8.1 is annotated with a column called, Level of Information. There are 5 levels; 0 is no data, 1 is anecdotal data, 2 is 1 to 2 years of data, 3 is 3 to 5 years of data and 4 is more than 5 years of data. The biological data is presented in Section 3. This procedure was suggested by NMFS in a Memorandum dated February 23rd, 2001.

8-2 RISK PROCESS

a. Determine the passage routes.

(1) Spillway
(2) B1 Bypass
(3) B1 Surface Collector
(4) B2 Bypass
(5) B2 Corner Collector

b. Determine a set of universal risk criteria:

(1) Ability to meet guidance expectations
(2) Ability to meet survival expectations
(3) Ability to protect other life histories and species
(4) Ability to meet guidance and survival goals under all operations

c. Rate each passage route for each of the four risk criteria using five risk factors: 1.0, 0.99, 0.98, 0.97 and 0.96. 1.0 is the lowest risk and 0.96 is the highest risk.

d. Multiply the four risk factors for each passage route to come up with a single risk factor. The risk factors were adjusted to fall between 1.0 and 0.96 because of the known survival rates for turbine passage are 0.9 to 0.92. If the factors made the survival rate of the other passage routes too small, the best route of passage would become the route that maximized turbine passage.

e. Multiply each SIMPAS passage route survival parameter by the combined risk factor.

f. Do steps 4 and 5 for each passage route, enter the new risk adjusted survival estimates into SIMPAS and run the model for each combination of passage route/flow scenarios.

g. Carry the best configurations forward through the time line and cost assessments.

In general, there was agreement from subgroup members on the team except the Columbia River Intertribal Fish Commission (CRITFC). CRITFC believes that the only safe route of passage is through the spillway or some other form of surface bypass, considered a normative route. A key concern associated with bypass systems is the potential for delayed mortality and multiple bypass mortality. Unfortunately it will take years to have affirmative answers on this issue. There is scientific data to support that the other routes of passage (JBS and Turbine) can meet the survival estimates used in the SIMPAS runs.

Two different risks were assigned to the spillway because there was some debate over the ability of the spillway to meet the guidance and survival estimates over the full range of spill. The group did believe that the spillway route of passage had the least risk associated with it and in both cases the spillway was the least risky.

The risks associated with the different routes of passage have been incorporated into Fortran version of SIMPAS to provide a screening mechanism to reduce the number of alternatives to be further evaluated. Table 8.2 presents the results for the configurations that have the highest guidance and survival. Appendix B list all of the results.

Based on Table 8.2, the no risk, risk 1 and risk 2 all provided the same relative ranking of alternatives. Thus slight changes in risk will most likely not change the overall ranking of the various alternatives. This occurs because all of the various routes of passage and thus the various alternatives have some level of risk associated with them. The risk evaluation did not change the ranking of any of the alternative.

Table 8.1 Risk Associated with Different Routes of Passage

	Score		Level of Information	
Spillway				
Ability to meet guidance expectations	0.99	0.99	4	
Aility to meet survival expectations	0.99	0.99	4	BPA feels this number is high based on available data
Ability to protect other life histories and species	0.98	0.98	3	
Ability to meet guidance and survival goals under all operations	0.97	0.98	3	
Composite Score	0.932	0.941		
B1 JBS				
Ability to meet guidance expectations	0.99		4	
Aility to meet survival expectations	0.98		0	No spring DSM survival, FY02 research to evaluate
Ability to protect other life histories and species	0.97		2	
Ability to meet guidance and survival goals under all operations	0.98		4	
Composite Score	0.922			
B1 Surface Collection/Deep Slot				
Ability to meet guidance expectations	0.97		3	
Aility to meet survival expectations	0.97		3	
Ability to protect other life histories and species	0.99		2	USACE issue with large conveyance
Ability to meet guidance and survival goals under all operations	0.97		2	
Composite Score	0.904			
B2 JBS				
Ability to meet guidance expectations	0.97		4	
Aility to meet survival expectations	0.99		4	
Ability to protect other life histories and species	0.97		2	
Ability to meet guidance and survival goals under all operations	0.98		3	
Composite Score	0.913			
B2 Corner Collector				
Ability to meet guidance expectations	0.97		2	
Aility to meet survival expectations	0.98		2	
Ability to protect other life histories and species	0.99		2	
Ability to meet guidance and survival goals under all operations	0.97		1	once B2CC is complete a full guidance and survival program will be initiated
Composite Score	0.913			

Table 8.2 Survival and Risk Survival

Survival										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Weighted Average of Flow Years										
Spring and Summer Chinook										
B2 CC&FGE	0.957	0.962	0.965	0.970	0.973	0.952	0.955	0.957	0.964	0.968
B2 CC&FGE B1 JBS/ESBS	0.968	0.969	0.971	0.973	0.975	0.968	0.970	0.972	0.974	0.976
B2 CC&FGE B1 SC	0.969	0.971	0.972	0.974	0.976	0.971	0.973	0.974	0.976	0.977
B2 CC&FGE B1 Shallow	0.958	0.962	0.965	0.970	0.973	0.956	0.959	0.962	0.967	0.963
B2 CC&FGE B1 Partial	0.964	0.965	0.968	0.970	0.974	0.959	0.962	0.964	0.970	0.972
Risk 1										
B2 CC&FGE	0.684	0.729	0.760	0.813	0.846	0.644	0.676	0.706	0.766	0.809
B2 CC&FGE B1 JBS/ESBS	0.752	0.776	0.798	0.834	0.861	0.752	0.776	0.798	0.834	0.861
B2 CC&FGE B1 SC	0.774	0.792	0.811	0.841	0.865	0.788	0.810	0.829	0.857	0.878
B2 CC&FGE B1 Shallow	0.659	0.704	0.738	0.796	0.834	0.630	0.666	0.699	0.762	0.807
B2 CC&FGE B1 Partial	0.723	0.743	0.772	0.807	0.849	0.689	0.721	0.750	0.806	0.837
Risk 2										
B2 CC&FGE	0.682	0.726	0.756	0.808	0.840	0.642	0.673	0.702	0.760	0.803
B2 CC&FGE B1 JBS/ESBS	0.750	0.773	0.794	0.828	0.854	0.750	0.773	0.794	0.829	0.854
B2 CC&FGE B1 SC	0.773	0.789	0.807	0.835	0.859	0.786	0.807	0.825	0.852	0.872
B2 CC&FGE B1 Shallow	0.657	0.701	0.734	0.791	0.828	0.628	0.663	0.695	0.756	0.801
B2 CC&FGE B1 Partial	0.721	0.740	0.768	0.802	0.842	0.687	0.718	0.746	0.801	0.831
Steelhead										
B2 CC&FGE	0.960	0.964	0.967	0.972	0.974	0.953	0.956	0.958	0.964	0.968
B2 CC&FGE B1 JBS/ESBS	0.972	0.973	0.974	0.976	0.977	0.973	0.974	0.975	0.977	0.978
B2 CC&FGE B1 SC	0.972	0.973	0.974	0.975	0.977	0.972	0.973	0.975	0.976	0.977
Risk 1										
B2 CC&FGE	0.717	0.758	0.785	0.833	0.860	0.670	0.696	0.722	0.777	0.816
B2 CC&FGE B1 JBS/ESBS	0.805	0.820	0.835	0.859	0.878	0.811	0.828	0.843	0.866	0.884
B2 CC&FGE B1 SC	0.797	0.814	0.830	0.857	0.877	0.797	0.815	0.831	0.858	0.877
Risk 2										
B2 CC&FGE	0.715	0.755	0.782	0.827	0.854	0.668	0.693	0.718	0.772	0.810
B2 CC&FGE B1 JBS/ESBS	0.803	0.817	0.831	0.854	0.872	0.809	0.825	0.839	0.861	0.877
B2 CC&FGE B1 SC	0.795	0.812	0.827	0.852	0.870	0.795	0.812	0.827	0.852	0.871
Fall Chinook										
B2 CC&FGE	0.957	0.970	0.973	0.975	0.975	0.928	0.947	0.953	0.952	0.949
B2 CC&FGE B1 JBS/ESBS	0.963	0.972	0.974	0.975	0.975	0.948	0.961	0.964	0.964	0.962
B2 CC&FGE B1 SC	0.968	0.973	0.975	0.975	0.975	0.970	0.974	0.975	0.976	0.976
Risk 1										
B2 CC&FGE	0.520	0.731	0.780	0.802	0.791	0.249	0.509	0.587	0.582	0.550
B2 CC&FGE B1 JBS/ESBS	0.562	0.743	0.787	0.802	0.791	0.419	0.621	0.679	0.680	0.658
B2 CC&FGE B1 SC	0.635	0.764	0.799	0.802	0.791	0.708	0.811	0.834	0.845	0.840
Risk 2										
B2 CC&FGE	0.520	0.726	0.775	0.797	0.786	0.249	0.506	0.582	0.577	0.545
B2 CC&FGE B1 JBS/ESBS	0.562	0.739	0.782	0.797	0.786	0.419	0.617	0.674	0.675	0.653
B2 CC&FGE B1 SC	0.635	0.760	0.793	0.797	0.786	0.708	0.807	0.829	0.840	0.835

SECTION 9

RESULTS AND OBSERVATIONS

9-1 GENERAL

In reviewing the SIMPAS results for guidance and survival and the SIMPAS results with risk included (Tables 7.4-7.6 and 8.2 and Appendix B) the following observations can be made:

High survival occurs with high spill volumes

High survival occurs when improvements are made at both powerhouse

High survival at B2 implies both FGE improvements and Corner Collector are implemented

All the alternatives had significant levels of risk. Therefore, the risk assessment did not alter that determination of appropriate alternatives to implement.

9-2 OBSERVATION SUGGESTIONS

Both powerhouses need additional juvenile fish passage improvements.

There has been considerable debate if improvements would have to be made at B1 if B2 was the priority powerhouse. Table 9.1 addresses this issue by identifying when B1 would operate given different spill scenarios and river flows. The table shows that on average, during May and June, no matter what the spill volume, B1 will operate. May and June are significant juvenile fish passage months. There are also three factors that should be considered when considering the spill volume. Impacts to migrating adults from high spill volumes, water quality requirements and potential limits on the level of spill due to power emergencies. These factors could minimize the spill available for fish. The case is made that improvements at both B1 and B2 are necessary to increase juvenile survival.

Although the survival estimates show similar results between a B1 and B2 priority, Tables 7.4-7.6 and 8.2 assume a B2 priority. The planned implementation at B2 utilizes the state-of-the-art JBS in combination with a high flow surface route (B2 Corner Collector). B2 priority/improvements provide high survival at the lowest cost and spread the risk between different routes of passage. In addition, there is a belief (not fully scientifically documented) that maximizing the flow at B2 may increase spillway effectiveness (increase the number of juveniles passing via the spillway without increasing the amount of spill). Based on these factors, agreement was reached on B2 priority with implementation of the B2 Corner Collector.

Table 9.1. Flow at B1 Assuming a B2 Priority

Flow at B1 Assuming B2 Priority				Percent Flow is Exceeded				
B2	Spillway	Total	Time Exceeded from Main Daily	April	May	June	July	August
150	0	150	1 Dec to 1 Aug	84	97	91	65	35
150	50	200	1 Mar to 10 Jul	55	91	76	40	11
150	75	225	20 Apr to 1 Jul	48	80	66	30	3
150	120	270	5 May to 20 Jun	25	50	55	10	0
150	150	300	28 May to 10 Jun	15	38	42	4	0

SECTION 10

RECOMMENDATIONS

10-1 RECOMMENDATIONS

Table 10.1 summarizes the positions of the agencies that participated in the development of the Bonneville Decision Document. Correspondence from the agencies can be found in Appendix F. From the table it is clear that there is general agreement among the participants. The following is recommended:

1. B2 will be priority powerhouse.

2. Implement the B2 Corner Collector as soon as possible.

3. Continue to evaluate methods to improve the B2 FGE and implement if results are favorable.

4. Defer decision on B1 until critical information is available (B1 Sluiceway Efficiency and Survival, B1 DSM Spring Survival and Adult Fallback with high spill) and a final B1 recommendation can be developed. Tentatively, the 2nd year testing for this critical information is scheduled in FY 03.

5. With the deferral of B1 decision, the performance standard for B1 as laid out in the December 2000 National Marine Fisheries Service Biological Opinion will also be deferred.

The subgroup also agreed that a decision regarding the appropriate measure to improve survival at B1 is not needed at this time. There was consensus that some type of improvement is needed at B1, but it is unclear what the appropriate fix should be given B2 priority and level of uncertainty regarding available biological information. With B2 as the priority powerhouse, and implementation of B2 Corner Collector over the next few years, funds would not be available for B1 implementation. This allows time to address the biological uncertainties, to lower the level of risk and explore lower cost options at B1 that might make sense given it's not the priority powerhouse.

The COE with support from the other agencies believe that additional data on the existing system at B1 needs to be collected. This data will verify/modify the inputs used in SIMPAS, which in turn will provide the necessary information needed to make a final decision for B1. In addition, multiple bypass mortality data will be gathered to gain a better understanding of the potential problem. The plan is to update SIMPAS inputs, rerun SIMPAS, summarizing the results and meet with the SCT subgroup annually (FY 02 biological data, FY 03 biological data and FY 04 biological data). At the end of FY 04 it is anticipated that a decision for B1 can be made and an addendum for the Decision Document developed by the COE and the SCT subgroup. There is a possibility that a desirable low-cost option may be generate by the COE subgroup & Bonneville Project during this process. These low-cost options will be evaluated as part of the yearly updates. Figure 10.1 is the Bonneville Fish Mitigation Schedule and list critical milestones between now and FY05. Following is the proposed scheduled to develop the addendum to the Decision Document.

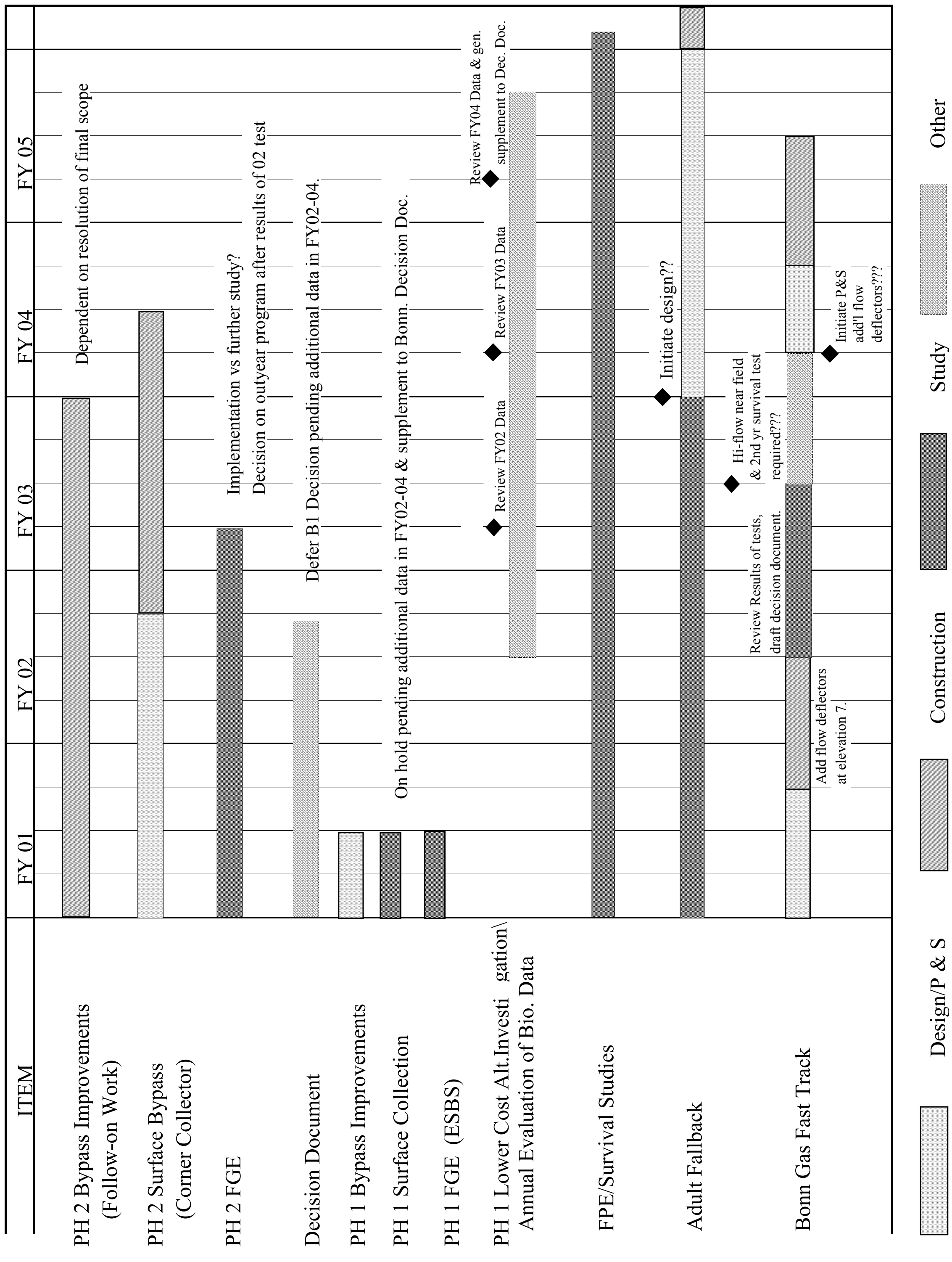
- Update SIMPAS inputs using FY02 Biological Results (December 2002)

- Run SIMPAS and summarize results (January 2003)
- SCT subgroup meeting to discuss results – finalize summary (February 2003)
- Update SIMPAS inputs using FY03 Biological Results (December 2003)
- Run SIMPAS and summarize results (January 2004)
- SCT subgroup meeting to discuss results – finalize summary (February 2004)
- Update SIMPAS inputs using FY04 Biological Results (December 2004)
- Run SIMPAS and summarize results (January 2005)
- SCT subgroup meeting to discuss results (February 2005)
- COE and SCT subgroup to develop addendum to Decision Document, included in the decision process will be the incorporation of information on multiple bypass mortality and the risk associated with making a B1 Decision (March 2005)

Table 10.1 Agency Positions

Bonneville Decision Document Recommendations							
	USACE	NMFS	BPA	USFWS	*CRITFC	ODFW	WDFW
B2 Priority	Y	Y	Y		Y		
B2 Corner Collector	Y	Y	Y		Y		
Continue Evaluation of B2 FGE Improvements	Y	Y	Y		NA*		
B1 needs improving	Y	Y	Y		D		
B1 Recommendation	D	D	D		D		
USFWS, OSFW, and WDFW have not provided recommendations at this time *CRIFC in general do not agree with screens and bypass systems							

Figure 10.1. Bonneville Fish Mitigation Schedule



SECTION 11

<u>OTHER CONSIDERATIONS</u>

11-1 GENERAL

Other biological research will be conducted in future years should provide insight into biological concerns associated with delayed/multiple bypass mortality associated with bypass systems. Research proposals are being developed/funded that should provide insight into the potential for delayed/multiple bypass mortality in the next several years.

11-2 NATIONAL MARINE FISHERIES SERVICE

National Marine Fisheries Service has been evaluating pit tag returns in recent years. Results from these evaluation suggest that in-river survival may be different depending on routes of passage through various projects. Essentially, differential survival has been observed for fish passing through spill or turbines versus fish passing through bypass systems one or more times. The results of the multiple bypasses fish suggest decreased survival in comparison to fish not detected in the system (ie fish passed through spill and/or turbines). Very few returning adults make up the data set (to date), but the trends indicated a decrease survival through bypass systems. However, the trend is not consistent for all years studied. Several studies are underway that may help to better characterize the effects of multiple bypass on juvenile fish passing through the hydro-system. It is anticipated that it will take 5 – 8 years to further characterize the relative affects of multi-bypassed fish in comparison to other fish passage routes.

11-3 JBS/ESBS SURVIVAL BENEFITS

The JBS/ESBS has similar survival benefits to that of the Deepslot Surface Collector, no negative impacts on power generation or turbine unit efficiency and would not require a minimum powerhouse flow for juvenile egress. In addition, data from adult fallback studies show increased fallback with high spill for fish. These studies have shown that fallback does affect spawning success. The risk of multiple bypass mortality needs to be weighed against adult fallback impacts from higher spill and water quality needs. In addition, the COE plans to evaluate other low-cost options at B1 that might make sense given it is not the priority powerhouse.

11-4 PHASE I DEFLECTORS AT BONNEVILLE

Phase I Deflectors at Bonneville were completed and have been available for the FY02 fish season. Post-construction testing will be conducted with the new deflectors to verify the TDG production and survival improvements. New spill patterns have been developed that achieve egress requirements as well as minimizing downstream TDG (as measured at the FMS). Adult fallback is currently being evaluated for changing spill volumes and the 2002 spill patterns. But the Fish Spill Program requires waivers of the TDG water quality standard. The water quality standard calls for a TDG of 110% and waivers are granted for TDG of 120% in the tailrace FMS and 115% at the downstream FMS. The State of Oregon and the State of Washington are in the process of developing Total Maximum Daily Load (TMDL) for the Columbia River. Oregon's draft TMDL for TDG identifies a spill volume of approximately 44 Kcfs for Bonneville to meet the water quality standards (during the post construction testing this volume might be increased).

APPENDIX A

ACRONYMS AND ABBREVIATIONS

APPENDIX A

LIST OF ACRONYMS AND ABBREVIATIONS

B1	Bonneville 1st Powerhouse
B2	Bonneville 2nd Powerhouse
BPA	Bonneville Power Authority
BOR	Bureau of Reclamation
BIOP	Biological Opinion dated December 2000
cfs	Cubic feet per second
COE	US Army Corps of Engineers
CRITFC	Columbia River Inter-Tribal Fish Council
ESA	Endangered Species Act
ESBS	Extended Length Bar Screens
ESU	Evolutionary Significant Unit
FCRPS	Federal Columbia River Power System
FMS	Fixed Monitor Station
FY	Fiscal Year
IDFG	Idaho Department of Fish and Game
Kcfs	1000 cubic feet per second
JBS	Juvenile Bypass System
MGR	Minimal Gap Runner
MW	Megawatt
NMFS	National Marine Fisheries Service
ODFW	Oregon Department of Fish and Wildlife
RPA	Reasonable and Prudent Alternative
SIMPAS	Spreadsheet model for fish passage survival estimates
SR	Snake River
STS	Submerged Traveling Screen
TDG	Total Dissolved Gas
TMDL	Total Maximum Daily Load
WDFW	Washington Department of Fish and Wildlife
USFWS	United States Fish and Wildlife Service

APPENDIX B

TABLES

APPENDIX B

TABLES

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse				
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.
Existing, E=1	0.39	0.9	0.9	0.22	0.98	0.48	0.9	0.98	0	0
Existing, E	0.39	0.9	0.9	0.22	0.98	0.48	0.9	0.98	0	0
Existing, E, B1 MGR	0.39	0.92	0.9	0.22	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B1 JBS/STS	0.39	0.92	0.98	0.22	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B1 JBS/ESBS	0.72	0.92	0.98	0.22	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B1 SC	0	0.92	0.9	0.89	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B2 FGE	0.39	0.92	0.9	0.22	0.98	0.6	0.9	0.98	0	0
E, B1 MGR, B2 CC	0.39	0.92	0.9	0.22	0.98	0.48	0.9	0.98	0.46	0.98
E, B1 MGR, B2 FGE, B2 CC	0.39	0.92	0.9	0.22	0.98	0.6	0.9	0.98	0.46	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.72	0.92	0.98	0.22	0.98	0.6	0.9	0.98	0.46	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0	0.92	0.9	0.89	0.98	0.6	0.9	0.98	0.46	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.39	0.92	0.9	0.89	0.98	0.6	0.9	0.98	0.46	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.39	0.92	0.9	0.6	0.98	0.6	0.9	0.98	0.46	0.98

Table B1

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse				
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.
Existing, E=1	0.41	0.9	0.9	0.22	0.98	0.48	0.9	0.98	0	0
Existing, E	0.41	0.9	0.9	0.22	0.98	0.48	0.9	0.98	0	0
Existing, E, B1 MGR	0.41	0.92	0.9	0.22	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B1 JBS/STS	0.41	0.92	0.98	0.22	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B1 JBS/ESBS	0.85	0.92	0.98	0.22	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B1 SC	0	0.92	0.9	0.86	0.98	0.48	0.9	0.98	0	0
E, B1 MGR, B2 FGE	0.41	0.92	0.9	0.22	0.98	0.6	0.9	0.98	0	0
E, B1 MGR, B2 CC	0.41	0.92	0.9	0.22	0.98	0.48	0.9	0.98	0.62	0.98
E, B1 MGR, B2 FGE, B2 CC	0.41	0.92	0.9	0.22	0.98	0.6	0.9	0.98	0.62	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.85	0.92	0.98	0.22	0.98	0.6	0.9	0.98	0.62	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0	0.92	0.9	0.86	0.98	0.6	0.9	0.98	0.62	0.98

Table B2

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse				
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Eff.	SBC or Sluice S.
Existing, E=1	0.09	0.8	0.82	0.06	0.95	0.28	0.94	0.98	0	0
Existing, E	0.09	0.8	0.82	0.06	0.95	0.28	0.94	0.98	0	0
Existing, E, B1 MGR	0.09	0.92	0.82	0.06	0.95	0.28	0.94	0.98	0	0
E, B1 MGR, B1 JBS/STS	0.09	0.92	0.98	0.06	0.95	0.28	0.94	0.98	0	0
E, B1 MGR, B1 JBS/ESBS	0.35	0.92	0.98	0.06	0.95	0.28	0.94	0.98	0	0
E, B1 MGR, B1 SC	0	0.92	0.82	0.84	0.98	0.28	0.94	0.98	0	0
E, B1 MGR, B2 FGE	0.09	0.92	0.82	0.06	0.95	0.4	0.94	0.98	0	0
E, B1 MGR, B2 CC	0.09	0.92	0.82	0.06	0.95	0.28	0.94	0.98	0.47	0.98
E, B1 MGR, B2 FGE, B2 CC	0.09	0.92	0.82	0.06	0.95	0.4	0.94	0.98	0.47	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.35	0.92	0.98	0.06	0.95	0.4	0.94	0.98	0.47	0.98
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0	0.92	0.82	0.84	0.98	0.4	0.94	0.98	0.47	0.98

Table B3

APPENDIX B

Project Survival Estimates	High Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.950	0.950	0.950	0.950	0.955	0.950	0.950	0.950	0.950	0.954
Existing, E, B1 MGR	0.952	0.952	0.952	0.953	0.957	0.952	0.952	0.952	0.953	0.956
E, B1 MGR, B1 JBS/STS	0.959	0.959	0.959	0.959	0.962	0.959	0.959	0.959	0.959	0.963
E, B1 MGR, B1 JBS/ESBS	0.963	0.963	0.963	0.963	0.965	0.963	0.963	0.963	0.963	0.967
E, B1 MGR, B1 SC	0.965	0.965	0.965	0.965	0.966	0.965	0.965	0.965	0.965	0.968
E, B1 MGR, B2 FGE	0.955	0.955	0.955	0.956	0.960	0.955	0.955	0.955	0.956	0.959
E, B1 MGR, B2 CC	0.959	0.959	0.959	0.959	0.963	0.959	0.959	0.959	0.959	0.961
E, B1 MGR, B2 FGE, B2 CC	0.960	0.960	0.960	0.961	0.965	0.960	0.960	0.960	0.960	0.962
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.971	0.971	0.971	0.971	0.972	0.971	0.971	0.971	0.971	0.973
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.974
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.964	0.964	0.964	0.965	0.970	0.964	0.964	0.964	0.965	0.967
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.962	0.962	0.962	0.963	0.966	0.962	0.962	0.962	0.963	0.965
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.950	0.950	0.950	0.950	0.955	0.950	0.950	0.950	0.950	0.954
Existing, E, B1 MGR	0.952	0.952	0.952	0.953	0.957	0.952	0.952	0.952	0.953	0.956
E, B1 MGR, B1 JBS/STS	0.959	0.959	0.959	0.959	0.962	0.959	0.959	0.959	0.960	0.963
E, B1 MGR, B1 JBS/ESBS	0.965	0.965	0.965	0.965	0.966	0.965	0.965	0.965	0.965	0.968
E, B1 MGR, B1 SC	0.964	0.964	0.964	0.965	0.965	0.964	0.964	0.964	0.965	0.968
E, B1 MGR, B2 FGE	0.955	0.955	0.955	0.956	0.960	0.955	0.955	0.955	0.956	0.959
E, B1 MGR, B2 CC	0.961	0.961	0.961	0.961	0.965	0.961	0.961	0.961	0.961	0.962
E, B1 MGR, B2 FGE, B2 CC	0.962	0.962	0.962	0.962	0.966	0.962	0.962	0.962	0.962	0.963
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.974	0.974	0.974	0.974	0.975	0.974	0.974	0.974	0.974	0.975
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.974	0.974	0.974	0.974	0.975	0.974	0.974	0.974	0.974	0.975
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.894	0.935	0.949	0.963	0.961	0.882	0.899	0.899	0.880	0.863
Existing, E, B1 MGR	0.936	0.953	0.959	0.963	0.961	0.933	0.943	0.945	0.940	0.934
E, B1 MGR, B1 JBS/STS	0.941	0.956	0.960	0.963	0.961	0.939	0.949	0.951	0.948	0.943
E, B1 MGR, B1 JBS/ESBS	0.947	0.958	0.962	0.963	0.961	0.947	0.955	0.957	0.957	0.954
E, B1 MGR, B1 SC	0.959	0.964	0.964	0.963	0.961	0.961	0.968	0.970	0.974	0.973
E, B1 MGR, B2 FGE	0.939	0.956	0.961	0.966	0.964	0.935	0.944	0.946	0.940	0.934
E, B1 MGR, B2 CC	0.944	0.960	0.966	0.971	0.970	0.940	0.947	0.947	0.940	0.934
E, B1 MGR, B2 FGE, B2 CC	0.945	0.962	0.967	0.973	0.972	0.941	0.948	0.948	0.940	0.934
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.957	0.967	0.970	0.973	0.972	0.955	0.960	0.960	0.957	0.954
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.969	0.972	0.973	0.973	0.972	0.969	0.972	0.973	0.974	0.973

Table B4

Project Survival Estimates	Medium Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.944	0.944	0.951	0.962	0.967	0.941	0.941	0.947	0.956	0.961
Existing, E, B1 MGR	0.946	0.946	0.952	0.962	0.967	0.945	0.945	0.950	0.959	0.964
E, B1 MGR, B1 JBS/STS	0.953	0.953	0.957	0.962	0.967	0.954	0.954	0.959	0.967	0.971
E, B1 MGR, B1 JBS/ESBS	0.957	0.957	0.959	0.963	0.967	0.960	0.960	0.965	0.972	0.976
E, B1 MGR, B1 SC	0.959	0.959	0.960	0.963	0.967	0.963	0.963	0.967	0.974	0.978
E, B1 MGR, B2 FGE	0.951	0.951	0.957	0.966	0.970	0.948	0.948	0.953	0.960	0.964
E, B1 MGR, B2 CC	0.955	0.955	0.961	0.970	0.973	0.952	0.952	0.955	0.961	0.964
E, B1 MGR, B2 FGE, B2 CC	0.958	0.958	0.963	0.973	0.975	0.953	0.953	0.956	0.961	0.964
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.968	0.968	0.970	0.973	0.975	0.969	0.969	0.971	0.974	0.976
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.970	0.970	0.971	0.973	0.975	0.971	0.971	0.973	0.976	0.978
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.965	0.965	0.969	0.971	0.973	0.960	0.960	0.963	0.968	0.971
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.959	0.959	0.963	0.970	0.973	0.957	0.957	0.960	0.965	0.968
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.944	0.944	0.951	0.962	0.967	0.941	0.941	0.947	0.956	0.961
Existing, E, B1 MGR	0.946	0.946	0.952	0.962	0.967	0.945	0.945	0.950	0.959	0.964
E, B1 MGR, B1 JBS/STS	0.953	0.953	0.957	0.962	0.967	0.955	0.955	0.960	0.967	0.971
E, B1 MGR, B1 JBS/ESBS	0.959	0.959	0.960	0.963	0.967	0.963	0.963	0.967	0.974	0.977
E, B1 MGR, B1 SC	0.958	0.958	0.960	0.963	0.967	0.962	0.962	0.967	0.973	0.977
E, B1 MGR, B2 FGE	0.951	0.951	0.957	0.966	0.970	0.948	0.948	0.952	0.960	0.964
E, B1 MGR, B2 CC	0.958	0.958	0.964	0.973	0.975	0.954	0.954	0.956	0.961	0.964
E, B1 MGR, B2 FGE, B2 CC	0.960	0.960	0.965	0.975	0.976	0.955	0.955	0.957	0.961	0.964
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.972	0.972	0.973	0.975	0.976	0.973	0.973	0.974	0.977	0.978
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.972	0.972	0.973	0.975	0.976	0.973	0.973	0.974	0.976	0.977
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.930	0.964	0.968	0.968	0.967	0.851	0.881	0.900	0.904	0.898
Existing, E, B1 MGR	0.946	0.964	0.968	0.968	0.967	0.924	0.941	0.948	0.950	0.948
E, B1 MGR, B1 JBS/STS	0.948	0.964	0.968	0.968	0.967	0.934	0.949	0.955	0.956	0.954
E, B1 MGR, B1 JBS/ESBS	0.950	0.964	0.968	0.968	0.967	0.944	0.958	0.962	0.963	0.961
E, B1 MGR, B1 SC	0.954	0.964	0.968	0.968	0.967	0.965	0.974	0.975	0.976	0.975
E, B1 MGR, B2 FGE	0.950	0.967	0.970	0.970	0.969	0.926	0.941	0.948	0.950	0.948
E, B1 MGR, B2 CC	0.957	0.972	0.973	0.974	0.973	0.928	0.941	0.948	0.950	0.948
E, B1 MGR, B2 FGE, B2 CC	0.959	0.973	0.975	0.975	0.974	0.929	0.941	0.948	0.950	0.948
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.963	0.973	0.975	0.975	0.974	0.949	0.958	0.962	0.963	0.961
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.968	0.973	0.975	0.975	0.974	0.970	0.974	0.975	0.976	0.975

Table B5

Project Survival Estimates	Low Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.933	0.954	0.961	0.972	0.979	0.926	0.943	0.952	0.968	0.979
Existing, E, B1 MGR	0.936	0.954	0.961	0.972	0.979	0.931	0.948	0.956	0.970	0.979
E, B1 MGR, B1 JBS/STS	0.942	0.954	0.961	0.972	0.979	0.947	0.961	0.967	0.975	0.979
E, B1 MGR, B1 JBS/ESBS	0.946	0.954	0.961	0.972	0.979	0.956	0.969	0.973	0.978	0.980
E, B1 MGR, B1 SC	0.948	0.954	0.961	0.972	0.979	0.960	0.972	0.976	0.979	0.980
E, B1 MGR, B2 FGE	0.943	0.960	0.965	0.974	0.979	0.935	0.949	0.956	0.970	0.979
E, B1 MGR, B2 CC	0.950	0.966	0.970	0.976	0.980	0.939	0.950	0.956	0.970	0.979
E, B1 MGR, B2 FGE, B2 CC	0.954	0.969	0.972	0.977	0.980	0.941	0.951	0.956	0.970	0.979
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.964	0.969	0.972	0.977	0.980	0.965	0.971	0.974	0.978	0.980
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.966	0.969	0.972	0.977	0.980	0.969	0.975	0.977	0.979	0.980
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.962	0.966	0.970	0.976	0.980	0.952	0.961	0.966	0.977	0.980
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.953	0.966	0.970	0.976	0.980	0.948	0.957	0.963	0.973	0.957
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.933	0.954	0.961	0.972	0.979	0.926	0.943	0.952	0.968	0.979
Existing, E, B1 MGR	0.935	0.954	0.961	0.972	0.979	0.931	0.948	0.956	0.970	0.979
E, B1 MGR, B1 JBS/STS	0.942	0.954	0.961	0.972	0.979	0.947	0.961	0.967	0.975	0.979
E, B1 MGR, B1 JBS/ESBS	0.947	0.954	0.961	0.972	0.979	0.960	0.972	0.976	0.979	0.980
E, B1 MGR, B1 SC	0.947	0.954	0.961	0.972	0.979	0.959	0.971	0.976	0.978	0.980
E, B1 MGR, B2 FGE	0.943	0.960	0.965	0.974	0.979	0.935	0.949	0.956	0.970	0.979
E, B1 MGR, B2 CC	0.955	0.970	0.973	0.977	0.980	0.941	0.951	0.956	0.970	0.979
E, B1 MGR, B2 FGE, B2 CC	0.957	0.972	0.974	0.978	0.980	0.942	0.951	0.956	0.970	0.979
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.969	0.972	0.974	0.978	0.980	0.971	0.975	0.977	0.979	0.980
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.969	0.972	0.974	0.978	0.980	0.970	0.974	0.976	0.978	0.980
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.951	0.970	0.975	0.976	0.976	0.811	0.914	0.941	0.946	0.946
Existing, E, B1 MGR	0.951	0.970	0.975	0.976	0.976	0.913	0.954	0.965	0.966	0.966
E, B1 MGR, B1 JBS/STS	0.951	0.970	0.975	0.976	0.976	0.927	0.959	0.968	0.969	0.969
E, B1 MGR, B1 JBS/ESBS	0.951	0.970	0.975	0.976	0.976	0.942	0.965	0.971	0.972	0.972
E, B1 MGR, B1 SC	0.951	0.970	0.975	0.976	0.976	0.970	0.976	0.978	0.978	0.978
E, B1 MGR, B2 FGE	0.956	0.972	0.976	0.976	0.976	0.913	0.954	0.965	0.966	0.966
E, B1 MGR, B2 CC	0.965	0.975	0.977	0.978	0.978	0.913	0.954	0.965	0.966	0.966
E, B1 MGR, B2 FGE, B2 CC	0.967	0.976	0.978	0.978	0.978	0.913	0.954	0.965	0.966	0.966
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.967	0.976	0.978	0.978	0.978	0.942	0.965	0.971	0.972	0.972
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.967	0.976	0.978	0.978	0.978	0.970	0.976	0.978	0.978	0.978

Table B6

Project Survival Estimates	Weighted Average of the Flow Years									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.942	0.949	0.953	0.962	0.967	0.939	0.944	0.949	0.958	0.964
Existing, E, B1 MGR	0.945	0.950	0.955	0.962	0.968	0.943	0.948	0.952	0.960	0.966
E, B1 MGR, B1 JBS/STS	0.951	0.955	0.958	0.964	0.969	0.953	0.958	0.961	0.967	0.971
E, B1 MGR, B1 JBS/ESBS	0.955	0.958	0.961	0.966	0.970	0.960	0.964	0.967	0.971	0.974
E, B1 MGR, B1 SC	0.957	0.959	0.962	0.966	0.970	0.963	0.966	0.969	0.973	0.975
E, B1 MGR, B2 FGE	0.950	0.955	0.959	0.965	0.970	0.946	0.951	0.954	0.962	0.967
E, B1 MGR, B2 CC	0.955	0.959	0.963	0.969	0.972	0.950	0.953	0.956	0.963	0.968
E, B1 MGR, B2 FGE, B2 CC	0.957	0.962	0.965	0.970	0.973	0.952	0.955	0.957	0.964	0.968
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.968	0.969	0.971	0.973	0.975	0.968	0.970	0.972	0.974	0.976
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.969	0.971	0.972	0.974	0.976	0.971	0.973	0.974	0.976	0.977
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.964	0.965	0.968	0.970	0.974	0.959	0.962	0.964	0.970	0.972
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.958	0.962	0.965	0.970	0.973	0.956	0.959	0.961	0.967	0.964
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.942	0.949	0.953	0.962	0.967	0.939	0.944	0.949	0.958	0.964
Existing, E, B1 MGR	0.945	0.950	0.955	0.962	0.968	0.943	0.948	0.952	0.960	0.966
E, B1 MGR, B1 JBS/STS	0.952	0.955	0.959	0.964	0.969	0.954	0.958	0.962	0.967	0.971
E, B1 MGR, B1 JBS/ESBS	0.957	0.959	0.962	0.966	0.970	0.962	0.966	0.969	0.973	0.975
E, B1 MGR, B1 SC	0.957	0.959	0.962	0.966	0.970	0.962	0.966	0.969	0.972	0.975
E, B1 MGR, B2 FGE	0.950	0.955	0.959	0.965	0.970	0.946	0.950	0.954	0.962	0.967
E, B1 MGR, B2 CC	0.958	0.963	0.966	0.971	0.973	0.952	0.955	0.958	0.964	0.968
E, B1 MGR, B2 FGE, B2 CC	0.960	0.964	0.967	0.972	0.974	0.953	0.956	0.958	0.964	0.968
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.972	0.973	0.974	0.976	0.977	0.973	0.974	0.975	0.977	0.978
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.972	0.973	0.974	0.975	0.977	0.972	0.973	0.975	0.976	0.977
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.925	0.957	0.964	0.969	0.968	0.848	0.896	0.912	0.909	0.902
Existing, E, B1 MGR	0.944	0.963	0.967	0.969	0.968	0.923	0.946	0.952	0.952	0.949
E, B1 MGR, B1 JBS/STS	0.947	0.963	0.968	0.969	0.968	0.933	0.952	0.957	0.958	0.956
E, B1 MGR, B1 JBS/ESBS	0.949	0.964	0.968	0.969	0.968	0.944	0.959	0.963	0.964	0.962
E, B1 MGR, B1 SC	0.955	0.966	0.969	0.969	0.968	0.965	0.973	0.975	0.976	0.976
E, B1 MGR, B2 FGE	0.948	0.965	0.969	0.971	0.970	0.925	0.946	0.952	0.952	0.949
E, B1 MGR, B2 CC	0.955	0.969	0.972	0.974	0.974	0.927	0.947	0.953	0.952	0.949
E, B1 MGR, B2 FGE, B2 CC	0.957	0.970	0.973	0.975	0.975	0.928	0.947	0.953	0.952	0.949
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.963	0.972	0.974	0.975	0.975	0.948	0.961	0.964	0.964	0.962
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.968	0.973	0.975	0.975	0.975	0.970	0.974	0.975	0.976	0.976

Table B7

FPE	High Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.703	0.703	0.703	0.708	0.749	0.703	0.703	0.703	0.709	0.752
Existing, E, B1 MGR	0.703	0.703	0.703	0.708	0.749	0.703	0.703	0.703	0.709	0.752
E, B1 MGR, B1 JBS/STS	0.703	0.703	0.703	0.708	0.749	0.703	0.703	0.703	0.709	0.752
E, B1 MGR, B1 JBS/ESBS	0.772	0.772	0.772	0.776	0.796	0.772	0.772	0.772	0.778	0.819
E, B1 MGR, B1 SC	0.801	0.801	0.801	0.804	0.816	0.801	0.801	0.801	0.807	0.847
E, B1 MGR, B2 FGE	0.742	0.742	0.742	0.747	0.787	0.742	0.742	0.742	0.746	0.781
E, B1 MGR, B2 CC	0.781	0.781	0.781	0.785	0.824	0.781	0.781	0.781	0.784	0.809
E, B1 MGR, B2 FGE, B2 CC	0.802	0.802	0.802	0.806	0.844	0.802	0.802	0.802	0.804	0.825
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.871	0.871	0.871	0.873	0.892	0.871	0.871	0.871	0.873	0.892
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.900	0.900	0.900	0.902	0.912	0.900	0.900	0.900	0.903	0.920
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.825	0.825	0.825	0.829	0.879	0.825	0.825	0.825	0.828	0.852
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.782	0.782	0.782	0.786	0.825	0.782	0.782	0.782	0.785	0.811
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.707	0.707	0.707	0.713	0.752	0.707	0.707	0.707	0.713	0.756
Existing, E, B1 MGR	0.707	0.707	0.707	0.713	0.752	0.707	0.707	0.707	0.713	0.756
E, B1 MGR, B1 JBS/STS	0.707	0.707	0.707	0.713	0.752	0.707	0.707	0.707	0.713	0.756
E, B1 MGR, B1 JBS/ESBS	0.799	0.799	0.799	0.803	0.815	0.799	0.799	0.799	0.805	0.845
E, B1 MGR, B1 SC	0.793	0.793	0.793	0.797	0.811	0.793	0.793	0.793	0.799	0.839
E, B1 MGR, B2 FGE	0.746	0.746	0.746	0.751	0.789	0.746	0.746	0.746	0.751	0.785
E, B1 MGR, B2 CC	0.812	0.812	0.812	0.816	0.853	0.812	0.812	0.812	0.814	0.833
E, B1 MGR, B2 FGE, B2 CC	0.827	0.827	0.827	0.831	0.867	0.827	0.827	0.827	0.829	0.844
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.919	0.919	0.919	0.921	0.931	0.919	0.919	0.919	0.921	0.933
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.913	0.913	0.913	0.915	0.926	0.913	0.913	0.913	0.915	0.927
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.225	0.480	0.548	0.575	0.522	0.214	0.429	0.481	0.474	0.411
Existing, E, B1 MGR	0.225	0.480	0.548	0.575	0.522	0.214	0.429	0.481	0.474	0.411
E, B1 MGR, B1 JBS/STS	0.225	0.480	0.548	0.575	0.522	0.214	0.429	0.481	0.474	0.411
E, B1 MGR, B1 JBS/ESBS	0.325	0.523	0.572	0.575	0.522	0.333	0.535	0.590	0.618	0.579
E, B1 MGR, B1 SC	0.510	0.604	0.616	0.575	0.522	0.554	0.731	0.791	0.884	0.890
E, B1 MGR, B2 FGE	0.295	0.541	0.609	0.646	0.601	0.275	0.462	0.504	0.478	0.411
E, B1 MGR, B2 CC	0.424	0.652	0.721	0.775	0.746	0.386	0.523	0.546	0.485	0.411
E, B1 MGR, B2 FGE, B2 CC	0.462	0.685	0.754	0.812	0.789	0.419	0.541	0.558	0.487	0.411
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.562	0.728	0.778	0.812	0.789	0.538	0.647	0.667	0.631	0.579
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.747	0.809	0.822	0.812	0.789	0.759	0.842	0.868	0.896	0.890

Table B8

FPE	Medium Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.628	0.628	0.686	0.780	0.840	0.633	0.633	0.695	0.794	0.853
Existing, E, B1 MGR	0.628	0.628	0.686	0.780	0.840	0.633	0.633	0.695	0.794	0.853
E, B1 MGR, B1 JBS/STS	0.628	0.628	0.686	0.780	0.840	0.633	0.633	0.695	0.794	0.853
E, B1 MGR, B1 JBS/ESBS	0.696	0.696	0.731	0.781	0.840	0.734	0.734	0.790	0.878	0.929
E, B1 MGR, B1 SC	0.725	0.725	0.750	0.781	0.840	0.777	0.777	0.831	0.913	0.961
E, B1 MGR, B2 FGE	0.685	0.685	0.740	0.830	0.877	0.675	0.675	0.725	0.806	0.855
E, B1 MGR, B2 CC	0.741	0.741	0.793	0.880	0.914	0.716	0.716	0.754	0.817	0.856
E, B1 MGR, B2 FGE, B2 CC	0.772	0.772	0.822	0.907	0.934	0.739	0.739	0.770	0.824	0.857
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.840	0.840	0.866	0.908	0.934	0.840	0.840	0.866	0.908	0.933
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.869	0.869	0.885	0.909	0.934	0.882	0.882	0.906	0.943	0.965
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.820	0.820	0.856	0.882	0.914	0.781	0.781	0.816	0.871	0.905
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.742	0.742	0.794	0.880	0.914	0.718	0.718	0.756	0.819	0.858
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.632	0.632	0.689	0.780	0.840	0.640	0.640	0.701	0.799	0.858
Existing, E, B1 MGR	0.632	0.632	0.689	0.780	0.840	0.640	0.640	0.701	0.799	0.858
E, B1 MGR, B1 JBS/STS	0.632	0.632	0.689	0.780	0.840	0.640	0.640	0.701	0.799	0.858
E, B1 MGR, B1 JBS/ESBS	0.723	0.723	0.748	0.781	0.840	0.774	0.774	0.828	0.911	0.959
E, B1 MGR, B1 SC	0.717	0.717	0.744	0.781	0.840	0.765	0.765	0.820	0.904	0.952
E, B1 MGR, B2 FGE	0.689	0.689	0.742	0.830	0.877	0.681	0.681	0.730	0.811	0.859
E, B1 MGR, B2 CC	0.784	0.784	0.832	0.915	0.939	0.751	0.751	0.780	0.831	0.862
E, B1 MGR, B2 FGE, B2 CC	0.806	0.806	0.853	0.934	0.953	0.767	0.767	0.792	0.835	0.862
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.897	0.897	0.912	0.936	0.953	0.902	0.902	0.919	0.947	0.964
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.891	0.891	0.908	0.936	0.953	0.893	0.893	0.911	0.940	0.957
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.260	0.604	0.687	0.707	0.680	0.184	0.502	0.594	0.616	0.586
Existing, E, B1 MGR	0.260	0.604	0.687	0.707	0.680	0.184	0.502	0.594	0.616	0.586
E, B1 MGR, B1 JBS/STS	0.260	0.604	0.687	0.707	0.680	0.184	0.502	0.594	0.616	0.586
E, B1 MGR, B1 JBS/ESBS	0.296	0.604	0.687	0.707	0.680	0.357	0.644	0.710	0.725	0.704
E, B1 MGR, B1 SC	0.364	0.604	0.687	0.707	0.680	0.678	0.907	0.924	0.928	0.923
E, B1 MGR, B2 FGE	0.362	0.670	0.739	0.756	0.734	0.219	0.502	0.594	0.616	0.586
E, B1 MGR, B2 CC	0.547	0.790	0.834	0.845	0.831	0.282	0.502	0.594	0.616	0.586
E, B1 MGR, B2 FGE, B2 CC	0.601	0.825	0.862	0.871	0.859	0.300	0.502	0.594	0.616	0.586
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.638	0.825	0.862	0.871	0.859	0.474	0.644	0.710	0.725	0.704
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.706	0.825	0.862	0.871	0.859	0.794	0.907	0.924	0.928	0.923

Table B9

FPE	Low Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.492	0.672	0.760	0.902	0.988	0.507	0.695	0.780	0.911	0.989
Existing, E, B1 MGR	0.492	0.672	0.760	0.902	0.988	0.507	0.695	0.780	0.911	0.989
E, B1 MGR, B1 JBS/STS	0.492	0.672	0.760	0.902	0.988	0.507	0.695	0.780	0.911	0.989
E, B1 MGR, B1 JBS/ESBS	0.558	0.672	0.760	0.902	0.988	0.667	0.830	0.894	0.959	0.995
E, B1 MGR, B1 SC	0.587	0.672	0.760	0.902	0.988	0.734	0.887	0.942	0.979	0.998
E, B1 MGR, B2 FGE	0.580	0.748	0.815	0.925	0.991	0.553	0.708	0.782	0.911	0.989
E, B1 MGR, B2 CC	0.669	0.823	0.870	0.947	0.994	0.598	0.721	0.784	0.911	0.989
E, B1 MGR, B2 FGE, B2 CC	0.717	0.864	0.900	0.960	0.995	0.623	0.728	0.785	0.911	0.989
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.783	0.864	0.900	0.960	0.995	0.783	0.863	0.899	0.959	0.995
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.812	0.864	0.900	0.960	0.995	0.850	0.919	0.947	0.979	0.998
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.794	0.824	0.870	0.947	0.994	0.701	0.808	0.858	0.866	0.998
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.670	0.823	0.870	0.947	0.994	0.601	0.723	0.786	0.912	0.989
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.496	0.672	0.760	0.902	0.988	0.517	0.703	0.787	0.914	0.989
Existing, E, B1 MGR	0.496	0.672	0.760	0.902	0.988	0.517	0.703	0.787	0.914	0.989
E, B1 MGR, B1 JBS/STS	0.496	0.672	0.760	0.902	0.988	0.517	0.703	0.787	0.914	0.989
E, B1 MGR, B1 JBS/ESBS	0.585	0.672	0.760	0.902	0.988	0.730	0.883	0.939	0.978	0.997
E, B1 MGR, B1 SC	0.579	0.672	0.760	0.902	0.988	0.716	0.871	0.928	0.974	0.997
E, B1 MGR, B2 FGE	0.584	0.748	0.815	0.925	0.991	0.563	0.716	0.789	0.914	0.989
E, B1 MGR, B2 CC	0.734	0.875	0.909	0.963	0.995	0.640	0.738	0.792	0.914	0.989
E, B1 MGR, B2 FGE, B2 CC	0.768	0.904	0.930	0.972	0.997	0.657	0.743	0.793	0.914	0.989
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.857	0.904	0.930	0.972	0.997	0.870	0.922	0.945	0.978	0.997
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.851	0.904	0.930	0.972	0.997	0.855	0.910	0.935	0.974	0.997
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.280	0.755	0.876	0.893	0.893	0.145	0.668	0.803	0.826	0.826
Existing, E, B1 MGR	0.280	0.755	0.876	0.893	0.893	0.145	0.668	0.803	0.826	0.826
E, B1 MGR, B1 JBS/STS	0.280	0.755	0.876	0.893	0.893	0.145	0.668	0.803	0.826	0.826
E, B1 MGR, B1 JBS/ESBS	0.280	0.755	0.876	0.893	0.893	0.389	0.763	0.859	0.875	0.875
E, B1 MGR, B1 SC	0.280	0.755	0.876	0.893	0.893	0.840	0.938	0.963	0.967	0.967
E, B1 MGR, B2 FGE	0.400	0.796	0.897	0.911	0.911	0.145	0.668	0.803	0.826	0.826
E, B1 MGR, B2 CC	0.618	0.870	0.934	0.944	0.944	0.145	0.668	0.803	0.826	0.826
E, B1 MGR, B2 FGE, B2 CC	0.682	0.892	0.945	0.953	0.953	0.145	0.668	0.803	0.826	0.826
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.682	0.892	0.945	0.953	0.953	0.389	0.763	0.859	0.875	0.875
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.682	0.892	0.945	0.953	0.953	0.840	0.938	0.963	0.967	0.967

Table B10

FPE	Weighted Average of the Flow Years									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.609	0.664	0.713	0.795	0.857	0.616	0.673	0.723	0.803	0.864
Existing, E, B1 MGR	0.609	0.664	0.713	0.795	0.857	0.616	0.673	0.723	0.803	0.864
E, B1 MGR, B1 JBS/STS	0.609	0.664	0.713	0.795	0.857	0.616	0.673	0.723	0.803	0.864
E, B1 MGR, B1 JBS/ESBS	0.678	0.712	0.752	0.816	0.871	0.725	0.774	0.816	0.872	0.916
E, B1 MGR, B1 SC	0.706	0.732	0.768	0.825	0.877	0.771	0.817	0.855	0.901	0.938
E, B1 MGR, B2 FGE	0.671	0.721	0.763	0.834	0.884	0.659	0.705	0.747	0.819	0.873
E, B1 MGR, B2 CC	0.731	0.778	0.813	0.872	0.911	0.700	0.737	0.771	0.835	0.882
E, B1 MGR, B2 FGE, B2 CC	0.764	0.808	0.839	0.893	0.925	0.723	0.755	0.784	0.844	0.887
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.832	0.856	0.878	0.913	0.939	0.832	0.856	0.877	0.913	0.939
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.861	0.877	0.894	0.922	0.945	0.878	0.899	0.917	0.942	0.961
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.814	0.823	0.851	0.885	0.927	0.770	0.802	0.831	0.857	0.917
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.733	0.778	0.813	0.872	0.911	0.702	0.739	0.773	0.837	0.883
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.614	0.667	0.716	0.796	0.858	0.623	0.679	0.728	0.808	0.867
Existing, E, B1 MGR	0.614	0.667	0.716	0.796	0.858	0.623	0.679	0.728	0.808	0.867
E, B1 MGR, B1 JBS/STS	0.614	0.667	0.716	0.796	0.858	0.623	0.679	0.728	0.808	0.867
E, B1 MGR, B1 JBS/ESBS	0.704	0.731	0.767	0.824	0.877	0.768	0.814	0.852	0.899	0.936
E, B1 MGR, B1 SC	0.698	0.726	0.764	0.822	0.876	0.758	0.805	0.844	0.893	0.932
E, B1 MGR, B2 FGE	0.675	0.724	0.765	0.835	0.885	0.665	0.711	0.753	0.824	0.876
E, B1 MGR, B2 CC	0.778	0.820	0.849	0.900	0.930	0.736	0.766	0.794	0.851	0.892
E, B1 MGR, B2 FGE, B2 CC	0.801	0.842	0.868	0.914	0.940	0.752	0.778	0.803	0.857	0.895
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.892	0.906	0.920	0.942	0.959	0.897	0.913	0.927	0.948	0.965
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.886	0.902	0.916	0.940	0.958	0.887	0.904	0.919	0.942	0.960
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1										
Existing, E	0.255	0.612	0.702	0.723	0.697	0.181	0.530	0.623	0.636	0.605
Existing, E, B1 MGR	0.255	0.612	0.702	0.723	0.697	0.181	0.530	0.623	0.636	0.605
E, B1 MGR, B1 JBS/STS	0.255	0.612	0.702	0.723	0.697	0.181	0.530	0.623	0.636	0.605
E, B1 MGR, B1 JBS/ESBS	0.300	0.625	0.709	0.723	0.697	0.360	0.647	0.719	0.738	0.718
E, B1 MGR, B1 SC	0.382	0.649	0.722	0.723	0.697	0.689	0.863	0.896	0.927	0.926
E, B1 MGR, B2 FGE	0.353	0.669	0.747	0.769	0.747	0.213	0.540	0.629	0.637	0.605
E, B1 MGR, B2 CC	0.532	0.773	0.830	0.853	0.839	0.272	0.558	0.642	0.639	0.605
E, B1 MGR, B2 FGE, B2 CC	0.584	0.803	0.854	0.878	0.866	0.289	0.563	0.646	0.640	0.605
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.628	0.816	0.861	0.878	0.866	0.468	0.681	0.742	0.742	0.718
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.711	0.840	0.875	0.878	0.866	0.798	0.897	0.919	0.930	0.926

Table B11

Screening 1	High Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.634	0.634	0.634	0.640	0.680	0.634	0.634	0.634	0.640	0.681
Existing, E	0.634	0.634	0.634	0.640	0.680	0.634	0.634	0.634	0.640	0.681
Existing, E, B1 MGR	0.634	0.634	0.634	0.640	0.680	0.634	0.634	0.634	0.640	0.681
E, B1 MGR, B1 JBS/STS	0.640	0.640	0.640	0.645	0.684	0.640	0.640	0.640	0.646	0.687
E, B1 MGR, B1 JBS/ESBS	0.703	0.703	0.703	0.707	0.727	0.703	0.703	0.703	0.708	0.747
E, B1 MGR, B1 SC	0.726	0.726	0.726	0.729	0.743	0.726	0.726	0.726	0.731	0.770
E, B1 MGR, B2 FGE	0.669	0.669	0.669	0.674	0.714	0.669	0.669	0.669	0.674	0.707
E, B1 MGR, B2 CC	0.704	0.704	0.704	0.708	0.747	0.704	0.704	0.704	0.707	0.732
E, B1 MGR, B2 FGE, B2 CC	0.723	0.723	0.723	0.727	0.765	0.723	0.723	0.723	0.725	0.746
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.791	0.791	0.791	0.794	0.812	0.791	0.791	0.791	0.794	0.812
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.814	0.814	0.814	0.816	0.828	0.814	0.814	0.814	0.817	0.835
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.746	0.746	0.746	0.749	0.798	0.746	0.746	0.746	0.749	0.773
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.708	0.708	0.708	0.712	0.750	0.708	0.708	0.708	0.711	0.736
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.638	0.638	0.638	0.643	0.682	0.638	0.638	0.638	0.643	0.685
Existing, E	0.638	0.638	0.638	0.643	0.682	0.638	0.638	0.638	0.643	0.685
Existing, E, B1 MGR	0.638	0.638	0.638	0.643	0.682	0.638	0.638	0.638	0.643	0.685
E, B1 MGR, B1 JBS/STS	0.644	0.644	0.644	0.649	0.687	0.644	0.644	0.644	0.649	0.691
E, B1 MGR, B1 JBS/ESBS	0.727	0.727	0.727	0.731	0.744	0.727	0.727	0.727	0.733	0.771
E, B1 MGR, B1 SC	0.718	0.718	0.718	0.722	0.738	0.718	0.718	0.718	0.724	0.763
E, B1 MGR, B2 FGE	0.673	0.673	0.673	0.677	0.716	0.673	0.673	0.673	0.677	0.710
E, B1 MGR, B2 CC	0.732	0.732	0.732	0.736	0.773	0.732	0.732	0.732	0.734	0.754
E, B1 MGR, B2 FGE, B2 CC	0.745	0.745	0.745	0.749	0.786	0.745	0.745	0.745	0.747	0.763
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.835	0.835	0.835	0.836	0.847	0.835	0.835	0.835	0.836	0.850
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.826	0.826	0.826	0.828	0.841	0.826	0.826	0.826	0.828	0.842
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.195	0.435	0.500	0.526	0.476	0.184	0.386	0.434	0.427	0.366
Existing, E	0.195	0.435	0.500	0.526	0.476	0.184	0.386	0.434	0.427	0.366
Existing, E, B1 MGR	0.195	0.435	0.500	0.526	0.476	0.184	0.386	0.434	0.427	0.366
E, B1 MGR, B1 JBS/STS	0.200	0.437	0.501	0.526	0.476	0.191	0.391	0.440	0.434	0.375
E, B1 MGR, B1 JBS/ESBS	0.291	0.477	0.522	0.526	0.476	0.299	0.487	0.538	0.564	0.527
E, B1 MGR, B1 SC	0.453	0.548	0.561	0.526	0.476	0.492	0.659	0.714	0.797	0.800
E, B1 MGR, B2 FGE	0.259	0.490	0.555	0.589	0.547	0.239	0.416	0.455	0.430	0.366
E, B1 MGR, B2 CC	0.374	0.590	0.655	0.705	0.677	0.339	0.470	0.492	0.436	0.366
E, B1 MGR, B2 FGE, B2 CC	0.407	0.619	0.684	0.738	0.715	0.368	0.486	0.503	0.438	0.366
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.503	0.660	0.707	0.738	0.715	0.482	0.587	0.607	0.575	0.527
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.665	0.731	0.745	0.738	0.715	0.676	0.758	0.783	0.808	0.800

Table B12

Screening 1	Medium Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.563	0.563	0.621	0.713	0.771	0.566	0.566	0.624	0.719	0.776
Existing, E	0.563	0.563	0.621	0.713	0.771	0.566	0.566	0.624	0.719	0.776
Existing, E, B1 MGR	0.563	0.563	0.621	0.713	0.771	0.566	0.566	0.624	0.719	0.776
E, B1 MGR, B1 JBS/STS	0.569	0.569	0.625	0.713	0.771	0.574	0.574	0.633	0.726	0.783
E, B1 MGR, B1 JBS/ESBS	0.631	0.631	0.665	0.714	0.771	0.665	0.665	0.719	0.802	0.851
E, B1 MGR, B1 SC	0.654	0.654	0.680	0.715	0.771	0.699	0.699	0.751	0.831	0.877
E, B1 MGR, B2 FGE	0.614	0.614	0.669	0.758	0.804	0.603	0.603	0.651	0.730	0.777
E, B1 MGR, B2 CC	0.664	0.664	0.716	0.803	0.837	0.640	0.640	0.677	0.740	0.779
E, B1 MGR, B2 FGE, B2 CC	0.692	0.692	0.742	0.828	0.854	0.660	0.660	0.692	0.746	0.779
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.760	0.760	0.786	0.829	0.854	0.760	0.760	0.786	0.829	0.855
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.782	0.782	0.801	0.829	0.854	0.793	0.793	0.818	0.857	0.880
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.738	0.738	0.775	0.805	0.837	0.700	0.700	0.735	0.791	0.824
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.668	0.668	0.718	0.803	0.837	0.645	0.645	0.682	0.745	0.783
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.567	0.567	0.623	0.713	0.771	0.571	0.571	0.629	0.723	0.780
Existing, E	0.567	0.567	0.623	0.713	0.771	0.571	0.571	0.629	0.723	0.780
Existing, E, B1 MGR	0.567	0.567	0.623	0.713	0.771	0.571	0.571	0.629	0.723	0.780
E, B1 MGR, B1 JBS/STS	0.573	0.573	0.627	0.714	0.771	0.580	0.580	0.638	0.731	0.787
E, B1 MGR, B1 JBS/ESBS	0.655	0.655	0.681	0.715	0.771	0.701	0.701	0.753	0.832	0.878
E, B1 MGR, B1 SC	0.647	0.647	0.675	0.715	0.771	0.689	0.689	0.741	0.822	0.869
E, B1 MGR, B2 FGE	0.617	0.617	0.671	0.759	0.804	0.608	0.608	0.656	0.734	0.781
E, B1 MGR, B2 CC	0.703	0.703	0.751	0.835	0.859	0.671	0.671	0.700	0.752	0.783
E, B1 MGR, B2 FGE, B2 CC	0.722	0.722	0.770	0.852	0.872	0.685	0.685	0.710	0.755	0.784
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.811	0.811	0.827	0.853	0.872	0.815	0.815	0.834	0.864	0.882
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.802	0.802	0.822	0.853	0.872	0.803	0.803	0.822	0.854	0.873
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.230	0.553	0.630	0.649	0.624	0.155	0.452	0.539	0.560	0.532
Existing, E	0.230	0.553	0.630	0.649	0.624	0.155	0.452	0.539	0.560	0.532
Existing, E, B1 MGR	0.230	0.553	0.630	0.649	0.624	0.155	0.452	0.539	0.560	0.532
E, B1 MGR, B1 JBS/STS	0.232	0.553	0.630	0.649	0.624	0.164	0.460	0.545	0.565	0.538
E, B1 MGR, B1 JBS/ESBS	0.265	0.553	0.630	0.649	0.624	0.320	0.588	0.650	0.665	0.645
E, B1 MGR, B1 SC	0.325	0.553	0.630	0.649	0.624	0.601	0.819	0.838	0.842	0.836
E, B1 MGR, B2 FGE	0.322	0.612	0.677	0.693	0.672	0.186	0.452	0.539	0.560	0.532
E, B1 MGR, B2 CC	0.488	0.719	0.762	0.772	0.758	0.243	0.452	0.539	0.560	0.532
E, B1 MGR, B2 FGE, B2 CC	0.536	0.751	0.786	0.795	0.784	0.259	0.452	0.539	0.560	0.532
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.571	0.751	0.786	0.795	0.784	0.425	0.588	0.650	0.665	0.645
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.630	0.751	0.786	0.795	0.784	0.705	0.819	0.838	0.842	0.836

Table B13

Screening 1	Low Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.434	0.611	0.695	0.830	0.911	0.441	0.621	0.703	0.833	0.911
Existing, E	0.434	0.611	0.695	0.830	0.911	0.441	0.621	0.703	0.833	0.911
Existing, E, B1 MGR	0.434	0.611	0.695	0.830	0.911	0.441	0.621	0.703	0.833	0.911
E, B1 MGR, B1 JBS/STS	0.440	0.611	0.695	0.830	0.911	0.455	0.633	0.713	0.837	0.912
E, B1 MGR, B1 JBS/ESBS	0.500	0.611	0.695	0.830	0.911	0.599	0.754	0.816	0.881	0.917
E, B1 MGR, B1 SC	0.523	0.611	0.695	0.830	0.911	0.652	0.799	0.854	0.897	0.919
E, B1 MGR, B2 FGE	0.514	0.679	0.744	0.850	0.913	0.481	0.632	0.705	0.833	0.911
E, B1 MGR, B2 CC	0.593	0.746	0.794	0.870	0.916	0.522	0.644	0.707	0.833	0.911
E, B1 MGR, B2 FGE, B2 CC	0.635	0.783	0.820	0.881	0.917	0.544	0.650	0.708	0.833	0.911
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.702	0.783	0.820	0.881	0.917	0.702	0.783	0.821	0.881	0.917
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.724	0.783	0.820	0.881	0.917	0.755	0.829	0.859	0.897	0.919
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.681	0.746	0.794	0.870	0.916	0.618	0.725	0.775	0.885	0.919
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.596	0.746	0.794	0.870	0.916	0.531	0.651	0.713	0.836	0.912
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.438	0.611	0.695	0.830	0.911	0.449	0.628	0.708	0.836	0.912
Existing, E	0.438	0.611	0.695	0.830	0.911	0.449	0.628	0.708	0.836	0.912
Existing, E, B1 MGR	0.438	0.611	0.695	0.830	0.911	0.449	0.628	0.708	0.836	0.912
E, B1 MGR, B1 JBS/STS	0.444	0.611	0.695	0.830	0.911	0.463	0.640	0.719	0.840	0.912
E, B1 MGR, B1 JBS/ESBS	0.524	0.611	0.695	0.830	0.911	0.656	0.802	0.856	0.898	0.919
E, B1 MGR, B1 SC	0.516	0.611	0.695	0.830	0.911	0.636	0.785	0.842	0.892	0.919
E, B1 MGR, B2 FGE	0.517	0.679	0.744	0.850	0.913	0.489	0.639	0.710	0.836	0.912
E, B1 MGR, B2 CC	0.651	0.793	0.828	0.884	0.918	0.558	0.659	0.714	0.836	0.912
E, B1 MGR, B2 FGE, B2 CC	0.681	0.819	0.847	0.892	0.918	0.574	0.663	0.715	0.836	0.912
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.768	0.819	0.847	0.892	0.918	0.781	0.838	0.862	0.898	0.919
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.760	0.819	0.847	0.892	0.918	0.761	0.821	0.848	0.892	0.919
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.251	0.694	0.806	0.823	0.823	0.116	0.609	0.736	0.758	0.758
Existing, E	0.251	0.694	0.806	0.823	0.823	0.116	0.609	0.736	0.758	0.758
Existing, E, B1 MGR	0.251	0.694	0.806	0.823	0.823	0.116	0.609	0.736	0.758	0.758
E, B1 MGR, B1 JBS/STS	0.251	0.694	0.806	0.823	0.823	0.128	0.614	0.739	0.760	0.760
E, B1 MGR, B1 JBS/ESBS	0.251	0.694	0.806	0.823	0.823	0.349	0.700	0.790	0.805	0.805
E, B1 MGR, B1 SC	0.251	0.694	0.806	0.823	0.823	0.744	0.853	0.881	0.886	0.886
E, B1 MGR, B2 FGE	0.358	0.730	0.825	0.839	0.839	0.116	0.609	0.736	0.758	0.758
E, B1 MGR, B2 CC	0.553	0.797	0.859	0.868	0.868	0.116	0.609	0.736	0.758	0.758
E, B1 MGR, B2 FGE, B2 CC	0.610	0.816	0.868	0.876	0.876	0.116	0.609	0.736	0.758	0.758
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.610	0.816	0.868	0.876	0.876	0.349	0.700	0.790	0.805	0.805
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.610	0.816	0.868	0.876	0.876	0.744	0.853	0.881	0.886	0.886

Table B14

Screening 1	Weighted Average Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.546	0.599	0.647	0.726	0.786	0.549	0.603	0.651	0.729	0.788
Existing, E	0.546	0.599	0.647	0.726	0.786	0.549	0.603	0.651	0.729	0.788
Existing, E, B1 MGR	0.546	0.599	0.647	0.726	0.786	0.549	0.603	0.651	0.729	0.788
E, B1 MGR, B1 JBS/STS	0.552	0.603	0.650	0.728	0.787	0.558	0.612	0.659	0.735	0.793
E, B1 MGR, B1 JBS/ESBS	0.613	0.647	0.685	0.747	0.800	0.656	0.703	0.743	0.798	0.840
E, B1 MGR, B1 SC	0.636	0.663	0.698	0.754	0.804	0.693	0.737	0.774	0.821	0.857
E, B1 MGR, B2 FGE	0.600	0.650	0.692	0.761	0.810	0.586	0.632	0.673	0.744	0.796
E, B1 MGR, B2 CC	0.655	0.701	0.736	0.795	0.833	0.624	0.660	0.694	0.758	0.805
E, B1 MGR, B2 FGE, B2 CC	0.684	0.729	0.760	0.813	0.846	0.644	0.676	0.706	0.766	0.809
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.752	0.776	0.798	0.834	0.861	0.752	0.776	0.798	0.834	0.861
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.774	0.792	0.811	0.841	0.865	0.788	0.810	0.829	0.857	0.878
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.723	0.743	0.772	0.807	0.849	0.689	0.721	0.750	0.806	0.837
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.659	0.704	0.738	0.796	0.834	0.630	0.666	0.699	0.762	0.807
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.549	0.601	0.649	0.727	0.786	0.554	0.608	0.655	0.733	0.791
Existing, E	0.549	0.601	0.649	0.727	0.786	0.554	0.608	0.655	0.733	0.791
Existing, E, B1 MGR	0.549	0.601	0.649	0.727	0.786	0.554	0.608	0.655	0.733	0.791
E, B1 MGR, B1 JBS/STS	0.555	0.606	0.652	0.729	0.788	0.564	0.617	0.664	0.739	0.796
E, B1 MGR, B1 JBS/ESBS	0.637	0.664	0.699	0.754	0.805	0.695	0.739	0.776	0.822	0.858
E, B1 MGR, B1 SC	0.629	0.658	0.694	0.751	0.803	0.682	0.727	0.765	0.814	0.852
E, B1 MGR, B2 FGE	0.604	0.653	0.693	0.762	0.810	0.592	0.637	0.677	0.747	0.799
E, B1 MGR, B2 CC	0.696	0.739	0.768	0.820	0.851	0.655	0.685	0.714	0.771	0.813
E, B1 MGR, B2 FGE, B2 CC	0.717	0.758	0.785	0.833	0.860	0.670	0.696	0.722	0.777	0.816
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.805	0.820	0.835	0.859	0.878	0.811	0.828	0.843	0.866	0.884
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.797	0.814	0.830	0.857	0.877	0.797	0.815	0.831	0.858	0.877
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.226	0.560	0.644	0.664	0.639	0.152	0.479	0.567	0.579	0.550
Existing, E	0.226	0.560	0.644	0.664	0.639	0.152	0.479	0.567	0.579	0.550
Existing, E, B1 MGR	0.226	0.560	0.644	0.664	0.639	0.152	0.479	0.567	0.579	0.550
E, B1 MGR, B1 JBS/STS	0.228	0.560	0.644	0.664	0.639	0.161	0.485	0.572	0.584	0.556
E, B1 MGR, B1 JBS/ESBS	0.269	0.572	0.651	0.664	0.639	0.322	0.591	0.658	0.677	0.658
E, B1 MGR, B1 SC	0.341	0.594	0.662	0.664	0.639	0.611	0.781	0.814	0.842	0.840
E, B1 MGR, B2 FGE	0.314	0.611	0.684	0.705	0.684	0.181	0.488	0.573	0.580	0.550
E, B1 MGR, B2 CC	0.473	0.704	0.759	0.780	0.767	0.233	0.505	0.584	0.582	0.550
E, B1 MGR, B2 FGE, B2 CC	0.520	0.731	0.780	0.802	0.791	0.249	0.509	0.587	0.582	0.550
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.562	0.743	0.787	0.802	0.791	0.419	0.621	0.679	0.680	0.658
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.635	0.764	0.799	0.802	0.791	0.708	0.811	0.834	0.845	0.840

Table B15

Screening 2	High Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.631	0.631	0.631	0.636	0.675	0.631	0.631	0.631	0.636	0.677
Existing, E	0.631	0.631	0.631	0.636	0.675	0.631	0.631	0.631	0.636	0.677
Existing, E, B1 MGR	0.631	0.631	0.631	0.636	0.675	0.631	0.631	0.631	0.636	0.677
E, B1 MGR, B1 JBS/STS	0.637	0.637	0.637	0.642	0.680	0.637	0.637	0.637	0.642	0.683
E, B1 MGR, B1 JBS/ESBS	0.699	0.699	0.699	0.703	0.722	0.699	0.699	0.699	0.704	0.743
E, B1 MGR, B1 SC	0.722	0.722	0.722	0.725	0.738	0.722	0.722	0.722	0.728	0.765
E, B1 MGR, B2 FGE	0.666	0.666	0.666	0.670	0.709	0.666	0.666	0.666	0.670	0.702
E, B1 MGR, B2 CC	0.701	0.701	0.701	0.705	0.743	0.701	0.701	0.701	0.703	0.728
E, B1 MGR, B2 FGE, B2 CC	0.720	0.720	0.720	0.723	0.761	0.720	0.720	0.720	0.722	0.742
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.788	0.788	0.788	0.790	0.808	0.788	0.788	0.788	0.790	0.808
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.811	0.811	0.811	0.813	0.824	0.811	0.811	0.811	0.813	0.830
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.742	0.742	0.742	0.745	0.794	0.742	0.742	0.742	0.745	0.768
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.704	0.704	0.704	0.708	0.745	0.704	0.704	0.704	0.707	0.732
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.634	0.634	0.634	0.639	0.678	0.634	0.634	0.634	0.639	0.680
Existing, E	0.634	0.634	0.634	0.639	0.678	0.634	0.634	0.634	0.639	0.680
Existing, E, B1 MGR	0.634	0.634	0.634	0.639	0.678	0.634	0.634	0.634	0.639	0.680
E, B1 MGR, B1 JBS/STS	0.641	0.641	0.641	0.646	0.682	0.641	0.641	0.641	0.646	0.686
E, B1 MGR, B1 JBS/ESBS	0.723	0.723	0.723	0.727	0.739	0.723	0.723	0.723	0.729	0.767
E, B1 MGR, B1 SC	0.715	0.715	0.715	0.718	0.733	0.715	0.715	0.715	0.720	0.758
E, B1 MGR, B2 FGE	0.669	0.669	0.669	0.674	0.712	0.669	0.669	0.669	0.673	0.706
E, B1 MGR, B2 CC	0.728	0.728	0.728	0.732	0.768	0.728	0.728	0.728	0.730	0.749
E, B1 MGR, B2 FGE, B2 CC	0.742	0.742	0.742	0.745	0.781	0.742	0.742	0.742	0.743	0.759
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.831	0.831	0.831	0.832	0.843	0.831	0.831	0.831	0.833	0.845
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.822	0.822	0.822	0.824	0.837	0.822	0.822	0.822	0.824	0.837
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.195	0.433	0.496	0.522	0.473	0.184	0.383	0.431	0.423	0.364
Existing, E	0.195	0.433	0.496	0.522	0.473	0.184	0.383	0.431	0.423	0.364
Existing, E, B1 MGR	0.195	0.433	0.496	0.522	0.473	0.184	0.383	0.431	0.423	0.364
E, B1 MGR, B1 JBS/STS	0.200	0.435	0.497	0.522	0.473	0.191	0.389	0.436	0.431	0.372
E, B1 MGR, B1 JBS/ESBS	0.291	0.474	0.519	0.522	0.473	0.299	0.485	0.535	0.561	0.524
E, B1 MGR, B1 SC	0.453	0.545	0.557	0.522	0.473	0.492	0.656	0.711	0.793	0.797
E, B1 MGR, B2 FGE	0.259	0.487	0.551	0.586	0.544	0.239	0.413	0.451	0.427	0.364
E, B1 MGR, B2 CC	0.374	0.587	0.651	0.701	0.674	0.339	0.467	0.489	0.433	0.364
E, B1 MGR, B2 FGE, B2 CC	0.407	0.616	0.680	0.734	0.712	0.368	0.483	0.500	0.434	0.364
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.503	0.658	0.703	0.734	0.712	0.482	0.584	0.604	0.572	0.524
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.665	0.729	0.742	0.734	0.712	0.676	0.756	0.780	0.804	0.797

Table B16

Screening 2	Medium Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.561	0.561	0.617	0.708	0.765	0.563	0.563	0.621	0.714	0.770
Existing, E	0.561	0.561	0.617	0.708	0.765	0.563	0.563	0.621	0.714	0.770
Existing, E, B1 MGR	0.561	0.561	0.617	0.708	0.765	0.563	0.563	0.621	0.714	0.770
E, B1 MGR, B1 JBS/STS	0.567	0.567	0.621	0.708	0.765	0.572	0.572	0.629	0.721	0.777
E, B1 MGR, B1 JBS/ESBS	0.629	0.629	0.662	0.709	0.765	0.663	0.663	0.715	0.797	0.845
E, B1 MGR, B1 SC	0.652	0.652	0.676	0.710	0.765	0.697	0.697	0.747	0.825	0.871
E, B1 MGR, B2 FGE	0.612	0.612	0.665	0.753	0.798	0.600	0.600	0.647	0.725	0.771
E, B1 MGR, B2 CC	0.662	0.662	0.713	0.798	0.830	0.637	0.637	0.674	0.735	0.773
E, B1 MGR, B2 FGE, B2 CC	0.689	0.689	0.738	0.822	0.848	0.658	0.658	0.688	0.741	0.773
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.757	0.757	0.783	0.824	0.848	0.757	0.757	0.783	0.824	0.849
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.780	0.780	0.797	0.824	0.848	0.791	0.791	0.815	0.852	0.874
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.735	0.735	0.772	0.800	0.830	0.698	0.698	0.731	0.786	0.818
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.666	0.666	0.715	0.798	0.830	0.643	0.643	0.679	0.740	0.777
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.564	0.564	0.620	0.708	0.765	0.568	0.568	0.626	0.718	0.774
Existing, E	0.564	0.564	0.620	0.708	0.765	0.568	0.568	0.626	0.718	0.774
Existing, E, B1 MGR	0.564	0.564	0.620	0.708	0.765	0.568	0.568	0.626	0.718	0.774
E, B1 MGR, B1 JBS/STS	0.571	0.571	0.624	0.708	0.765	0.577	0.577	0.634	0.726	0.781
E, B1 MGR, B1 JBS/ESBS	0.653	0.653	0.677	0.710	0.765	0.699	0.699	0.749	0.827	0.872
E, B1 MGR, B1 SC	0.645	0.645	0.672	0.710	0.765	0.686	0.686	0.738	0.817	0.863
E, B1 MGR, B2 FGE	0.615	0.615	0.667	0.753	0.798	0.606	0.606	0.652	0.729	0.775
E, B1 MGR, B2 CC	0.701	0.701	0.748	0.829	0.853	0.668	0.668	0.697	0.746	0.777
E, B1 MGR, B2 FGE, B2 CC	0.720	0.720	0.766	0.847	0.866	0.683	0.683	0.707	0.750	0.778
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.809	0.809	0.824	0.848	0.866	0.813	0.813	0.831	0.859	0.876
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.800	0.800	0.818	0.848	0.866	0.801	0.801	0.819	0.849	0.867
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.230	0.549	0.625	0.644	0.619	0.155	0.449	0.534	0.555	0.527
Existing, E	0.230	0.549	0.625	0.644	0.619	0.155	0.449	0.534	0.555	0.527
Existing, E, B1 MGR	0.230	0.549	0.625	0.644	0.619	0.155	0.449	0.534	0.555	0.527
E, B1 MGR, B1 JBS/STS	0.232	0.549	0.625	0.644	0.619	0.164	0.456	0.540	0.560	0.533
E, B1 MGR, B1 JBS/ESBS	0.265	0.549	0.625	0.644	0.619	0.320	0.585	0.645	0.660	0.640
E, B1 MGR, B1 SC	0.325	0.549	0.625	0.644	0.619	0.601	0.815	0.833	0.837	0.832
E, B1 MGR, B2 FGE	0.322	0.608	0.672	0.687	0.667	0.186	0.449	0.534	0.555	0.527
E, B1 MGR, B2 CC	0.488	0.715	0.757	0.767	0.754	0.243	0.449	0.534	0.555	0.527
E, B1 MGR, B2 FGE, B2 CC	0.536	0.747	0.781	0.790	0.779	0.259	0.449	0.534	0.555	0.527
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.571	0.747	0.781	0.790	0.779	0.425	0.585	0.645	0.660	0.640
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.630	0.747	0.781	0.790	0.779	0.705	0.815	0.833	0.837	0.832

Table B17

Screening 2	Low Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.434	0.608	0.690	0.823	0.902	0.441	0.618	0.698	0.826	0.903
Existing, E	0.434	0.608	0.690	0.823	0.902	0.441	0.618	0.698	0.826	0.903
Existing, E, B1 MGR	0.434	0.608	0.690	0.823	0.902	0.441	0.618	0.698	0.826	0.903
E, B1 MGR, B1 JBS/STS	0.440	0.608	0.690	0.823	0.902	0.455	0.629	0.708	0.830	0.903
E, B1 MGR, B1 JBS/ESBS	0.500	0.608	0.690	0.823	0.902	0.599	0.751	0.811	0.874	0.909
E, B1 MGR, B1 SC	0.523	0.608	0.690	0.823	0.902	0.652	0.796	0.849	0.890	0.911
E, B1 MGR, B2 FGE	0.514	0.676	0.740	0.843	0.905	0.481	0.629	0.700	0.826	0.903
E, B1 MGR, B2 CC	0.593	0.743	0.789	0.863	0.907	0.522	0.640	0.702	0.826	0.903
E, B1 MGR, B2 FGE, B2 CC	0.635	0.780	0.816	0.874	0.909	0.544	0.647	0.703	0.826	0.903
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.702	0.780	0.816	0.874	0.909	0.702	0.780	0.816	0.874	0.909
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.724	0.780	0.816	0.874	0.909	0.755	0.825	0.854	0.890	0.911
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.681	0.743	0.789	0.863	0.907	0.618	0.722	0.771	0.878	0.911
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.596	0.743	0.789	0.863	0.907	0.531	0.648	0.708	0.829	0.903
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.438	0.608	0.690	0.823	0.902	0.449	0.624	0.704	0.828	0.903
Existing, E	0.438	0.608	0.690	0.823	0.902	0.449	0.624	0.704	0.828	0.903
Existing, E, B1 MGR	0.438	0.608	0.690	0.823	0.902	0.449	0.624	0.704	0.828	0.903
E, B1 MGR, B1 JBS/STS	0.444	0.608	0.690	0.823	0.902	0.463	0.637	0.714	0.833	0.903
E, B1 MGR, B1 JBS/ESBS	0.524	0.608	0.690	0.823	0.902	0.656	0.799	0.852	0.891	0.911
E, B1 MGR, B1 SC	0.516	0.608	0.690	0.823	0.902	0.636	0.782	0.837	0.885	0.910
E, B1 MGR, B2 FGE	0.517	0.676	0.740	0.843	0.905	0.489	0.636	0.706	0.828	0.903
E, B1 MGR, B2 CC	0.651	0.790	0.823	0.877	0.909	0.558	0.655	0.709	0.828	0.903
E, B1 MGR, B2 FGE, B2 CC	0.681	0.816	0.842	0.884	0.910	0.574	0.660	0.710	0.828	0.903
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.768	0.816	0.842	0.884	0.910	0.781	0.834	0.858	0.891	0.911
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.760	0.816	0.842	0.884	0.910	0.761	0.818	0.843	0.885	0.910
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.251	0.688	0.799	0.815	0.815	0.116	0.604	0.729	0.751	0.751
Existing, E	0.251	0.688	0.799	0.815	0.815	0.116	0.604	0.729	0.751	0.751
Existing, E, B1 MGR	0.251	0.688	0.799	0.815	0.815	0.116	0.604	0.729	0.751	0.751
E, B1 MGR, B1 JBS/STS	0.251	0.688	0.799	0.815	0.815	0.128	0.609	0.732	0.753	0.753
E, B1 MGR, B1 JBS/ESBS	0.251	0.688	0.799	0.815	0.815	0.349	0.694	0.783	0.798	0.798
E, B1 MGR, B1 SC	0.251	0.688	0.799	0.815	0.815	0.744	0.848	0.874	0.879	0.879
E, B1 MGR, B2 FGE	0.358	0.724	0.818	0.831	0.831	0.116	0.604	0.729	0.751	0.751
E, B1 MGR, B2 CC	0.553	0.791	0.851	0.860	0.860	0.116	0.604	0.729	0.751	0.751
E, B1 MGR, B2 FGE, B2 CC	0.610	0.810	0.861	0.869	0.869	0.116	0.604	0.729	0.751	0.751
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.610	0.810	0.861	0.869	0.869	0.349	0.694	0.783	0.798	0.798
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.610	0.810	0.861	0.869	0.869	0.744	0.848	0.874	0.879	0.879

Table B18

APPENDIX B

Screening 2	Weighted Average Flow Year									
Spring and Summer Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.544	0.596	0.643	0.721	0.779	0.547	0.600	0.647	0.724	0.782
Existing, E	0.544	0.596	0.643	0.721	0.779	0.547	0.600	0.647	0.724	0.782
Existing, E, B1 MGR	0.544	0.596	0.643	0.721	0.779	0.547	0.600	0.647	0.724	0.782
E, B1 MGR, B1 JBS/STS	0.550	0.600	0.646	0.723	0.780	0.556	0.609	0.655	0.730	0.786
E, B1 MGR, B1 JBS/ESBS	0.611	0.644	0.681	0.741	0.793	0.654	0.700	0.739	0.792	0.833
E, B1 MGR, B1 SC	0.634	0.660	0.694	0.748	0.798	0.691	0.734	0.770	0.815	0.851
E, B1 MGR, B2 FGE	0.598	0.647	0.688	0.755	0.803	0.584	0.629	0.669	0.739	0.790
E, B1 MGR, B2 CC	0.653	0.698	0.732	0.789	0.827	0.622	0.657	0.690	0.753	0.798
E, B1 MGR, B2 FGE, B2 CC	0.682	0.726	0.756	0.808	0.840	0.642	0.673	0.702	0.760	0.803
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.750	0.773	0.794	0.828	0.854	0.750	0.773	0.794	0.829	0.854
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.773	0.789	0.807	0.835	0.859	0.786	0.807	0.825	0.852	0.872
E, B1 MGR, B2 FGE, B2 CC, B1 PSC	0.721	0.740	0.768	0.802	0.842	0.687	0.718	0.746	0.801	0.831
E, B1 MGR, B2 FGE, B2 CC, B1 SSC	0.657	0.701	0.734	0.791	0.828	0.628	0.663	0.695	0.756	0.801
Steelhead										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.547	0.598	0.645	0.722	0.780	0.552	0.605	0.652	0.728	0.784
Existing, E	0.547	0.598	0.645	0.722	0.780	0.552	0.605	0.652	0.728	0.784
Existing, E, B1 MGR	0.547	0.598	0.645	0.722	0.780	0.552	0.605	0.652	0.728	0.784
E, B1 MGR, B1 JBS/STS	0.553	0.603	0.649	0.724	0.781	0.562	0.614	0.660	0.734	0.789
E, B1 MGR, B1 JBS/ESBS	0.635	0.661	0.695	0.749	0.798	0.693	0.736	0.772	0.817	0.852
E, B1 MGR, B1 SC	0.627	0.655	0.690	0.746	0.797	0.680	0.724	0.761	0.808	0.846
E, B1 MGR, B2 FGE	0.602	0.650	0.690	0.756	0.804	0.590	0.634	0.673	0.742	0.793
E, B1 MGR, B2 CC	0.694	0.736	0.765	0.814	0.845	0.653	0.682	0.710	0.766	0.807
E, B1 MGR, B2 FGE, B2 CC	0.715	0.755	0.782	0.827	0.854	0.668	0.693	0.718	0.772	0.810
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.803	0.817	0.831	0.854	0.872	0.809	0.825	0.839	0.861	0.877
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.795	0.812	0.827	0.852	0.870	0.795	0.812	0.827	0.852	0.871
Fall Chinook										
Conditions	**B2/Q=0**	**B2/Q=50**	**B2/Q=75**	**B2/Q=120**	**B2/Q=150**	**B1/Q=0**	**B1/Q=50**	**B1/Q=75**	**B1/Q=120**	**B1/Q=150**
Existing, E=1	0.226	0.556	0.638	0.659	0.634	0.152	0.476	0.562	0.574	0.545
Existing, E	0.226	0.556	0.638	0.659	0.634	0.152	0.476	0.562	0.574	0.545
Existing, E, B1 MGR	0.226	0.556	0.638	0.659	0.634	0.152	0.476	0.562	0.574	0.545
E, B1 MGR, B1 JBS/STS	0.228	0.556	0.639	0.659	0.634	0.161	0.482	0.567	0.579	0.551
E, B1 MGR, B1 JBS/ESBS	0.269	0.568	0.645	0.659	0.634	0.322	0.587	0.653	0.671	0.653
E, B1 MGR, B1 SC	0.341	0.589	0.657	0.659	0.634	0.611	0.777	0.809	0.837	0.835
E, B1 MGR, B2 FGE	0.314	0.607	0.679	0.700	0.679	0.181	0.485	0.568	0.575	0.545
E, B1 MGR, B2 CC	0.473	0.699	0.753	0.775	0.762	0.233	0.501	0.579	0.577	0.545
E, B1 MGR, B2 FGE, B2 CC	0.520	0.726	0.775	0.797	0.786	0.249	0.506	0.582	0.577	0.545
E, B1 MGR, B2 FGE, B2 CC, B1 JBS/ESBS	0.562	0.739	0.782	0.797	0.786	0.419	0.617	0.674	0.675	0.653
E, B1 MGR, B2 FGE, B2 CC, B1 SC	0.635	0.760	0.793	0.797	0.786	0.708	0.807	0.829	0.840	0.835

Table B19

Alternative	Priority	Spill	Screening 1	Screening 2	Survival	FPE	Annualize Cost (excluding Power)	Power Cost	net
B2 FGE & CC, B1 SC	B1	150	0.878	0.872	0.977	0.961	$11,504	-$33,700	-$45,204
B2 FGE & CC, B1 SC	B2	150	0.867	0.860	0.976	0.945	$11,504	-$33,900	-$45,404
B2 FGE & CC, B1 SC	B1	120	0.857	0.852	0.976	0.942	$11,504	-$24,800	-$36,304
B2 FGE & CC, B1 JBS/ESBS	B1	150	0.861	0.855	0.976	0.939	$8,347	-$19,500	-$27,847
B2 FGE & CC, B1 JBS/ESBS	B2	150	0.861	0.855	0.975	0.939	$8,347	-$19,700	-$28,047
B1 SC	B1	150	0.855	0.849	0.974	0.938	$9,170	-$33,700	-$42,870
B2 FGE & CC, B1 SC	B2	120	0.842	0.837	0.974	0.922	$11,504	-$25,100	-$36,604
B2 FGE & CC, B1 SC	B1	75	0.830	0.827	0.974	0.917	$11,504	-$8,700	-$20,204
B1 JBS/ESBS	B1	150	0.839	0.832	0.974	0.916	$6,013	-$19,500	-$25,513
B2 FGE & CC, B1 JBS/ESBS	B1	120	0.835	0.829	0.974	0.913	$8,347	-$10,600	-$18,947
B2 FGE & CC	B2	150	0.846	0.839	0.973	0.925	$2,334	-$19,700	-$22,034
B2 FGE & CC, B1 JBS/ESBS	B2	120	0.834	0.829	0.973	0.913	$8,347	-$10,900	-$19,247
B1 SC	B1	120	0.820	0.814	0.973	0.901	$9,170	-$24,800	-$33,970
B2 FGE & CC, B1 SC	B1	50	0.812	0.809	0.973	0.899	$11,504	-$200	-$11,704
B2 CC	B2	150	0.833	0.827	0.972	0.911	$1,539	-$19,700	-$21,239
B2 FGE & CC, B1 SC	B2	75	0.812	0.808	0.972	0.894	$11,504	-$8,900	-$20,404
B2 FGE & CC	B2	120	0.812	0.806	0.970	0.893	$2,334	-$10,900	-$13,234
B2 FGE	B2	150	0.810	0.804	0.970	0.884	$795	-$19,700	-$20,495
B1 SC	B2	150	0.808	0.802	0.970	0.877	$9,170	-$33,900	-$43,070
B1 JBS/ESBS	B2	150	0.803	0.796	0.970	0.871	$6,013	-$19,700	-$25,713
B2 FGE & CC	B1	150	0.812	0.806	0.968	0.887	$2,334	-$19,500	-$21,834
B2 CC	B1	150	0.807	0.801	0.968	0.882	$9,170	-$19,500	-$28,670

Table B20

Alternative	Priority	Spill	Screening 1	Screening 2	Survival	FPE	Annualize Cost (excluding Power)	Power Cost	net
B2 FGE & CC, B1 JBS/ESBS	B1	150	0.884	0.877	0.978	0.965	$8,347	-$19,500	-$27,847
B2 FGE & CC, B1 SC	B1	150	0.878	0.871	0.977	0.960	$11,504	-$33,700	-$45,204
B2 FGE & CC, B1 JBS/ESBS	B2	150	0.879	0.873	0.977	0.959	$8,347	-$19,700	-$28,047
B2 FGE & CC, B1 SC	B2	150	0.877	0.871	0.977	0.958	$11,504	-$33,900	-$45,404
B2 FGE & CC, B1 JBS/ESBS	B1	120	0.866	0.861	0.977	0.948	$8,347	-$10,600	-$18,947
B2 FGE & CC, B1 JBS/ESBS	B2	120	0.860	0.855	0.976	0.942	$8,347	-$10,900	-$19,247
B2 FGE & CC, B1 SC	B1	120	0.858	0.853	0.976	0.942	$11,504	-$24,800	-$36,304
B2 FGE & CC, B1 SC	B2	120	0.857	0.852	0.975	0.940	$11,504	-$25,100	-$36,604
B1 JBS/ESBS	B1	150	0.856	0.850	0.975	0.936	$6,013	-$19,500	-$25,513
B1 SC	B1	150	0.850	0.844	0.975	0.932	$9,170	-$33,700	-$42,870
B2 FGE & CC, B1 JBS/ESBS	B1	75	0.844	0.840	0.975	0.927	$8,347	$5,500	-$2,847
B2 FGE & CC, B1 SC	B1	75	0.832	0.828	0.975	0.919	$11,504	-$8,700	-$20,204
B2 FGE & CC	B2	150	0.859	0.852	0.974	0.940	$2,334	-$19,700	-$22,034
B2 FGE & CC, B1 JBS/ESBS	B2	75	0.836	0.832	0.974	0.920	$8,347	$5,300	-$3,047
B2 FGE & CC, B1 SC	B2	75	0.831	0.828	0.974	0.916	$11,504	-$8,900	-$20,404
B2 FGE & CC, B1 JBS/ESBS	B1	50	0.829	0.826	0.974	0.913	$8,347	$14,000	$5,653
B2 CC	B2	150	0.850	0.844	0.973	0.930	$1,539	-$19,700	-$21,239
B2 FGE & CC, B1 JBS/ESBS	B2	50	0.822	0.818	0.973	0.906	$8,347	$13,900	$5,553
B2 FGE & CC, B1 SC	B1	50	0.816	0.813	0.973	0.904	$11,504	-$200	-$11,704
B2 FGE & CC, B1 SC	B2	50	0.816	0.813	0.973	0.902	$11,504	-$28,100	-$39,604
B1 JBS/ESBS	B1	120	0.821	0.816	0.973	0.899	$6,013	-$10,600	-$16,613
B2 FGE & CC, B1 JBS/ESBS	B1	0	0.810	0.808	0.973	0.897	$8,347	$28,600	$20,253
B2 FGE & CC	B2	120	0.831	0.825	0.972	0.914	$2,334	-$10,900	-$13,234
B1 SC	B1	120	0.813	0.807	0.972	0.893	$9,170	-$24,800	-$33,970
B2 FGE & CC, B1 JBS/ESBS	B2	0	0.804	0.802	0.972	0.892	$8,347	$28,500	$20,153
B2 CC	B2	120	0.818	0.813	0.971	0.900	$1,539	-$10,900	-$12,439
B2 FGE	B2	150	0.811	0.805	0.970	0.885	$795	-$19,700	-$20,495
B1 SC	B2	150	0.806	0.800	0.970	0.878	$9,170	-$33,900	-$43,070
B1 JBS/ESBS	B2	150	0.808	0.802	0.970	0.877	$6,013	-$19,700	-$25,713
B2 FGE & CC	B1	150	0.820	0.813	0.968	0.895	$2,334	-$19,500	-$21,834
B2 CC	B1	150	0.816	0.810	0.968	0.892	$1,539	-$19,500	-$21,039
B2 FGE	B1	150	0.801	0.795	0.967	0.876	$795	-$19,500	-$20,295

Table B21

Alternative	Priority	Spill	Screening 1	Screening 2	Survival	FPE	Annualize Cost (excluding Power)	Power Cost	net
B2 FGE & CC B1 SC	B1	120	0.845	0.840	0.976	0.930	$11,504	-$24,800	-$36,304
B1 SC	B1	120	0.842	0.837	0.976	0.927	$9,170	-$24,800	-$33,970
B1 SC	B1	150	0.841	0.836	0.976	0.926	$9,170	-$33,700	-$42,870
B2 FGE & CC B1 SC	B1	150	0.841	0.836	0.976	0.926	$11,504	-$33,700	-$45,204
B2 FGE & CC B1 SC	B1	75	0.834	0.829	0.975	0.919	$11,504	-$8,700	-$20,204
B1 SC	B1	75	0.811	0.806	0.975	0.896	$9,170	-$8,700	-$17,870
B2 FGE & CC	B2	120	0.803	0.798	0.975	0.878	$2,334	-$25,100	-$27,434
B2 FGE & CC B1 JBS/ESBS	B2	120	0.803	0.798	0.975	0.878	$8,347	-$25,100	-$33,447
B2 FGE & CC B1 SC	B2	120	0.803	0.798	0.975	0.878	$11,504	-$25,100	-$36,604
B2 FGE & CC B1 SC	B2	75	0.800	0.795	0.975	0.875	$11,504	-$8,900	-$20,404
B2 FGE & CC B1 SC	B1	50	0.810	0.806	0.974	0.897	$11,504	-$200	-$11,704

Table B22

APPPENDIX C

LIST OF REFERENCES

APPENDIX C

LIST OF REFERENCES

BIOP 2000	2000 FCRPS Biological Opinion, National Marine Fisheries Service, December 21st, 2000.
Johnson	Monitoring and Evaluation of the Prototype Surface Collector at Bonneville First Powerhouse in 2000: Synthesis of Results, PNNL – 13516, June 2001.
Ploskey 2000	Hydroacoustic Evaluation of Fish Passage Through Bonneville Dam in 2000, USACE, Waterways Experiment Station, Draft Technical Report, December 2000.
Fast Track	Bonneville Spillway Flow Deflectors and Gate Hoist, Bonneville Lock and Dam, Design Document Report No. 46, USACE, May 20, 2001.
B1 PSC	Bonneville First Powerhouse Deep Slot Surface Collector Prototype Alternatives Study, HARZA, January 2001.
B1 JBS	Supplement No. 2 to Design Memorandum No. 37, Bonneville Lock & Dam, Bonneville First Powerhouse Juvenile Bypass System Improvements, January 15th, 1999.
B1 ESBS	Interim Status Report, Bonneville First Powerhouse, Fish Guidance Efficiency Improvements, FGE, December 1999.
B2 CC	Bonneville Second Powerhouse High Flow Outfall Bypass System 90% Design Document Report (DDR), Bonneville Lock and Dam, USACE, September 2001.
B2 JBS Decision Document	Bonneville Fish Mitigation Plan and Columbia River Salmon Mitigation Program Bonneville Lock and Dam Juvenile Bypass System Improvements Evaluation Paper.
Fish Passage Plan 2000	Fish Passage Plan for Corps of Engineers Project, USACE, Northwestern Division, Portland, Oregon, February 2001.
Draft TMDL	Preliminary Draft Columbia River Total Maximum Daily Load (TMDL) for Total Dissolved Gas, Oregon Department of Environmental Quality, July 2001.

APPPENDIX D

POWER ANALYSIS

APPENDIX D

POWER ANALYSIS

BONNEVILLE DECISION DOCUMENT STUDY

AN ANALYSIS OF HYDROPOWER IMPACTS DUE TO FISH BYPASS MEASURES

1 PURPOSE

The purpose of this study is to determine the impacts to hydropower generation and the associated cost of the reduced hydropower generation at Bonneville First Powerhouse due to the alternatives of 1) placing extended submersible bar screens (ESBS) in the turbine intakes, and 2) placing a powerhouse surface collector (PSC) in front of the turbine intakes. The base case consists of the existing condition, where submersible traveling screens (STS's) are installed in the turbine intakes. The ESBS's, PSC, and STS's aid in diverting fish away from the turbine intakes so they do not pass through the turbines. Results of this study will be used in the Bonneville Decision Document study that is being prepared by the Corps of Engineers, Portland District.

2 SCOPE OF WORK

The Hydropower Analysis Center's (HAC), Northwestern Division, task was to develop Hydropower Allocation (HALLO) computer modeling data to determine the hydropower impacts due to installation of the ESBS's and the PSC. Hydro System Seasonal Regulation (HYSSR) computer model data was collected to provide input to the HALLO generation model. A base case and 13 alternatives were studied. An estimate of the economic impacts due to the alternatives for energy generation and capacity has been prepared. Unit performance data was provided by the Hydroelectric Design Center (HDC). A report of the findings has been prepared. Results of this study for the PSC alternative is intended as a feasibility level estimate of the economic impacts because the unit performance data is estimated based on the PSC prototype test structure, which does not fully represent the final PSC configuration.

3 COORDINATION

The Portland District requested the HAC to prepare an evaluation of the hydropower economic impacts due to operating with ESBS's and a PSC at the Bonneville Dam Project. This study will be used as part of the Bonneville Decision Document Study led by the Portland District. The scope of work and determination of alternatives to be studied were coordinated with the Portland District: Laurie Ebner, Hydraulic Engineer; Doug Clarke, Project Manager, Ed Woodruff, Chief of Economics, Varis Ratniecks, HDC; Rod Wittinger, HDC; and Dan Ramirez, HDC. The report was prepared by Patti Etzel of the HAC. The report was reviewed by Kamau Sadiki, of the HAC. Results of this report will be provided to Phil Thor and Mike Berger of the Bonneville Power Administration.

4 ALTERNATIVES

One Base Case and 13 alternatives were developed. Descriptions of the alternatives are as follows:

4.1 BASE CASE

The Base Case consists of 20 foot-long STS's in the turbine intakes that are located at the bulkhead slots of the first powerhouse. The STS's are located in each of the three bays of the turbine intakes. The STS's are in place March through November, and are removed December through February. Spill for fish is 120,000 cubic feet per second (cfs) at night and 75,000 cfs during the day. Day and night time spill hours are as stated in the Corps of Engineers, Northwestern Division, February 2000 Fish Passage Plan. Unit loading priorities are as stated in the Fish Passage Plan

4.2 ALTERNATIVE 1

Alternative 1 is the same as the base case except ESBS's will be used instead of the STS's. ESBS's are 40 foot-long screens and are in the same location as the STS's.

4.3 ALTERNATIVE 2

Alternative 2 consists of a PSC located in front of the first powerhouse and is in place year-round. A flow of 15,000 cfs enters slots in the front of the box and provides attraction flow for fish during March through November. This flow is unavailable for generation. During December through February, there is no flow entering the PSC. Spill for fish is the same as in the base case.

4.4 ALTERNATIVE 3

Alternative 3 is the same as Alternative 2, except that there is no spill for fish.

4.5 ALTERNATIVE 4

Alternative 4 is similar to the Base Case, except that there is no spill for fish, and instead of following the unit loading order from the Fish Passage Plan, the first powerhouse generating units are always loaded before any of the units in the second powerhouse.

4.6 ALTERNATIVE 5.

Alternative 5 is similar to Alternative 4, except that fish spill is included and is limited to 50,000 cfs during the spill months, rather than the spill levels specified in the fish passage plan, and used in the Base Case.

4.7 ALTERNATIVE 6

Alternative 6 is similar to Alternative 5, except that the fish spill is limited to 75,000 cfs during the spill months.

4.8 ALTERNATIVE 7

Alternative 7 is similar to Alternative 5, except that the fish spill is limited to 120,000 cfs during the spill months.

4.9 ALTERNATIVE 8.

Alternative 8 is similar to Alternative 5, except that the fish spill is limited to 150,000 cfs during the spill months.

4.10 ALTERNATIVE 9

Alternative 9 is similar to Alternative 4, except that instead of loading the first powerhouse generating units first, the second powerhouse generating units are always loaded before any of the units in the first powerhouse.

4.11 ALTERNATIVE 10

Alternative 10 is similar to Alternative 9, except that the fish spill is included and is limited to 50,000 cfs during the spill months, rather than the spill levels specified in the fish passage plan, and used in the Base Case.

4.12 ALTERNATIVE 11

Alternative 11 is similar to Alternative 9, except that the fish spill is limited to 75,000 cfs during the spill months.

4.13 ALTERNATIVE 12

Alternative 12 is similar to Alternative 9, except that the fish spill is limited to 120,000 cfs during the spill months.

4.14 ALTERNATIVE 13

Alternative 13 is similar to Alternative 9, except that the fish spill is limited to 150,000 cfs during the spill months.

5 ENERGY VALUE DETERMINATION

Monthly unit energy values ($/MWh) were previously developed for the Corps of Engineers for the John Day Drawdown Study (Corps of Engineers, Portland District, February 2000). The energy values were prepared by Henwood Energy Services, Inc. (HESI) of Sacramento, CA, using the model, PROSYM. The data was prepared under contract with the HAC. The data was prepared for the years 2000, 2005, 2010, 2015, and 2020 in the John Day study, but only the years 2005 through 2020 were used in this study. These monthly unit energy values were used to develop levelized monthly values discussed in paragraph 5.0.2. For this report, a 42-year economic life with an interest rate of 6.375 % was used to compute the levelized monthly energy value. The interest rate is based on the Federal Water Resource Interest Rate for FY01.

5.1 DEVELOPMENT OF MONTHLY UNIT ENERGY VALUES.

To obtain the unit energy values for the John Day Drawdown Study, a system analysis was performed in which the power system was modeled under two different conditions, a baseline condition that includes the hydropower facility as a generating resource, and an alternative condition that excludes the hydropower facility. The differences in annual power system production costs between the two conditions divided by the average historical annual energy generation of the hydropower project gives the annual unit energy values. In this way, the value of the hydropower is directly measured by the cost of the alternative power required to replace it.

Unit energy values used in this study were calculated from the results of power system modeling previously completed as part of the John Day Drawdown Study. It was believed that these values are reasonable for use in this study, since both Bonneville and

John Day are hydropower facilities that are operated similarly, and are located relatively close to one another within the Pacific Northwest (PNW) electrical transmission subsystem. Although John Day is a flood control storage project and Bonneville is not, due to constraints imposed on the operation of the John Day project, it operates much like a run-of-river project. When it does operate for flood control, the pool will rise for short periods, then drawn back down, which is considered to have an insignificant affect in a monthly model.

For the John Day study, the operation of the regional power system was modeled with and without the John Day generating capacity for the five years of 2000, 2005, 2010, 2015, and 2020. Only the five years were modeled because it has been proven that taking trends between discrete modeled years gives reasonably accurate predictions without having to go through the extra effort of modeling every year. Determination of unit energy values between modeled years was done by interpolation between those years. Years beyond 2020 were not modeled due to the uncertainty associated with forecasting too far into the future, and were assumed to be the same as the year 2020.

The regional power system modeled was the Western Systems Coordinating Council (WSCC), one of nine self-governed regional electric power reliability councils that form the North American Electric Reliability Council (NERC). The WSCC consists of all fourteen states west of the Rocky Mountains, the Canadian provinces of British Columbia and Alberta, and a small portion of Northern Mexico. The PNW subsystem is one of eighteen inter-connected electrical transmission subsystems within the WSCC that is modeled by a power system model called PROSYM. The power system modeling for the John Day study was completed under contract by HESI. HESI is the developer and licenser of PROSYM.

PROSYM is a chronological hourly electricity production cost model that is a more capable refinement of POWRSYM, an older production cost model originally developed and still used by the Tennessee Valley Authority. Basically, the PROSYM model dispatches hydropower and thermal generating resources on an hourly basis to meet the system power loads. It estimates the most cost-effective operation to meet these power loads by first dispatching hydropower resources in the peak power demand periods, and then dispatching the thermal resources in order of increasing energy production cost to meet the residual power loads. Any power load still not satisfied due to a lack of available generating resources is classified as unserved load. In addition, the different transmission subsystems are connected by transmission links to allow for the exchange of energy between the areas with respect to all system constraints. All of this is very similar to an ideal system operation scenario where power dispatchers make the same decisions on a real-time basis.

System production costs, which include variable operating costs (mainly fuel consumption and variable O&M) and fixed operating costs (mainly fixed O&M), are computed for each transmission subsystem and summed to provide the system total. In PROSYM, one load year is analyzed at a time, with the model dispatching generating resources hour-by-hour over one-week periods.

5.2 MONTHLY LEVELIZED UNIT ENERGY VALUES.

Monthly levelized unit energy values were computed for the Bonneville study, and are provided in Table 1. Monthly levelized unit energy values are multiplied by the generation differences between the base case and alternatives to determine the cost of lost hydropower due to the various alternatives. An economic life of n = 42 years was assumed for this study. Half of the ESBS's are scheduled for installation in 2004, and half in 2005. The PSC is expected to be installed in 2012. A life of 35 years starting from the point the PSC is to be installed was used. To make the evaluation comparable, the study was developed for the 42-year period 2005 through 2046, assuming the ESBS's to be installed the entire period. For the PSC alternative, STS's are installed from 2005-2011, and the PSC installed 2012 through 2046. The unit energy values were levelized over the 42-year-period and applied to the generation losses computed from HALLO model output. An interest rate, of I = 6.375 % was used, and is based on the Federal Water Resource Interest Rate for FY01. In Table 1, the numbers in the "Pr. Yr." Column, are the number of the period (year) in the 42-year economic life. The present worth factor is determined by Equation 1.

$$\text{Present Worth Factor} = \text{PW FACT.} = \frac{1}{(1+i)^{\mathrm{Pr}.Yr.}} \qquad \text{(Equation 1)}$$

The values in the "$/MWh" column for the years 2005, 2010, 2015, and 2020 were determined by the PROSYM runs from the John Day Drawdown Study. Values in between these years were interpolated. Values after the year 2020 were assumed to be constant. Present worth values were determined by Equation 2.

$$\text{PW} = \text{Present Worth} = (\$/\text{MWh}) \times \text{PW FACT.} \qquad \text{(Equation 2)}$$

The Levelized Value was determined by Equation 3.

$$\text{Levelized Value} = \left\{ \frac{1}{\left[\frac{(1+i)^n - 1}{i}\right]} + i \right\} \times \sum PW \qquad \text{(Equation 3)}$$

i = INTEREST Water Resource Interest Rate for FY 01

η = Economic life assumed to be 42 years

Pr. Yr. = Number of Period (Years)

In the 50 year life

$/MWh = Value of Energy

The monthly levelized values shown in Table 1 were multiplied by the monthly differences in generation between the base case and the alternatives to determine the economic impacts per month. The monthly differences in generation were determined by the HALLO modeling output discussed in paragraph 7.0.

Table 1a
Monthly Levelized Energy Values

Year	Pr. Yr.	PW Fact.	AUGUST ($/MWh)	AUGUST PW	SEPTEMBER ($/MWh)	SEPTEMBER PW	OCTOBER ($/MWh)	OCTOBER PW	NOVEMBER ($/MWh)	NOVEMBER PW	DECEMBER ($/MWh)	DECEMBER PW	JANUARY ($/MWh)	JANUARY PW
2005	1.00	0.94	45.84	43.09	35.44	33.32	35.76	33.62	34.60	32.53	35.16	33.05	42.31	39.77
2006	2.00	0.88	46.31	40.93	35.05	30.97	35.78	31.62	34.72	30.68	35.55	31.42	42.39	37.46
2007	3.00	0.83	46.78	38.86	34.66	28.79	35.80	29.74	34.84	28.94	35.94	29.86	42.48	35.29
2008	4.00	0.78	47.25	36.90	34.26	26.76	35.81	27.97	34.95	27.30	36.33	28.37	42.56	33.24
2009	5.00	0.73	47.72	35.04	33.87	24.87	35.83	26.31	35.07	25.75	36.72	26.96	42.65	31.31
2010	6.00	0.69	48.19	33.26	33.48	23.11	35.85	24.74	35.19	24.29	37.11	25.61	42.73	29.49
2011	7.00	0.65	47.51	30.83	32.80	21.28	35.33	22.93	35.24	22.87	37.25	24.17	42.18	27.36
2012	8.00	0.61	46.83	28.57	32.12	19.59	34.82	21.24	35.29	21.53	37.40	22.81	41.62	25.39
2013	9.00	0.57	46.16	26.47	31.44	18.03	34.30	19.67	35.35	20.27	37.54	21.53	41.07	23.55
2014	10.00	0.54	45.48	24.51	30.76	16.58	33.79	18.21	35.40	19.08	37.69	20.31	40.51	21.84
2015	11.00	0.51	44.80	22.70	30.08	15.24	33.27	16.86	35.45	17.96	37.83	19.17	39.96	20.25
2016	12.00	0.48	43.50	20.72	29.70	14.15	32.61	15.53	34.73	16.54	37.11	17.68	40.01	19.06
2017	13.00	0.45	42.20	18.90	29.32	13.13	31.94	14.30	34.00	15.23	36.40	16.30	40.06	17.94
2018	14.00	0.42	40.90	17.22	28.93	12.18	31.28	13.17	33.28	14.01	35.68	15.02	40.11	16.88
2019	15.00	0.40	39.60	15.67	28.55	11.30	30.61	12.12	32.55	12.88	34.97	13.84	40.16	15.89
2020	16.00	0.37	38.30	14.25	28.17	10.48	29.95	11.14	31.83	11.84	34.25	12.74	40.21	14.96
2021	17.00	0.35	38.30	13.39	28.17	9.85	29.95	10.47	31.83	11.13	34.25	11.98	40.21	14.06
2022	18.00	0.33	38.30	12.59	28.17	9.26	29.95	9.85	31.83	10.46	34.25	11.26	40.21	13.22
2023	19.00	0.31	38.30	11.84	28.17	8.71	29.95	9.26	31.83	9.84	34.25	10.59	40.21	12.43
2024	20.00	0.29	38.30	11.13	28.17	8.18	29.95	8.70	31.83	9.25	34.25	9.95	40.21	11.68
2025	21.00	0.27	38.30	10.46	28.17	7.69	29.95	8.18	31.83	8.69	34.25	9.35	40.21	10.98
2026	22.00	0.26	38.30	9.83	28.17	7.23	29.95	7.69	31.83	8.17	34.25	8.79	40.21	10.32
2027	23.00	0.24	38.30	9.24	28.17	6.80	29.95	7.23	31.83	7.68	34.25	8.27	40.21	9.71
2028	24.00	0.23	38.30	8.69	28.17	6.39	29.95	6.80	31.83	7.22	34.25	7.77	40.21	9.12
2029	25.00	0.21	38.30	8.17	28.17	6.01	29.95	6.39	31.83	6.79	34.25	7.31	40.21	8.58
2030	26.00	0.20	38.30	7.68	28.17	5.65	29.95	6.01	31.83	6.38	34.25	6.87	40.21	8.06
2031	27.00	0.19	38.30	7.22	28.17	5.31	29.95	5.65	31.83	6.00	34.25	6.46	40.21	7.58
2032	28.00	0.18	38.30	6.79	28.17	4.99	29.95	5.31	31.83	5.64	34.25	6.07	40.21	7.13
2033	29.00	0.17	38.30	6.38	28.17	4.69	29.95	4.99	31.83	5.30	34.25	5.71	40.21	6.70
2034	30.00	0.16	38.30	6.00	28.17	4.41	29.95	4.69	31.83	4.98	34.25	5.36	40.21	6.30
2035	31.00	0.15	38.30	5.64	28.17	4.15	29.95	4.41	31.83	4.69	34.25	5.04	40.21	5.92
2036	32.00	0.14	38.30	5.30	28.17	3.90	29.95	4.15	31.83	4.41	34.25	4.74	40.21	5.57
2037	33.00	0.13	38.30	4.98	28.17	3.67	29.95	3.90	31.83	4.14	34.25	4.46	40.21	5.23
2038	34.00	0.12	38.30	4.68	28.17	3.45	29.95	3.66	31.83	3.89	34.25	4.19	40.21	4.92
2039	35.00	0.11	38.30	4.40	28.17	3.24	29.95	3.44	31.83	3.66	34.25	3.94	40.21	4.62
2040	36.00	0.11	38.30	4.14	28.17	3.04	29.95	3.24	31.83	3.44	34.25	3.70	40.21	4.35
2041	37.00	0.10	38.30	3.89	28.17	2.86	29.95	3.04	31.83	3.23	34.25	3.48	40.21	4.09
2042	38.00	0.10	38.30	3.66	28.17	2.69	29.95	2.86	31.83	3.04	34.25	3.27	40.21	3.84
2043	39.00	0.09	38.30	3.44	28.17	2.53	29.95	2.69	31.83	2.86	34.25	3.08	40.21	3.61
2044	40.00	0.08	38.30	3.23	28.17	2.38	29.95	2.53	31.83	2.69	34.25	2.89	40.21	3.39
2045	41.00	0.08	38.30	3.04	28.17	2.24	29.95	2.38	31.83	2.53	34.25	2.72	40.21	3.19
2046	42.00	0.07	38.30	2.86	28.17	2.10	29.95	2.23	31.83	2.37	34.25	2.56	40.21	3.00
Summation of PW				**626.5**		**451.2**		**478.8**		**490.1**		**518.6**		**597.2**
Levelized Value				**43.17**		**31.08**		**32.99**		**33.77**		**35.73**		**41.15**

Table 1b
Monthly Levelized Energy Values

			FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY	
Year	Pr. Yr.	PW Fact.	($/MWh)	PW	($/MWh)	PW	($/MWh)	PW	($/MWh)	PW	($/MWh)	PW	($/MWh)	PW
2005	1.00	0.94	40.39	37.97	25.40	23.88	18.11	17.02	23.62	22.20	25.53	24.00	34.64	32.56
2006	2.00	0.88	40.36	35.67	25.58	22.61	18.18	16.06	23.68	20.93	25.73	22.74	34.71	30.68
2007	3.00	0.83	40.33	33.51	25.76	21.40	18.25	15.16	23.75	19.73	25.93	21.54	34.79	28.90
2008	4.00	0.78	40.31	31.48	25.95	20.26	18.31	14.30	23.81	18.60	26.12	20.40	34.86	27.23
2009	5.00	0.73	40.28	29.57	26.13	19.18	18.38	13.50	23.88	17.53	26.32	19.33	34.94	25.65
2010	6.00	0.69	40.25	27.78	26.31	18.16	18.45	12.73	23.94	16.52	26.52	18.30	35.01	24.16
2011	7.00	0.65	40.44	26.24	26.20	17.00	18.35	11.91	23.77	15.42	26.62	17.27	35.12	22.79
2012	8.00	0.61	40.64	24.79	26.09	15.91	18.25	11.13	23.60	14.39	26.71	16.29	35.23	21.49
2013	9.00	0.57	40.83	23.41	25.98	14.90	18.16	10.41	23.43	13.43	26.81	15.37	35.33	20.26
2014	10.00	0.54	41.03	22.11	25.87	13.94	18.06	9.73	23.26	12.54	26.90	14.50	35.44	19.10
2015	11.00	0.51	41.22	20.89	25.76	13.05	17.96	9.10	23.09	11.70	27.00	13.68	35.55	18.01
2016	12.00	0.48	40.28	19.19	25.44	12.12	17.63	8.40	23.08	10.99	26.44	12.59	34.85	16.60
2017	13.00	0.45	39.35	17.62	25.12	11.25	17.30	7.75	23.06	10.33	25.88	11.59	34.15	15.29
2018	14.00	0.42	38.41	16.17	24.80	10.44	16.98	7.15	23.05	9.70	25.31	10.66	33.46	14.08
2019	15.00	0.40	37.48	14.83	24.48	9.69	16.65	6.59	23.03	9.12	24.75	9.80	32.76	12.96
2020	16.00	0.37	36.54	13.59	24.16	8.99	16.32	6.07	23.02	8.56	24.19	9.00	32.06	11.93
2021	17.00	0.35	36.54	12.78	24.16	8.45	16.32	5.71	23.02	8.05	24.19	8.46	32.06	11.21
2022	18.00	0.33	36.54	12.01	24.16	7.94	16.32	5.37	23.02	7.57	24.19	7.95	32.06	10.54
2023	19.00	0.31	36.54	11.29	24.16	7.47	16.32	5.04	23.02	7.11	24.19	7.48	32.06	9.91
2024	20.00	0.29	36.54	10.62	24.16	7.02	16.32	4.74	23.02	6.69	24.19	7.03	32.06	9.31
2025	21.00	0.27	36.54	9.98	24.16	6.60	16.32	4.46	23.02	6.29	24.19	6.61	32.06	8.76
2026	22.00	0.26	36.54	9.38	24.16	6.20	16.32	4.19	23.02	5.91	24.19	6.21	32.06	8.23
2027	23.00	0.24	36.54	8.82	24.16	5.83	16.32	3.94	23.02	5.56	24.19	5.84	32.06	7.74
2028	24.00	0.23	36.54	8.29	24.16	5.48	16.32	3.70	23.02	5.22	24.19	5.49	32.06	7.27
2029	25.00	0.21	36.54	7.79	24.16	5.15	16.32	3.48	23.02	4.91	24.19	5.16	32.06	6.84
2030	26.00	0.20	36.54	7.33	24.16	4.84	16.32	3.27	23.02	4.62	24.19	4.85	32.06	6.43
2031	27.00	0.19	36.54	6.89	24.16	4.55	16.32	3.08	23.02	4.34	24.19	4.56	32.06	6.04
2032	28.00	0.18	36.54	6.48	24.16	4.28	16.32	2.89	23.02	4.08	24.19	4.29	32.06	5.68
2033	29.00	0.17	36.54	6.09	24.16	4.02	16.32	2.72	23.02	3.83	24.19	4.03	32.06	5.34
2034	30.00	0.16	36.54	5.72	24.16	3.78	16.32	2.56	23.02	3.61	24.19	3.79	32.06	5.02
2035	31.00	0.15	36.54	5.38	24.16	3.56	16.32	2.40	23.02	3.39	24.19	3.56	32.06	4.72
2036	32.00	0.14	36.54	5.06	24.16	3.34	16.32	2.26	23.02	3.19	24.19	3.35	32.06	4.44
2037	33.00	0.13	36.54	4.75	24.16	3.14	16.32	2.12	23.02	3.00	24.19	3.15	32.06	4.17
2038	34.00	0.12	36.54	4.47	24.16	2.95	16.32	2.00	23.02	2.82	24.19	2.96	32.06	3.92
2039	35.00	0.11	36.54	4.20	24.16	2.78	16.32	1.88	23.02	2.65	24.19	2.78	32.06	3.69
2040	36.00	0.11	36.54	3.95	24.16	2.61	16.32	1.76	23.02	2.49	24.19	2.61	32.06	3.47
2041	37.00	0.10	36.54	3.71	24.16	2.45	16.32	1.66	23.02	2.34	24.19	2.46	32.06	3.26
2042	38.00	0.10	36.54	3.49	24.16	2.31	16.32	1.56	23.02	2.20	24.19	2.31	32.06	3.06
2043	39.00	0.09	36.54	3.28	24.16	2.17	16.32	1.47	23.02	2.07	24.19	2.17	32.06	2.88
2044	40.00	0.08	36.54	3.08	24.16	2.04	16.32	1.38	23.02	1.94	24.19	2.04	32.06	2.71
2045	41.00	0.08	36.54	2.90	24.16	1.92	16.32	1.30	23.02	1.83	24.19	1.92	32.06	2.54
2046	42.00	0.07	36.54	2.73	24.16	1.80	16.32	1.22	23.02	1.72	24.19	1.80	32.06	2.39
SUMMATION OF PW				**565.2**		**365.5**		**253.1**		**339.1**		**369.9**		**491.2**
Levelized Value				**38.94**		**25.18**		**17.44**		**23.36**		**25.48**		**33.84**

6 HYSSR DATA

The HYSSR model was used to determine the flow volumes through the Bonneville project. These flow volumes were used as input to the HALLO modeling studies. HYSSR is a monthly model that simulates the operation of a hydro system as it meets various requirements such as power generation, flood control, fish requirements, navigation, water quality, irrigation, etc. This model was used to simulate the entire Columbia River and its tributaries. The operation scenario used was based on information from the consultations between the Federal Agencies regarding the 2000 National Marine Fisheries Service and U. S. Fish and Wildlife Service Biological Opinions. This operation includes the Pacific Northwest Coordination Agreement (PNCA) Operation Year 99-00 power loads, power rule curves, reservoir refill rule curves, and federal and non-federal project operating constraints.

The model was run in continuous mode using 60 historical water years from August 1928 through July 1988. HYSSR modeling output of regulated flow at Bonneville is provided in Table 2.

7 HALLO MODEL DATA

The HALLO model was used to determine generation values for the Base Case and alternatives. HALLO is a monthly model that takes 60 years of monthly flow data (from HYSSR output) for a specific project and produces generation data given unit performance data, unit loading sequences, tailwater curve, forebay elevation, flow losses, and spill for fish.

7.1 UNIT PERFORMANCE DATA

Unit performance data for minimum gap runners (MGR) in the first powerhouse were obtained from HDC in December, 2000. Unit performance data for the second powerhouse (Units 11-18) was taken from the 1993 Bonneville Major Rehab Study. Equation 4 defines unit output at best gate (PBG), unit output at full gate (PFG), efficiency at best gate (EBG), and efficiency at full gate (EFG):

$$\text{PBG, PFG, EBG, and EFG} = A_2 * H^2 + A_1 * H + A_0 \qquad \text{(Equation 4)}$$

Where H equals gross head in feet, and A_2, A_1, and A_0 are coefficients shown in Table 3.

Units were assumed to be operated within 1% of best efficiency year-round. This guideline applies between March 15 and October 31, but during the rest of the year, the project will continue to operate within this range. Two unit loading sequences were used. The first powerhouse units are numbered 1-10, and the second powerhouse units are numbered 11-18. For the base case and alternatives 1-3, the second powerhouse has priority in loading in the period September through May and the first powerhouse is loaded first in June – August during the fish passage season. The following unit loading sequences were used:

September-May	Units 18, 11, 17, 12-16, 10, 9, 1, 2, 6, 4, 5, 7, 8, 3
June – August	Units 10, 9, 1, 2, 6, 4, 5, 7, 8, 3, 18, 11, 17, 12-16

For alternatives 4-8, the first powerhouse priority loading order was used in all months, and in alternatives 9-13, the second powerhouse priority loading orders was used in all months. No forced outages or derated units were assumed for this analysis. A constant forebay of El. 74.1 was assumed for this analysis.

Table 2

TABOUT.MS5,STCHAR2.OUT NO SPR BONNEVILLE MS5
TARGETS,VARQ REGULATED FLOW - cfs 10/06/00

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE	YEAR
28-29	203596	133485	99796	100708	109253	125405	110469	88287	110809	119709	176072	202291	227155	144179	136232	28-29
29-30	136301	129058	94630	101400	112648	125007	91743	121639	106440	119922	131361	212227	225393	135526	132081	29-30
30-31	144331	120597	94231	101746	109966	126937	94042	90899	106241	151208	123073	220358	184204	150965	129099	30-31
31-32	140922	124409	97696	102825	109638	115481	100249	107529	166218	242234	292599	274638	297783	212441	165382	31-32
32-33	196228	164741	111996	107585	125012	148398	195644	152262	174620	188929	231723	259696	353353	287059	192203	32-33
33-34	210786	208372	136713	131506	153929	259449	316100	201951	226448	351857	420527	331992	208761	150758	226115	33-34
34-35	143674	129631	100630	98482	115648	137738	180109	151244	131623	156621	237254	226541	253198	219373	162348	34-35
35-36	210191	177103	106671	104638	115660	125007	129886	113502	141996	150149	316746	329991	217337	151003	163565	35-36
36-37	142814	131716	99638	102740	117271	124014	106942	90609	107807	115563	144258	188941	230783	156346	132689	36-37
37-38	148561	131891	99299	101121	114080	134366	188594	156154	202716	201780	312736	329203	282700	206919	184386	37-38
38-39	151817	132453	106046	111110	112581	125072	154330	90481	120624	207747	253489	258041	217718	148122	151407	38-39
39-40	144930	130735	98720	105299	119307	125058	114330	119216	177883	221367	276054	245342	227842	142290	155153	39-40
40-41	146593	127112	102074	106081	118525	131268	109578	99360	110429	138369	229788	234588	238019	140753	142634	40-41
41-42	135090	122796	104472	107556	122012	167059	180052	142400	139217	211296	274272	239000	243495	180304	166441	41-42
42-43	165504	141350	104696	108556	118497	152616	197169	202735	203248	342083	424432	289611	317830	242859	206208	42-43
43-44	210577	174980	104303	104958	113812	127427	124978	92219	95017	141253	170562	217608	208402	133176	139216	43-44
44-45	130158	113611	100229	103641	114028	104560	111904	109431	105780	122933	157462	236466	244505	187231	139988	44-45
45-46	148669	130275	97441	95626	109493	133287	189093	167900	197552	230233	309614	351765	248898	217076	184794	45-46
46-47	209142	155503	111656	109181	117736	199655	213493	184947	194943	251561	277161	347775	230508	209515	197174	46-47
47-48	194460	132715	105967	155540	139185	165405	225117	199041	204884	197966	283966	438815	521409	225523	232120	47-48
48-49	208559	195303	120012	116136	115958	126871	171096	151834	223941	256917	314699	340803	272755	172193	191611	48-49
49-50	150683	117876	97911	99095	108622	145509	195409	201364	230450	286723	304894	305143	409755	287940	209274	49-50
50-51	210147	206956	122717	131069	159200	222976	228731	239213	247140	364609	371844	388543	279364	218068	234483	50-51
51-52	212172	178172	113961	144100	125011	166660	206220	173221	179552	301927	382104	399427	260023	200809	208848	51-52
52-53	194269	136962	98497	104776	113602	124914	189752	206041	165426	163756	220912	271375	324779	236842	182830	52-53
53-54	206856	168769	109438	113548	121666	149668	215719	169480	212708	243506	275746	358323	358167	248361	208710	53-54
54-55	222868	207709	164127	126033	129013	152898	202217	123974	126411	179360	189688	223436	298930	294273	186760	54-55
55-56	213468	200158	112723	126071	141534	227173	243891	208309	240895	328368	443899	481803	413620	243213	252681	55-56
56-57	211565	173108	112673	118209	117856	159563	185354	150774	217470	253131	250407	424220	356233	163190	204137	56-57
57-58	160456	123555	98695	105286	112053	132660	187049	204297	185271	228469	277490	402255	256980	165739	187106	57-58
58-59	157552	134064	100572	110678	124984	179036	233689	190700	216619	301927	274123	285852	343288	251436	205891	58-59
59-60	209308	176008	156068	185567	162034	189791	204160	151975	192151	325719	288623	230614	270410	223916	205543	59-60
60-61	205664	153614	103509	110813	124993	129716	211448	213359	219907	240510	207490	309758	371188	183717	198504	60-61
61-62	163103	138860	96185	106028	109890	124942	185227	132376	154761	255910	321371	240715	248890	209271	170659	61-62
62-63	197112	143324	96861	119995	127673	178988	197417	181552	146439	224609	238788	230728	237821	204942	177028	62-63
63-64	194364	145873	106729	101703	110708	124979	197998	131107	149317	215411	212686	228917	428295	266101	185835	63-64
64-65	206080	190780	119813	128607	124415	231139	240794	227566	232155	301927	400340	331373	330803	220986	228101	64-65
65-66	208221	206268	120922	119283	125029	140415	211406	98409	146762	270310	236361	243489	212768	193185	172687	65-66
66-67	198490	126697	97704	102737	111215	147524	213676	186820	179073	191158	190890	259136	437469	223019	192666	66-67
67-68	203130	171553	106464	114154	124327	145052	207838	170444	177184	185099	197507	227477	271470	218131	178432	67-68
68-69	204234	169078	131894	131458	135968	164711	228275	202184	212069	343514	394762	280142	262412	201485	208866	68-69
69-70	150864	117974	94700	111837	108435	128568	232730	162312	151762	191280	191618	233480	303281	181107	169507	69-70
70-71	150370	123599	93590	99284	106797	146801	237896	261005	242905	301927	309656	423810	399687	244764	224943	70-71
71-72	200434	200329	109929	105661	123576	143803	234606	241661	376506	330764	269402	437330	487099	237858	249874	71-72
72-73	206579	208138	119674	114664	116626	155620	153585	93846	111774	124845	184705	226852	227044	134909	151394	72-73
73-74	130464	119855	91884	100345	118569	203140	286683	293898	262264	338729	389055	388891	502725	312388	254153	73-74
74-75	207601	206780	118843	106905	115516	136968	201663	160057	188015	181721	230938	294210	370934	291639	199856	74-75
75-76	189848	165352	114707	124489	150600	254943	229588	197458	221077	336976	336843	385100	282722	238917	226176	75-76
76-77	240584	225300	179025	119950	115086	131960	125018	84786	86696	150159	166123	211080	170042	125832	145047	76-77
77-78	139961	123384	98171	102037	109654	154155	118313	161973	191847	270644	269704	284416	254923	224480	175151	77-78
78-79	181119	143888	126332	108791	113543	127366	160280	121749	140756	188156	237369	284202	220223	141352	159988	78-79
79-80	128445	125583	94229	99934	112526	122722	146188	166482	141680	177620	320234	329449	237997	167387	166211	79-80
80-81	144694	126069	97400	109144	121161	193411	216411	207066	202648	201515	234952	271476	252952	211239	186377	80-81
81-82	202199	190202	106714	108257	117858	154132	211479	240896	277420	310168	304946	335405	399427	283494	228237	81-82
82-83	210775	194212	138234	128391	124923	176672	238911	220035	286173	301927	315368	315190	291049	248697	223285	82-83
83-84	207386	180551	115743	106524	160990	172647	239318	206293	253146	301927	333771	266041	361507	261114	221262	83-84
84-85	194771	150273	114288	109665	126111	156378	192493	115290	142085	289084	294695	282152	215822	146616	172109	84-85
85-86	138525	123065	98069	109851	125083	135138	205483	220911	283754	328463	292140	260386	276768	166870	193617	85-86
86-87	170747	126058	93840	102733	124961	140477	131819	105460	163364	169260	217856	260075	241649	125758	152675	86-87
87-88	127720	111939	91093	100829	110019	122684	108663	95465	104590	123617	142882	231817	237845	147535	133635	87-88
AVE.	179595	153996	109347	112415	121601	152932	186038	162557	181810	232407	268000	293663	292640	202669	186056	AVE.
MED.	194412	142337	104584	107921	117857	144427	196406	162142	179312	226539	274197	277390	266411	208095		

TABLE 3. Unit Performance Coefficients

Units 1-10 Minimum Gap Runner, no Screens			
	A_0	**A_1**	**A_2**
PBG (MW)	4.1816	.35966	.00300
PFG (MW)	-3.0796	.87278	.00139
EBG (%)	75.6369	.54048	-.00436
EFG (%)	67.4726	.76494	-.0063
Units 1-10 Minimum Gap Runner, with STS's			
	A_0	**A_1**	**A_2**
PBG (MW)	4.0407	.34636	.00289
PFG (MW)	-3.0796	.87278	.00139
EBG (%)	75.2334	.53748	-.00434
EFG (%)	66.9791	.75945	-.00625
Units 1-10 Minimum Gap Runner, with ESBS's			
	A_0	**A_1**	**A_2**
PBG (MW)	4.1476	.35612	.00297
PFG (MW)	-3.0796	.87278	.00139
EBG (%)	75.2286	.53755	-.00434
EFG (%)	66.7581	.75699	-.00623
Units 1-10 Minimum Gap Runner, with PSC			
	A_0	**A_1**	**A_2**
PBG (MW)	4.1878	.36166	.00301
PFG (MW)	-3.0796	.87278	.00139
EBG (%)	70.1755	.50177	-.00405
EFG (%)	62.8824	.71386	-.00587
Units 11-18 Data from Bonneville Major Rehab Report.			
	A_0	**A_1**	**A_2**
PBG (MW)	-7.6519	1.09341	.00129
PFG (MW)	-121.1978	6.50091	-.05255
EBG (%)	67.7599	.74905	-.00579
EFG (%)	75.9376	.21663	.00025

Table 4 shows the flow volumes unavailable for power generation due to losses through the project. The 7,300 cfs accounts for leakage, lockages and fish facility losses. The 340 cfs in the March through November accounts for juvenile fish bypass losses, and the 15,000 cfs for Alternative 2 accounts for the flow through the PSC.

TABLE 4

Flow Unavailable for Power Generation

Alternative	March – November (cfs)	December – February (cfs)
Basecase (STS)	7,300 + 340 = 7,640	7,300
Alternative 1 and 4-13	7,300 + 340 = 7,640	7,300
Alternative 2 (PSC)	15,000 + 7,300 = 22,300	7,300

The HALLO program recomputes project spill based on the HYSSR project regulated flow and the hydraulic capability of the project as constrained by HALLO program inputs. Currently, the HALLO program is only capable computing spill for fish based on a percentage of the regulated flow. In real operations, Bonneville will spill at its spill cap instead of at a percentage of the regulated flow. To best simulate the fish spill using HALLO, the spill percent input value per month was adjusted until the 60-year average of the fishspill was equal to the fish spill caps. This would cause excess spill and decreased generation in some years and not enough spill and excess generation in other years. Since the levelized energy value is the same in every year for each specific month, the 60-year average generation would be appropriate.

8 DETERMINATION OF GENERATION FOR ALTERNATIVES.

Sixty-year average HALLO generation data are provided in Tables 5 through 7 for each of the alternatives evaluated. The average generation for the base case and alternatives is provided in Table 5. Differences in the average generation between the base case and alternatives are provided in Table 6. The difference in total generation megawatt-hours (MWh) between the base case and alternatives is provided in Table 7. The difference in total generation (MWh) is determined by multiplying the number of hours in a month by the difference in average generation from Table 6.

The economic impacts due to differences in energy generation between the base case and each alternative is provided in Table 8. Benefits are computed by multiplying the levelized energy values from Table 1 by the differences in generation from Table 7.

It should be noted that the unit performance data provided by HDC for the PSC alternative is based on index testing for a prototype test structure that does not fully represent the final structure, therefore, actual generation differences and economic benefits for a final structure may be different than that computed in this study. Unit performance data for the base case and the ESBS alternative are considered to be accurate.

Table 5

Bonneville Average Generation for Years 2005-2046 (aMW)

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	Annual Generation
Base	303	493	506	544	660	767	686	735	766	713	708	456	611
Alt. 1	303	493	506	544	660	767	686	734	764	713	707	456	610
Alt. 2	264	433	445	485	653	752	675	678	730	679	668	408	572
Alt. 3	564	433	445	485	653	752	675	678	793	839	828	684	652
Alt. 4	709	494	507	544	661	767	687	735	829	880	876	802	708
Alt. 5	486	494	507	544	661	767	687	735	803	813	800	621	660
Alt. 6	373	494	507	544	661	767	687	735	783	758	743	514	630
Alt. 7	185	494	507	544	661	767	687	735	734	626	617	324	572
Alt. 8	138	494	507	544	661	767	687	735	699	524	519	191	537
Alt. 9	709	493	506	544	660	767	686	735	829	880	876	802	708
Alt. 10	486	493	506	544	660	767	686	735	803	813	800	621	659
Alt. 11	371	493	506	544	660	767	686	735	783	758	743	513	629
Alt. 12	183	493	506	544	660	767	686	735	733	626	616	321	571
Alt. 13	138	493	506	544	660	767	686	735	698	523	518	186	536

Table 6. Difference in Energy (aMW) Between Alternative and Base Case

DIFFERENCE FROM BASE	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
ALT. 1 – BASE	0	0	0	0	0	0	0	-1	-2	0	-1	0
ALT. 2 – BASE	-39	-60	-61	-59	-8	-15	-11	-57	-36	-34	-40	-48
ALT. 3 – BASE	261	-60	-61	-59	-8	-15	-11	-57	28	126	120	228
ALT. 4 –BASE	406	1	1	0	1	0	1	0	64	167	168	346
ALT. 5 – BASE	184	1	1	0	1	0	1	0	37	100	92	165
ALT.6 – BASE	71	1	1	0	1	0	1	0	18	45	35	58
ALT.7 – BASE	-117	1	1	0	1	0	1	0	-32	-87	-91	-132
ALT.8 – BASE	-165	1	1	0	1	0	1	0	-67	-189	-189	-265
ALT.9 – BASE	406	0	0	0	0	0	0	0	64	167	168	346
ALT 10 – BASE	183	0	0	0	0	0	0	0	37	100	92	165
ALT. 11 – BASE	69	0	0	0	0	0	0	0	18	45	35	57
ALT. 12 – BASE	-120	0	0	0	0	0	0	0	-33	-87	-92	-135
ALT 13 – BASE	-165	0	0	0	0	0	0	0	-68	-190	-190	-270

Table 7. Difference in Energy (MWh) Between Alternative and Base Case

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
ALT. 1 – BASE	0	0	0	0	0	0	0	-744	-1080	0	-720	0
ALT. 2 – BASE	-28700	-43200	-45260	-42600	-5580	-11160	-7280	-42160	-25800	-25420	-28800	-35960
ALT. 3 – BASE	194280	-43200	-45260	-42600	-5580	-11160	-7280	-42160	20100	93620	86400	169260
ALT. 4 –BASE	302376	720	744	0	744	0	672	0	45720	124248	120960	257424
ALT. 5 – BASE	136752	720	744	0	744	0	672	0	26640	74400	66240	122760
ALT.6 – BASE	52680	720	744	0	744	0	672	0	12600	33480	25200	43152
ALT.7 – BASE	-87360	720	744	0	744	0	672	0	-23040	-64728	-65520	-98208
ALT.8 – BASE	-122808	720	744	0	744	0	672	0	-48240	-140616	-136080	-197160
ALT.9 – BASE	302376	0	0	0	0	0	0	0	45720	124248	120960	257424
ALT 10 – BASE	136368	0	0	0	0	0	0	0	26640	74400	66240	122760
ALT 11 – BASE	51192	0	0	0	0	0	0	0	12600	33480	25200	42408
ALT 12 – BASE	-89352	0	0	0	0	0	0	0	-23400	-64728	-66240	-100440
ALT 13 – BASE	-122472	0	0	0	0	0	0	0	-48600	-141360	-136800	-200880

Table 8. Average Annual Energy Benefit for Years 2005 – 2046

Alternative "n" – Base Case
($ Thousands)

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	Average Annual Benefit
Levelized Energy Value	$43.17	31.08	32.99	33.77	35.73	41.15	38.94	25.18	17.44	23.36	25.48	33.84	
ALT. 1 – BASE	$0	$0	$0	$0	$0	$0	$0	-$19	-$19	$0	-$18	$0	-$56
ALT. 2 – BASE	-$1,239	-$1,343	-$1,493	-$1,439	-$199	-$459	-$283	-$1,062	-$450	-$594	-$734	-$1,217	-$10,512
ALT. 3 – BASE	$8,387	-$1,343	-$1,493	-$1,439	-$199	-$459	-$283	-$1,062	$351	$2,187	$2,201	$5,728	$12,576
ALT. 4 –BASE	$13,054	$22	$25	$0	$27	$0	$26	$0	$797	$2,902	$3,082	$8,711	$28,646
ALT. 5 – BASE	$5,904	$22	$25	$0	$27	$0	$26	$0	$465	$1,738	$1,688	$4,154	$14,048
ALT.6 – BASE	$2,274	$22	$25	$0	$27	$0	$26	$0	$220	$782	$642	$1,460	$5,478
ALT.7 – BASE	-$3,771	$22	$25	$0	$27	$0	$26	$0	-$402	-$1,512	-$1,669	-$3,323	-$10,578
ALT.8 – BASE	-$5,302	$22	$25	$0	$27	$0	$26	$0	-$841	-$3,285	-$3,467	-$6,672	-$19,467
ALT.9 – BASE	$13,054	$0	$0	$0	$0	$0	$0	$0	$797	$2,902	$3,082	$8,711	$28,547
ALT 10 – BASE	$5,887	$0	$0	$0	$0	$0	$0	$0	$465	$1,738	$1,688	$4,154	$13,932
ALT. 11 – BASE	$2,210	$0	$0	$0	$0	$0	$0	$0	$220	$782	$642	$1,435	$5,289
ALT. 12 – BASE	-$3,857	$0	$0	$0	$0	$0	$0	$0	-$408	-$1,512	-$1,688	-$3,399	-$10,864
ALT 13 – BASE	-$5,287	$0	$0	$0	$0	$0	$0	$0	-$848	-$3,302	-$3,486	-$6,798	-$19,720

9 CAPACITY BENEFITS ANALYSIS PROCEDURE.

Hydropower capacity benefits are intended to measure the cost of the replacement thermal generating capacity that would be deferred by implementation of a hydropower rehabilitation plan. They are typically computed as the product of the project dependable capacity gain (or dependable capacity loss avoided) and the regional power system composite unit capacity value, which is based on the unit cost of constructing and maintaining the most likely alternative thermal generating resource mix to replace the hydropower plant under study. For this particular study, there is a loss in capacity due to the installation of the PSC. The dependable capacity analysis used in this study is similar to the analysis used for the Ice Harbor Major Rehabilitation Report (dated March 1997) prepared by the HAC.

There are four parts in determining the capacity benefits: a) a dependable capacity for the Bonneville project was determined; b) a 60-year average generation capability was computed and then limited to the dependable capacity determined from a) for the base case and as recommended from HDC for the PSC alternatives; c) a unit capacity value for was determined; d) the average annual capacity benefits were determined by multiplying the difference between the average annual dependable capacity for the base case and the average annual dependable capacity for the alternatives by the unit capacity value.

9.1 DEPENDABLE CAPACITY

Dependable capacity is a term that describes how much generating capacity a hydropower project has available for use when demanded. However, the general definition of dependable capacity does not specify how long and when the capacity is to be available. For some projects, the dependable capacity is defined as the instantaneous maximum generating capability of the powerplant, and for others, it is defined as the sustained (varying number of hours) generating capability of the powerplant under low streamflow conditions (head and/or flow limitations). The decision on how to define and use dependable capacity is heavily influenced by the role of the particular hydropower project in its regional power system. How a hydropower plant is operated, what its hydrologic characteristics are, and where it is relatively located in its regional power system, are the main determinants of its dependable capacity.

For the general purposes of the HAC, a study of dependable capacity for the Corps projects on the Columbia and Snake rivers was previously conducted to determine what the sustained peaking capacity for the projects would be under a period of high power demand and low streamflow conditions. The study examined several different alternatives for estimating the dependable capacity of each project and recommended the most appropriate case. This study was performed by Richard Mittelstadt, a retired HAC senior technical engineer.

From the dependable capacity study, it was recommended that the most appropriate alternative defined the dependable capacity as the highest hourly load carried in the week under the February 1989 cold snap. This case was recommended because it represented the highest achievable but not overly restrictive interpretation of dependable capacity from a power peaking operation perspective. It incorporated the commonly used period of high power demand due to an extreme cold weather event that occurred on 2-8 February 1989. In addition, from a hydrologic standpoint, this time period was part of the fifth driest December-February period in a 61-year period of record from 1928 through 1989. Examination of the Bonneville historical hourly data records showed that the peak power output of 992 MW occurred on 0500 hours, 3 February 1989 with a project powerhouse discharge of 244.4 kcfs and a gross hydraulic head of 54.4 feet.

9.2 DETERMINATION OF DEPENDABLE CAPACITY FOR BASE CASE AND ALTERNATIVES.

The difference in average annual dependable capacity between the base case and alternatives were considered in the months of January and February. These are the months where the capacity of the projects are most likely reached due to high load demand during the winter months, and low water availability for generation. The difference in dependable capacity in January and February between the base case and all alternatives except alternatives 2 and 3 is zero because the screens are removed from the turbine intakes, thus, the turbine unit performance data is the same. Alternatives 2 and 3 have the PSC installed in January and February, so these alternatives impact generation in these months due to the loss of generating head caused by the PSC. Alternatives 2 and 3 are essentially the same in January and February, so the following text will be denoted as alternatives 2/3. The assumptions made in the capacity analysis were: 1) The dependable capacity of the Bonneville project under existing conditions is 992 MW. 2) The peak time is 200 hours per month. This was determined based on requiring a peaking ability of 10 hours per day, 5 days per week, and 4 weeks per month (this criteria was used in the Ice Harbor Rehabilitation report). 3) For the PSC, HDC estimated that there is a capacity loss of 3 MW per unit due to the effect of the PSC on turbine performance.

The following steps were taken to determine the generating capability and dependable capacity under the base case and alternatives 2/3.

a. For the base case, determine the amount of generation (aMW) produced due to the minimum flow requirement for each of the 60 years of data. The project minimum flow is either 100,000 cfs or 125,000 cfs. The average daily minimum flow is 100,000 cfs as stated in the “Project Data and Operating Limits”, by the US Army Corps of Engineers, North Pacific Division, July 1989. But, due to the 2000 USFWS Biological Opinion, a minimum flow of 125,000 cfs is desired for chum spawning downstream of Bonneville if it does not interfere with the ability of the upstream projects to store the desired amount of water for later release in the spring and summer for other endangered species. The generation based on the minimum flow is considered to be the generation during non-peak hours. Non-peak hours in January is the total hours in January (744 hours) minus peak hours (200 hours) which is equal to 544 hours. The non-peak hours in February is 672 –200 = 472 hours. Multiply the number of non-peak hours by the average megawatt generation over non-peak hours to get the MWh produced during non-peak times.

b. Determine the generation availiabe for peaking in MWh for the base case for each of the 60-years. This is determined by first computing the total MWh produced based on HALLO generation. HALLO output provides generation in aMW. Multiply the HALLO aMW by the number of hours in a month to get HALLO total MWh. Determine the generation available during peaking in MWh by subtracting the generation during non-peak hours MWh from the total generation.

c. Determine the peak capability (aMW) available for each of the 60-years during the peak time by dividing the MWh from 2) by 200 hours.

d. Limit the peak capability from 3) to 992 aMW in each year that the peak capability is greater than 992 aMW to determine the dependable capacity for each of the 60 years.

e. Compute the 60-year average dependable capacity by averaging the 60 years of data in step 4).

f. For Alternative 2/3, repeat steps 1) through 5), but limit the peak capability value in step 3) to 962 aMW. This limit is based on 992 aMW (dependable capacity without surface collector) minus a maximum of 3 MW per unit capacity loss multiplied by 10 units.

g. The loss in dependable capacity due to the PSC, was determined by subtracting the 60-year average dependable capacity for the PSC alternative from the 60-year average dependable capacity of the base case. The results of this analysis shows that on average, the dependable capacity loss in January and February is 25 and 21 aMW respectively. Table 9 shows the average dependable capacity for January and February for the base case and PSC alternatives. To determine the economic loss due to dependable capacity, unit capacity values are multiplied by the dependable capacity loss. Derivation of the unit capacity values are discussed below.

9.3 Determination of Capacity Values

The steps in determining the capacity value are: 1) the Federal Energy Regulatory Commission (FERC) individual unit capacity and energy values were determined for each type of thermal plant that could be used to replace the lost capacity at Bonneville. The FERC values are used to develop a screening curve; 2) the screening curve was developed to determine the least cost thermal alternative for a given plant factor, and was used in combination with a one-year hourly generation-exceedence curve for Bonneville to determine least cost mix (Figure 1). The mix is the percent of capacity each of the replacement thermal plant types use to replace the lost hydro capacity; 3) a composite unit capacity value was determined by taking the individual capacity values and applying the ratios of the mix of the replacement plants.

TABLE 9. Dependable Capacity for Base Case and PSC Alternatives 2/3

	PSC Alt.2 and 3 (aMW)		Base Case (aMW)		PSC – Base Case (aMW)	
	JAN	FEB	JAN	FEB	JAN	FEB
	572	131	572	131	0	0
	242	737	242	737	0	0
	280	252	280	252	0	0
	386	520	386	520	0	0
	962	880	992	917	-30	-37
	962	962	992	992	-30	-30
	962	867	992	904	-30	-37
	576	607	591	607	-15	0
	515	244	515	244	0	0
	962	934	992	975	-30	-40
	947	244	991	244	-45	0
	634	702	634	702	0	0
	559	382	559	382	0	0
	962	746	992	777	-30	-30
	962	962	992	992	-30	-30
	498	274	509	274	-11	0
	596	547	596	547	0	0
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	873	992	910	-30	-37
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	764	992	774	-30	-10
	962	962	992	992	-30	-30
	962	860	992	900	-30	-40
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	877	992	914	-30	-37
	962	962	992	992	-30	-30
	962	610	992	630	-30	-20
	962	962	992	992	-30	-30
	962	598	992	611	-30	-13
	962	962	992	992	-30	-30
	962	366	992	366	-30	0
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	933	300	981	300	-48	0
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	498	125	509	125	-11	0
	710	962	710	992	0	-30
	962	740	992	740	-30	0
	826	962	860	992	-33	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	962	992	992	-30	-30
	962	631	992	631	-30	0
	962	962	992	992	-30	-30
	604	489	626	489	-22	0
	541	322	541	322	0	0
60-yr Average	855	773	879	794	-25	-21

a. <u>FERC Individual Unit Capacity Values</u>**.** Unit capacity values represent the unit capital construction and fixed O&M costs for building and maintaining new power generation facilities in the same region as the hydropower facility under study. Currently, only three types of standard thermal powerplants are being considered by the industry for construction, coal (CO), combined cycle (CC), and combustion turbine (CT). The CO type of powerplant is really not cost competitive at this time, largely because of the added costs to comply with the legal requirements for emissions control. The unit capacity values for CO, CC , and CT plants were computed by the HAC using a spreadsheet model obtained from the Chicago Regional Office of FERC. The computations completed by the FERC model are extensive and beyond the scope of this report to discuss in-depth. It is sufficient to say that the FERC model takes the most current capital construction costs from construction cost indexes, the most current fixed O&M costs from the other industry publications, along with various other costs and calculates the annual value of these costs given the interest rate and the price level date.

The computed FERC unit capacity values (CVORIG) incorporate the two hydropower advantage factors of Availability (HMA/TMA) and Flexibility (1+F) as shown in Equation 5. The Availability factor as defined by the ratio of Hydropower Mechanical Availability (HMA) to Thermal Mechanical Availability (TMA) accounts for the relative mechanical/electrical reliability of hydropower generation compared to the alternative thermal generation, while the Flexibility factor (1+F) accounts for the added operational flexibility of hydropower generation compared to the alternative thermal generation. The source of the standard values used for the F, HMA, and TMA variables can be found in the FERC publication, *Hydroelectric Power Evaluation, 1979.* For use in the screening-curve analysis, the two factors of Availability and Flexibility were removed to derive at the modified unit capacity values (CVMOD) for each of the thermal plant types using the equation shown below.

CVORIG = (CVMOD) (HMA/TMA) (1+F) (Equation 5)

The original and modified unit capacity values, based on a current FY-01 Federal interest rate of 6-3/8 % and an 1 January 2001 price level are shown below in Table 10.

Table 10. FERC Unit Capacity Values for the Pacific Northwest

Thermal Alternative Plant Type	Original Unit Capacity Value ($/kW-yr)	FERC Hydropower Advantage Adjustment Variables			Modified Unit Capacity Value ($/kW-yr)
		HMA	TMA	F	
CO	230.56	0.98	0.85	0.050	190.45
CC	111.66	0.98	0.90	0.025	100.04
CT	62.56	0.98	0.90	0.025	56.05

Individual unit energy values for CO, CC, and CT plants were also produced by the FERC power value model based on the most recent one-year average fuel cost data obtained from the *EIA Electric Power Monthly (DOE/EIA-0226)* publication from 10/98-09/99, as well as the heat rate and variable O&M data obtained from the *1993 EPRI Technical Assessment Guide (TAG) for Electricity Supply*. Unit energy values are used in the screening curve analysis to determine the mix of the least cost alternative. The heat rate data was left unchanged and the variable O&M data was updated to the current price level date using the historical GDP deflator rates. It was recognized that the heat rate data might be outdated being from 1993, but they appeared to still be reasonable when compared to current data. Since current Corps policy dictates that no real fuel cost escalation should be used, the calculated unit energy values for the three types of thermal plants were considered constant throughout the economic life of the project and no levelization of the unit energy values was necessary. The unit energy values produced by the FERC model are shown below in Table 11.

b. Screening-Curve Analysis. A screening-curve analysis was developed to determine the alternative thermal generating resource mix that would most likely be the least-cost power generation replacement for the Bonneville project. Three basic types of alternative thermal plants were considered. The modified unit capacity values for each type of thermal plant were weighted based on the resource mix determined from the screening curve and a composite unit capacity value was determined. This composite unit capacity value was used for valuing the dependable capacity.

Table 11 Unit Energy Values

Thermal Alternative Plant Type	Unit Energy Value ($/MWh)
CO	13.47
CC	16.8
CT	25.66

To determine the most likely alternative thermal generating resource mix to replace the generation lost at Bonneville due to the PSC, a screening-curve analysis along with a generation-exceedence curve was completed and consisted of the following steps.

A diagram of total plant cost (in $/kW-yr) versus annual plant factor (in percent) was constructed and includes a curve for each type of thermal plant available in the system for replacing the hydropower project under study. The plant cost is the cost to run the plant and includes initial cost to construct the plant and the operating cost. The plant factor is ratio of the average load on the plant to the total rating for the plant. This screening curve shows which types of thermal plants are the least costly to construct, maintain, and operate over the entire range of plant factors.

The modified unit capacity values of 190.45, 100.04, and 56.05 ($/kW-yr) along with the unit energy values of 13.47, 16.8, and 25.66 ($/MWh) for the respective CO, CC, and CT plant types were utilized in order to develop a plot of total plant cost versus annual plant factor. The plot for each thermal alternative was developed by computing the annual plant cost for various plant factors ranging from zero to 100%. The annual thermal plant costs were computed using the following equation:

$$AC = CVMOD + (0.0876 * PF * EV) \qquad \text{(Equation 6)}$$

where: AC = thermal plant total cost ($/kW-yr)
CVMOD = thermal plant modified unit capacity value ($/kW-yr)
EV = thermal plant unit energy value ($/MWh)
PF = annual plant factor (percent)
and 0.0876 is a conversion factor used to convert $/MWh to $/kW-yr.

Essentially the plot uses the modified unit capacity values as the starting point for the curves and uses the individual unit energy values to define the slope of the curves. As shown in Figure 1, there was only one breakpoint (the intersection of two or more curves) that was between the CT and CC curves. For any given plant factor, the lowest curve on the plot is predicted to be the least-cost alternative thermal resource replacement for hydropower for that plant factor.

The breakpoint between the CT and the CC curve was determined to occur at a plant factor of 56.7%. Thus, CT plants are more economical for plant factors less than 56.7% and CC plants are more economical for plant factors greater than 56.7%. Because CO plants were never the least-cost thermal alternative for any range of plant factors, they were not considered as an alternative thermal power generation resource to the Bonneville powerplant.

c. Generation Exceedence Curve**.** An annual generation-exceedence curve for the Bonneville was constructed. This curve was based on actual hourly powerplant output for the year of 1998. The year 1998 was chosen because it was a recent year, and its average energy generation was closest to the 1983-1999 period average (post second powerhouse construction when both Bonneville powerhouses were operational). The percent exceedence x-axis of the plot will be used to the represent plant factor.

On the generation-exceedence curve, the 56.7% plant factor CT-CC breakpoint was matched to the percent exceedence level on the generation-exceedence curve, and was found to fall at the 557 MW level out of a powerplant maximum capacity of 1060 MW shown in the 1998 hourly data. This indicated that the portion of the maximum power load to be carried by CC plants was 557 MW, with the remaining 503 MW (1060-557) to be carried by CT plants. Thus, the most likely, least-cost thermal alternative generating capacity for the Bonneville project was found to consist of 557 MW (52.5%) of CC plants and 503 MW (47.5%) of CT plants. The screening curve and generation-exceedence curve showing the 56.7% plant factor/percent exceedence level are shown in Figures 1 and 2.

d. Composite Unit Capacity Value**.** A composite modified unit capacity value is derived by applying the capacity components of the least-cost thermal alternatives as weighting factors to the corresponding modified unit capacity values from Table 10. Modified unit capacity values were used in the derivation of the composite unit capacity value. The derivation of the composite modified unit capacity value is provided below.

Modified Unit Capacity Values (without the hydropower advantage factors):

CC: $100.04 / kW-yr
CT: $ 56.06 / kW-yr

Least-Cost Alternative Thermal Replacement Capacity Mix:

CC: 556.8 MW
CT: 503.2 MW
Total: 1060 MW

Calculation of Composite Unit Capacity Value:

CC Capacity Value = \$ 100.04 / kW-yr * (557 MW / 1060 MW)
= \$ 52.57 / kW-yr

CT Capacity Value = \$ 56.06 / kW-yr * (503 MW / 1060 MW)
= \$ 26.60 / kW-yr

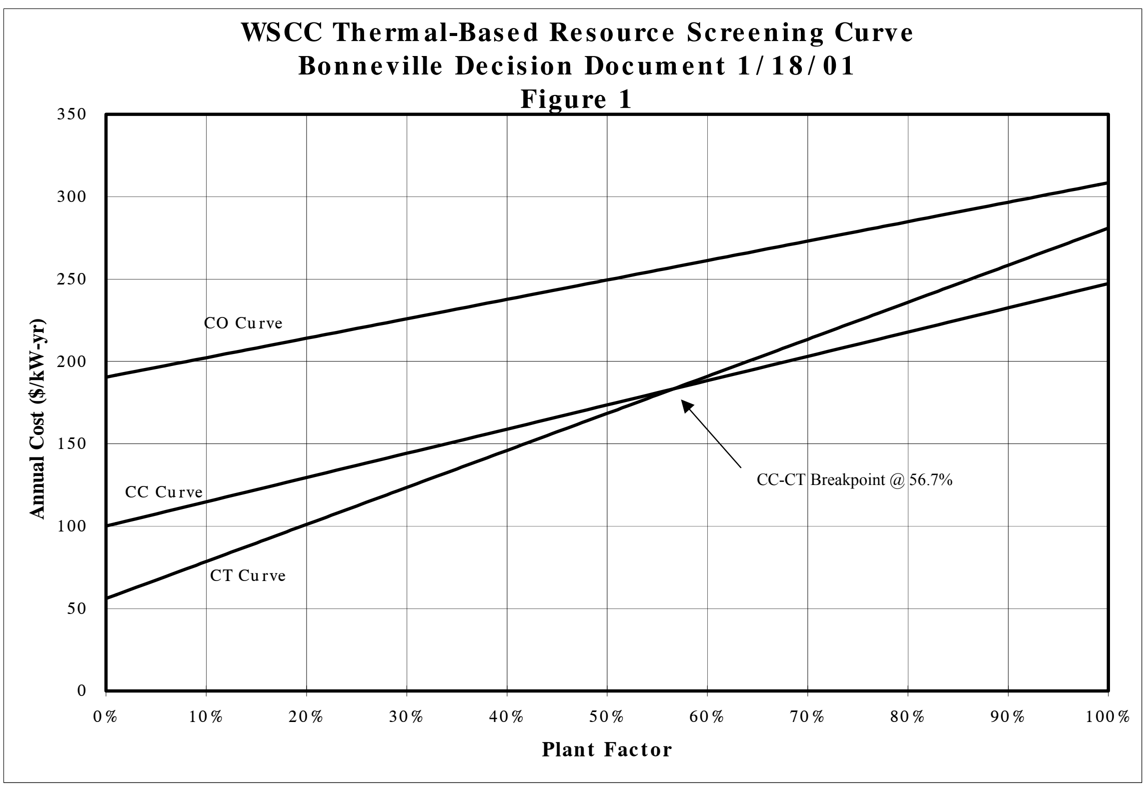
Composite Unit Capacity Value = \$ 52.57 + \$ 26.60 = \$ 79.17 / kW-yr

9.4 COMPUTE CAPACITY BENEFITS.

The composite unit capacity value was multiplied by the capacity difference to determine the cost of lost capacity as discussed in section 9.0.2.7). In January, the capacity loss due to the PSC is 25 MW, or 25,000 KW. Multiply this by \$79.17 and the economic loss due to the PSC in January is \$1,979,250. Similarly, in February, the capacity loss is 21 MW or 21,000 KW, multiplied by \$79.17, and the economic loss due to the PSC in February is \$1,662,570. Adding the values for January and February, the annual economic loss for capacity due to the PSC is \$3,641,800.

10 SUMMARY.

The combined average annual benefits for each alternative compared to the base case is provided in Table 12.



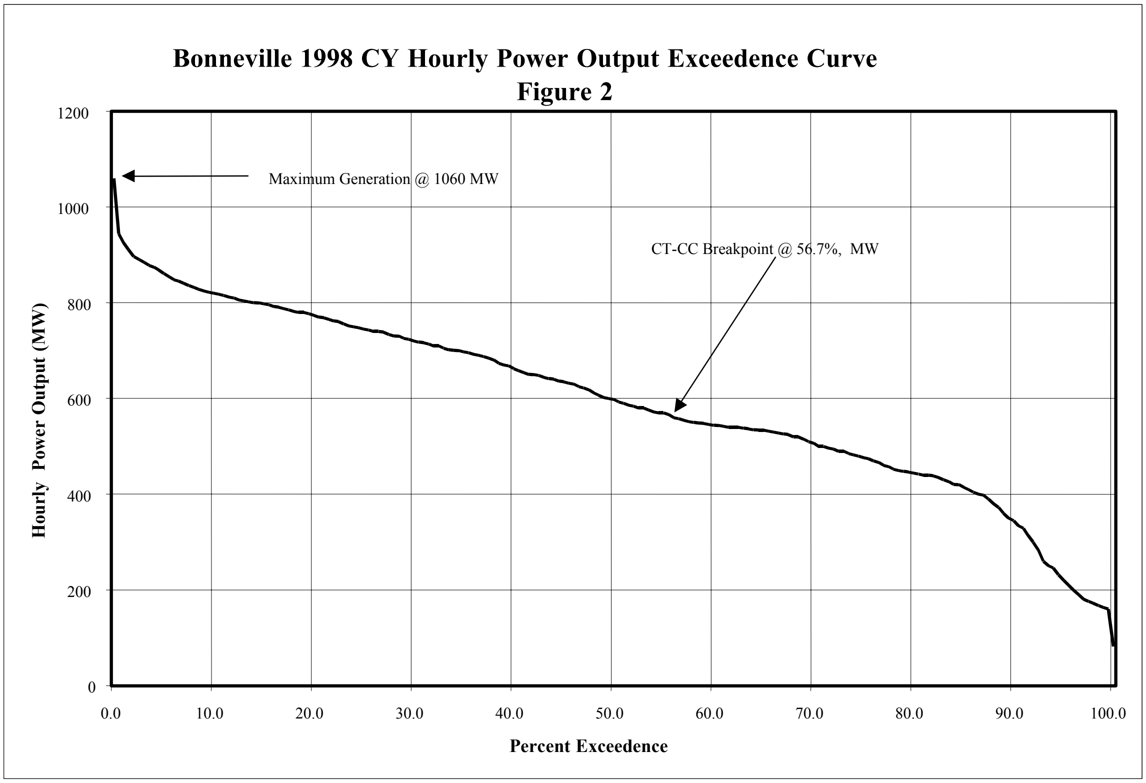


Table 12

Average Annual Energy and Capacity Benefits

$ Thousands

Alternative	Energy	Capacity	Combined
1	-$56		-$56
2	-$10,512	-$3,642	-$14,154
3	$12,576	-$3,642	$8,934
4	$28,646		$28,646
5	$14,048		$14,048
6	$5,478		$5,478
7	-$10,578		-$10,578
8	-$19,467		-$19,467
9	$28,547		$28,547
10	$13,932		$13,932
11	$5,289		$5,289
12	-$10,864		-$10,864
13	-$19,720		-$19,720

The PSC installation with the existing spill conditions (alternative 2) results in a loss of $14,154,000. The PSC installation without spill (alternative 3) results in a benefit of

$8,934,000. The no spill alternatives with the STS in place provides a benefit of about $28,600,000 (approximate average of alternatives 4 and 9). The maximum spill alternative with 150,000 cfs spill in April through August results in a loss of about $19,600,000 (average of alternatives 8 and 13). It should be noted that the 150,000 cfs spill could not be achieved in all years of the 60-year study because there was a minimum powerhouse flow of 30,000, and in most years, there was not enough water to meet both criteria.

In comparing alternatives 4 through 8 with alternatives 9 through 12, the only differences in the inputs between the sets of alternatives are the unit loading priorities. Alternatives 9 through 12 have the second powerhouse as the unit loading priority whereas alternatives 4 through 8 have the first powerhouse as a priority. In comparing alternatives 4, 5, and 6 to alternatives 9, 10, and 11, respectively, alternatives 4-6 show slightly more economic benefit than 9 through 11. Comparing alternatives 7 and 8, to 11 and 12, respectively, alternatives 7 and 8 show slightly more cost than 12 and 13. The reasoning is that the new turbines in the first powerhouse are more efficient, thus, more energy could be generated with the same amount of water when the first powerhouse is loaded first.

This report will be provided to the Portland District Corps of Engineers for use as an appendix to the Bonneville Decision Document Study. For additional information regarding this hydropower study, please contact the Hydropower Analysis Center, Northwestern Division.

APPPENDIX E

COST ESTIMATE FOR PARTIAL DEEPSLOT AND SHALLOW SURFACE COLLECTION

APPENDIX E

COST ESTIMATE FOR PARTIAL DEEPSLOT AND SHALLOW SURFACE COLLECTION

Alternatives: Surface Collection at the 1st Powerhouse

Concerns have been raised that the cost estimates for the different surface collection options at the 1st Powerhouse were not an apple-to-apple comparison. Steve Rainey and Laurie Ebner set down and developed a "relative" cost estimate for the different surface collection options for B1 using the PSC and B2 Corner Collector as the reference points. The attached spreadsheet contains the numbers and hopefully the following will explain our rationale. In addition the COE Surface Collection team has reviewed this document and some of their thoughts have been incorporated into the cost estimates.

We identified five major structural components to surface collection. The first structural component is the collection channel in the forebay. The second is vertical occlusion of the intakes. The third is a transition from the collection channel in the forebay to the outfall channel. The fourth is the outfall channel with the appropriate outfall (adjustable cantilever or mid-level cantilever). The fifth item was an added cost if any of the outfall was over water.

We started with the B2 Corner Collector (F-Tip location) cost estimate of 35-45 million. Recognizing that we don't have the details to the cost estimate we broke the cost down into two major components. The transition from the forebay to the new outfall channel and the new outfall channel. The transition piece would include the modifications to the intake, the ogee work and breaking out of the existing sluice chute outfall to the new outfall channel. The outfall channel would include the new flume from the existing sluice chute outfall to the tip of Cascade Island, the sheet pile structure at the tip of Cascade Island, the mid level cantilever and the plunge pool. We didn't know the exact breakout but we assumed that 5 million was associated with the transition and 30-40 million was associated with the new outfall.

Then we used the Deepslot Alternative Study to develop the cost associated with Deepslot. We included the engineering in the cost of each component and costs were taken from Tables 6-1, 6-2 and 6-3.

For the Partial Deepslot the cost associated with the surface collector were taken from Table 6-1. The number was bumped from 37.5 to 40 to account for a more permanent vertical occlusion installed in from of units 4 – 6. In the initial cost estimate done by CENWP-EC-HD we hadn't specifically addressed the cost associated with transitioning from the collection channel in the forebay to the outfall. The route would be to the south and the ice and trash sluiceway has insufficient capacity. The area is congested with the old lock, roads and bridges. The cost for a transition channel for the Deepslot alternative was 7 million and the volume for the Partial Deepslot is more in line with B2 so we used 5 million. For the outfall we assumed that the length was approximately 75% of F-Tip and used 75% of the cost associated with F-Tip. In addition we assumed that to get acceptable egress conditions we would need to have the outfall over water. We didn't have a good feel for what this might be but used 2/3 of the Deepslot alternative 37.7 million. This provided a cost of 105.2 to 112.7 million, which is very similar to that original cost developed, 91 million.

For the shallow surface collection we assumed that we could design and build the channel for 30 million and the occlusion for 10 million. For a total of 40 million, which is the same as the partial deepslot and 40% of the full deepslot. This should be in the ballpark since the channel would be about 50% of the volume of the deepslot channel and there wouldn't be any ramps. The occlusion insert would be the minimum required structurally to attain turbine intake hydraulic conditions similar to the J-block design at The Dalles Dam. The same issues associated with transitioning from the channel to the outfall and the outfall itself exist for this alternative as the partial deepslot and the cost are assumed to be the same. The shallow surface collection system might have slightly higher cost if the volume being conveyed is higher than the partial deepslot.

RM&E. The other piece of information on the spreadsheet is an estimate of the level of effort associated with research, prototype testing etc. The B1 JBS/ESBS and B2 Corner Collector have a very low cost/impact associated with this (perhaps $1 million range and 1-2 years evaluation). The B1 JBS/ESBS has been tested and the only testing left is evaluating the performance of the installed system. The B2 Corner Collector has not been tested to the same extent as the B1 JBS/ESBS but the plan is to install the B2 Corner Collector and evaluate the performance of the installed system. Thus both options are rated low. There is a high research, prototype, etc component associated with the Deepslot option (perhaps $20 million range over nearly 10 years). There is significant more prototyping and physical model testing yet to be done – thus a high rating. The Partial Deepslot option has a medium rating since there should be some prototype testing of the ramp with provisions to make modifications to refine the ramp (perhaps $5 million over several years). The Shallow Surface option is ranked high and there are two prototypes and one final evaluation estimated. The 1st prototype would involve modifying the existing PSC to have shallow slots. A one-year prototype to determine if the fish will find the shallow slots. The 2nd prototype would be to test a shallow surface collection with actual collection channel. Then the Shallow Surface Collector would be installed and field-tested in the final configuration. Cost would be similar to that of the Deepslot option of 20 million.

(Steve Rainey's initial estimate: The Shallow Surface option is ranked low because a prototype test is recommended (one year of testing the existing PSC with modified gate settings at a cost in the $1-2 million range) but it is to determine if a Shallow Surface option would work.)

The last row in the spreadsheet is the first year the system could be available. Realistically speaking the B2 Corner Collector will most likely meet the target schedule and be available in FY04 but the options for B1 could experience delays. Whatever option is selected for B1 will have to compete for dollars with all of the other proposed structural modifications on the Lower Snake and Lower Columbia.

An additional cost that could factor into the Partial Deepslot and the Shallow Surface options are some upgrades to the existing JBS system.

Other considerations:

For B-1 occlusion options, it was generally agreed that intake ceiling transitions, and recamming turbines for optimum efficiency, would reduce previous power-lost projections by approximately 1 to 2% of the 6.7% assumed.

Ambient velocity requirements at any B-1 surface collection high-flow outfall will require a minimum of 60 kcfs or more discharge to provide good egress. Since flow approaching B-2 and the spillway results in a disproportionately high percentage of fish passing over the spillway in the spring (Ploskey, 2000), excessive operation of B-1 (in the context of a B-2 operating priority) will result in a disproportionate shift of fish from the spillway to B-1. In contrast, the B-1 FGE alternative (with an outfall adjacent to the new B-2 site) will allow as little as one-unit operation at B-1 – allowing minimum draw of yearling fish from the spillway and routing JBS bypassed fish to the new site near the B-2 outfall.

APPENDIX F

AGENCY CORRESPONDENCE

Joint Technical Staff Memorandum

CRITFC, USFWS, ODFW, WDFW, IDFG

February 6, 2001

Robert E. Willis, Chief, Environmental Resources Branch
Portland District, Corps of Engineers
P.O. Box 2946
Portland, OR 97208-2946

RE: Bonneville First Powerhouse Deep Slot Surface Collector Prototype Alternatives Study

Dear Mr. Willis:

The joint staff of the above listed agencies staff have reviewed the Corps of Engineers' (COE) Bonneville First Powerhouse Deep Slot Surface Collector Prototype Alternatives Study. We are providing the following input for the regional decision-making process for Bonneville Dam surface bypass options for Powerhouse I. These are preliminary technical comments and should be used to aid the Bonneville 1st Powerhouse Surface Bypass decision process move forward. Additional comments may be forthcoming.

Staff members attended and provided verbal comments at the COE Fish Facility Design and Review Work Group (FFDRWG) meeting on December 14, 2000. We appreciate the effort the COE has made to seek input from the region. After review and internal discussions we provide the following comments. These comments only pertain to the decisions for options at Bonneville Powerhouse 1 Surface Collector Prototypes. The final decision for what activities will proceed at Powerhouse 1 will be made in the Bonneville Decision making process.

Of the options presented in the study, we have identified Alternative 2 with three base case modules in front of unit 1 – 3, as the best option to proceed forward with. Option 2 (with the 3 base case units) will also provide a potential long-term partial solution for Powerhouse 1 passage. We generally support the goals and strategies outlined for this alternative.

Although the overall plan for Bonneville Dam is still undecided, staff believes that spill provides the best passage route possible, and thus should be maximized. The priorities we are setting for Bonneville are as follows:

1) Installing end-bay deflectors
2) Modifying current deflectors if the study shows that an improvement in performance can be attained
3) Operate Powerhouse 2 as the priority Powerhouse
4) Design and Construct Corner Collector at Powerhouse 2
5) Modifications to Powerhouse 1 for juveniles, when it is operated
6) Additional modifications to further improve passage

The modifications we envision for the short term for Powerhouse 1 correspond to Alternative 2 outlined in this report. This alternative would provide protection for units 1 – 3. Units 4 – 6 would either have the PSC structure still in front of them and/or a steel curtain structure to reduce entrainment and encourage juveniles to move towards the entrances provided at unit 1 – 3. This would allow for operation of over half the powerhouse. The peak of the average mean daily flow year for Bonneville is ~ 300 kcfs. The peak of the maximum flow 25th percentile is ~370 kcfs. With the current spill cap, (~120 kcfs), powerhouse 2 (~160 kcfs), and units 1 – 6 (~ 55 kcfs) this should provide adequate hydraulic capacity for most of the flows encountered during the migration season. This does not include the potential increase in spill volumes that should be achieved with the end-bay deflectors and improvements to the current deflectors.

This approach is consistent with the Independent & Scientific Advisory Board's concept of passing juveniles in the most normative method possible, which does not select against different life stages and non-listed species.

Alternative 2 is not the overall least expensive alternative but it has the potential to provide the greatest amount of protection in the shortest amount of time, with the least cost. Furthermore, if 3-unit base case is shown to be highly effective, the modular construction allows for expansion of the base case units to cover the entire powerhouse.

There is no current outfall available to pass the proposed ~5000 cfs for alternative 2. The alternative study outlines the use of a modified ice and trash sluiceway. We agree that this may be a plausible option, however investigation with a hydraulic model to investigate egress and hydraulic conditions along the bank needs to be conducted before this alternative proceeds. If the study indicates that an adequate outfall can be constructed, we believe that Alternative 2 should be expedited and installed in the shortest period of time possible.

February 6, 2001
Page 3

Thank you for time and consideration of these comments. If there are any questions or comments please contact Tom Lorz at (503) 238-3574 or email

Lort@CRITFC.org. We look forward to working closely with your staff on this important and complex issue.

Sincerely,

Christine Mallette
Oregon Department of Fish and Wildlife

Dave Wills
U.S. Fish and Wildlife Service

Steve Pettit
Idaho Department of Fish and Game

Bob Heinith
Columbia River Intertribal Fish Commission

James R. Nielsen
Washington Department of Fish and Wildlife

29-01.doc

APPENDIX F

February 23, 2001 F/NWO3

MEMO FOR: Dennis Schwartz and Laurie Ebner

FROM: Gary Fredricks

SUBJECT: Proposed Process for Risk Assessment

I sat down last week and tried to work through the proposed risk assessment that we talked about in our last meeting. It quickly became apparent that the criteria in the proposed process were too specific and did not apply well to the different passage routes. Also, I had trouble trying to determine how to apply the 1-10 ranking to the Simpas model. To address this I came up with the following proposed process that should apply equally well to all passage routes (and be easily explainable to SCT and other folks that haven't been involved in our meetings). I suggest we use the this process in the next meeting to arrive at combined risk factors for each passage route that the entire group can live with. I think it is very important that this be done in the meeting rather than separately prior to the meeting.

1. Determine the passage routes (done). For Bonneville these include: 1) Spill, 2) B1 Bypass, 3) B1 Surface Collector, 4) B2 Bypass, 5) B2 Corner Collector.

2. Determine a set of universal risk criteria such as:

1. Ability to meet guidance expectations
2. Ability to meet survival expectations
3. Ability to protect other life histories and species
4. Ability to meet guidance and survival goals under all operations

3. Rate each passage route for each of the four risk criteria using five risk factors: 1.0, 0.99, 0.98, 0.97, 0.96. 1.0 is lowest risk and 0.96 highest.

4. Multiply the four risk factors for each passage route to come up with a single risk factor. For example, for the spillway we might say:

criteria #1 = 1.0
criteria #2 = 0.99
criteria #3 = 0.99
criteria #4 = 1.0

1.0*0.99*0.99*1.0 equals a combined risk factor of 0.98 for the spillway.

5. Multiply each Simpas passage route survival parameter by the combined risk factor. For example, if spillway survival is 98% in Simpas, multiply 0.98 by the combined risk factor of

0.98 giving a new risk adjusted survival estimate of 0.96 for the spillway.

6. Do steps 4 and 5 for each passage route, enter the new risk adjusted survival estimates into Simpas and run the model for each combination of passage route/flow scenarios.

7. Carry the best (top five or so) scenarios forward through the time line and cost assessments.

APPENDIX F

BONNEVILLE DECISION PROCESS

B-1 SHALLOW SURFACE COLLECTOR

NMFS - 3/30/01

Introduction: Based on the delay of initiating bid solicitation for B-1 DSM and Outfall Relocation for a minimum nominal period of one year, the question has been raised at BDP meetings whether it is appropriate to further examine B-1 Surface Collection options that may entail reduced cost and implementation time. CRITFC, the states, and USFWS submitted a joint proposal that a "Partial B-1 Surface Collector" be investigated further. If the decision is made within the BDP to designate time and resources during the next months to determine whether all variations of surface collection at B-1 have been identified and scoped, the following option is proposed for equal consideration.

Description: (See attachment) This option includes occlusion of the upper turbine intakes at B-1, down to an elevation similar to the B-1 PSC. It includes three 2500 cfs overflow entrances, strategically spaced across the upstream powerhouse face, that discharge into a lateral channel with 7500 cfs capacity. No new intake screens or JBS modifications would be included. A full-flow bypass to a tailrace destination would be involved.

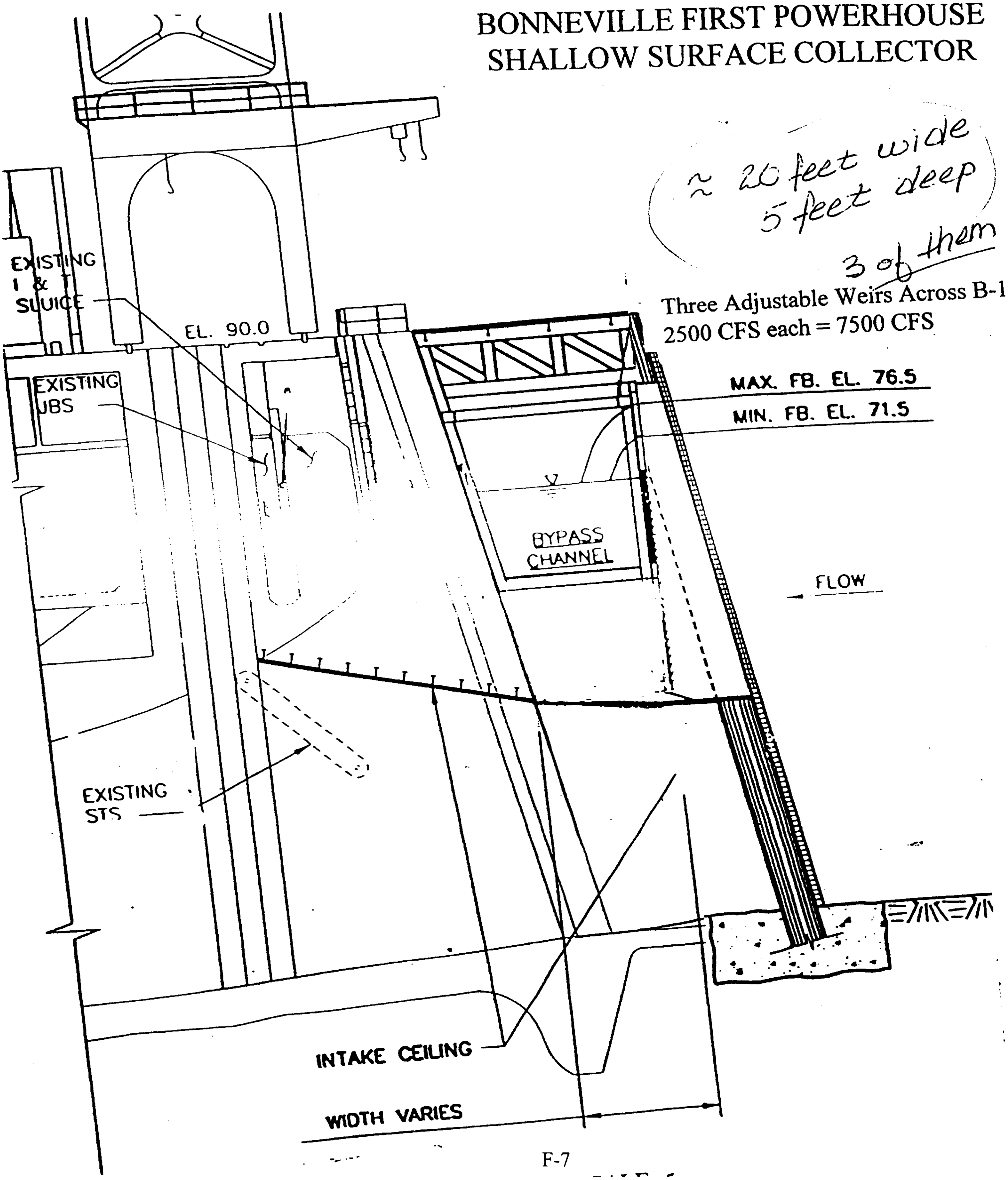
Biological Rationale: This concept assumes that the primary feature contributing to relatively strong B-1 forebay collection performance in 1998-2000 was the occlusion feature, not the deep-slot entrance. Further, it assumes that an overflow, ice and trash sluiceway-type entrance will attract fish upstream of the occlusion as well or better than the deep-slot entrance. Anecdotal information from other occlusion prototypes and sluiceway entrances suggest that this tandem would perform at a high level.

Cost and Scheduling Rationale: It is anticipated that over $50 million would be saved from the deep-slot "Base Case" B-1 surface collection alternative, purely on the basis of limited hardware expense upstream of the lateral channel (the deep-slot and ramp transition). The reduction from 15 kcfs to 7.5 kcfs would include additional savings. Scheduling benefits would include not having to conduct an extensive and costly intermediate prototype study of the ramp transition.

Prototype Confirmation of Assumptions: If deemed worthy of adoption, it would be easy to conduct a down-sized evaluation of the existing PSC with bulkheads occluding the lower deep-slot openings, and only a few surface-oriented 20-ft wide entrances opened to emulate the shallow weir entrance conditions.

Conclusion: While NMFS-Hydro stops short of endorsing this concept, we do recommend it be scoped further, and at the same level of detail as the previously-referenced "Partial Surface Collection" option. While we believe this may be the most feasible surface collection option at B-1, the final decision on an optimum configuration feature should be made on the basis of a full range of concepts (rather than the deep-slot vs ESBS/DSM-OF options only).

BONNEVILLE FIRST POWERHOUSE SHALLOW SURFACE COLLECTOR



State of Washington
DEPARTMENT OF FISH AND WILDLIFE

Mailing Address: 600 Capitol Way N • Olympia, WA 98501-1091 • (360) 902-2200, TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia, WA

September 12, 2001

Mr. Robert E. Willis, Chief
Environmental Resources Branch
Portland District, Corps of Engineers
Post Office Box 2946
Portland, Oregon 97208-2946

Dear Mr. Willis:

This letter is to provide comments on the August 20, 2001, version of the Draft Bonneville Decision Document (Draft Decision Document) prepared in response to the 2000 FCRPS biological opinion. We concur with the basic recommendation as described by the Army Corps of Engineers at Pages 19 and 20 of the Decision Document, Juvenile Fish Passage Recommendation.

The one exception we recommend is that the B2 FGE improvements only be approved for further evaluation at this time, and that any future structural modifications to improve FGE be subject to further regional review prior to being included in the Regional Prioritization Process for funding.

We appreciate the opportunity to provide out review and comment on the Draft Decision Document. If you have further questions, please contact Mr. Rod Woodin at (360) 902-2811.

Sincerely,

Bill Tweit
Columbia River Policy Lead
Intergovernmental Policy

BT:SS:dak

cc: Rod Woodin
Shane Scott

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
525 NE Oregon Street
PORTLAND, OREGON 97232-2737

F/NWR5

September 13, 2001

Robert E. Willis
US Army Corps of Engineers, Portland District
PO Box 2946
Portland, OR 97208-2946

Subject: Draft Bonneville Decision Document

Dear Mr. Willis:

We appreciate the opportunity to participate in the Bonneville Decision Process (BDP), and review this draft document. We also appreciate the U.S. Army Corps of Engineers' (Corps) efforts to reconcile diverse regional concerns relative to selection of configuration alternatives for improved survival at Bonneville. We have the following comments on the draft BDP report:

1. Page 5, paragraph 1 - As discussed at BDP subcommittee meetings, we do not agree that the Surface Collection alternative would necessarily result in full implementation in 2012. This date appears to reflect the projected full implementation date of the deep-slot surface collector at Bonneville 1st Powerhouse (B-1), but not the shallow surface collection alternative. It is the National Marine Fisheries Service's (NMFS) opinion that the relatively undeveloped shallow surface collector may be equally effective, less expensive, and can be fully implemented well before 2012. We recommend that wording in this paragraph be changed to reflect that more than one surface collection device is still under consideration.

2. Page 5, paragraph 2 - Cost considerations, including impacts to power production, should be used for alternative consideration only in cases where the biological benefits of each alternative are equal.

3. Page 20, Recommendations (Relative to the Shallow Surface Collector) - This section captures many of NMFS' views, but not all - especially in the context of the shallow surface collector. We recommend the following references be included in the final text:

   - Bonneville 2nd Powerhouse (B-2) operational priority, additional spillway deflectors, B-2 fish guidance efficiency (FGE) improvements, and the B-2 corner collector either are being, or will be, implemented as soon as possible. Each will improve fish survival. The incremental survival benefit of a juvenile bypass system (JBS) or surface collector at B-1 may be relatively low, compared to that of the above measures. Therefore, it is NMFS' opinion that there is time to gather additional information about JBS research uncertainties, more feasible surface collection options, and incremental survival benefits of other measures (relative to the 2000 Federal Columbia River Power System Biological Opinion performance standard) before making a decision on improvements at B-1. NMFS is concerned that the limited development of a potentially more feasible surface collection alternative was a significant weakness of B-1 improvement investigations. We recommend the shallow surface collector be developed further to determine relative costs, performance, and implementation time.

- Whereby the deep-slot surface collector captured over 80% of juvenile fish at each unit, the shallow surface collector efficiency rate was estimated at 60% for numerical modeling comparisons in the report. Based on our more recent (unwritten) synthesis of surface collection prototype results in the region since 1995, and particularly the effectiveness of upper intake occlusion devices at reducing turbine entrainment, we suspect the shallow collector efficiency rate will be closer to that obtained by the deep-slot surface collector prototype (PSC).

- Further study of the shallow surface collector prototype would be only a minor variation of the 1998-2000 PSC evaluations, and the additional one-year study could be tailored to conduct condensed hydroacoustic and radio-telemetry evaluations addressing only a few metrics to address collector efficiency performance relative to the deep-slot PSC. The PSC hardware is still in place at B-1. We recommend that a Fish Facilities Design Review Work Group (FFDRWG) subcommittee be convened to investigate conducting a one-year prototype study to determine collection efficiency of the shallow collector concept.

- It is NMFS' opinion that the shallow surface collector could be completed by 2006 with only one year of additional prototype testing. A second shallow surface collector prototype may not be required to confirm that fish would enter the permanent facility (with free discharging weir flow). A submerged weir discharge passing through a 20-ft. wide, nominal 12-ft. deep PSC surface-oriented entrance could achieve collection efficiencies near the levels observed in deep-slot PSC evaluations in 1998-2000. Further, ice and trash sluiceway investigations over the last few decades confirm that fish move readily and efficiently over free discharging weirs - such as would be included in the permanent shallow collector lateral channel.

- The cost estimate for the shallow surface collector appears to be based only on a conceptual assessment, and additional investigations of this option could lower the cost projection to a figure closer to the JBS estimate.

In summary, it is our recommendation that a final decision regarding juvenile passage alternatives at the Bonneville Dam First Powerhouse be deferred until more information is collected on shallow slot surface collection, spring migrant survival through the current bypass, and an evaluation of survival through the other high priority routes of juvenile passage (spillway, B2 corner collector, B2 JBS). The final recommendation of this report should reference this deferral.

Thank you for the opportunity to review and comment on the subject document. We request that the responses in this letter be included in the report, to assure that NMFS' views are more precisely represented. If there are questions, please contact Steve Rainey, 503-230-5418, or Gary Fredricks, 503-231-6855.

Sincerely,

James D. Ruff

James D. Ruff, Chief
Federal Columbia River Power System Branch

APPENDIX F

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

September 24, 2001

Colonel Randall Butler
District Engineer
Corps of Engineers
Portland District
Attn: CENWP-PM-E
P.O. Box 2946
Portland, Oregon 97208-2946

RE: Comments on the August 2001 Bonneville Decision Document- Juvenile Fish Passage Recommendation

The Columbia River Inter-Tribal Fish Commission (CRITFC)[1] has reviewed the document entitled, "August 2001 Bonneville Decision Document- Juvenile Fish Passage Recommendation" ("Document"). The long-term decision for fish passage at the First Powerhouse is of critical importance to CRITFC and its member tribes. We offer the following comments on the document and incorporate by reference our August 10, 2001 comments on the Bonneville First Powerhouse Fish Bypass Transportation Flume and Bridge Flume Environmental Assessment (EA).

General and Specific Comments

CRITFC has worked closely with the Corps of Engineers and the state and federal fishery agencies in an attempt to come to a consensus Document recommendation. While we agree with most of the recommendations outlined in the Document, we do not agree with the Document's recommendation to proceed with construction of the First Powerhouse Flume and to modify the First Powerhouse screen bypass system. CRITFC reiterates our position, stated in our comments to the EA that it is premature to decide on which path to proceed for the long-term passage system at the First Powerhouse. We reiterate this position for several reasons.

First, Bonneville Dam is now operating under different powerhouse priority criteria than in the past, which may alter the need for a new passage system at the First Powerhouse. In 2001, the region decided to change the fish passage priority from the First Powerhouse to the Second Powerhouse. This is reflected in the Corps' 2001 Fish Passage Plan. Since The First Powerhouse is

[1] The CRITFC was created in 1977 by formal resolution of the governing bodies of the four Columbia River treaty tribes: the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Spring Reservation of Oregon and the Nez Perce Tribe. The Commission is comprised of elected and appointed tribal officials who are members of their respective tribal fish and wildlife committees or commissions. The Commission has technical and legal resources that provide assistance to the tribes in protecting and enhancing their federally-reserved trust resources.

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only used after the Second Powerhouse is fully loaded and after fish spill is implemented,[2] there will only be a minimal period during the juvenile fish passage migration when the First Powerhouse will be used. This will be limited to high runoff periods during the spring migration, or during emergencies. When flows drop below 220 kcfs, there will not be enough river flow to operate the First Powerhouse. Thus, juvenile migrants will only have to pass through the First Powerhouse at limited times. With this change in operational priority, the importance of installing a separate passage system Powerhouse I is greatly diminished. If the Second Powerhouse is operating as the priority project priority, adopting the Document's additional recommendation to install the First Powerhouse Flume with screen system modifications will result in a small project survival improvement of less than 1% (weighted average).[3]

Second, CRITFC believes that the First Powerhouse surface collection options have great potential if a future passage system is needed, given the previous discussion that few migrants will be passing through the First Powerhouse. SIMPAS modeling indicated that the First Powerhouse deep slot surface collection system would produce the highest survival of any option considered at Bonneville, assuming a 75 kcfs daytime spill cap (Document Table 19). However, the Corps has decided that the deep slot option is too expensive and did not recommend it in the Document.

The Document examines other surface bypass options. For example, a partial surface bypass system was considered that would allow testing of the deep slot concept. If this option was successful, it could be expanded to cover more of the powerhouse. Another option that was considered was a shallow surface collector, however fish survival appeared lower than the flume and screen system due to poorer fish guidance. Both the shallow slot and the partial surface bypass system options were similar in cost to the flume and screen system options yet neither system has been prototyped and tested. At this time, there is little reliable site-specific information to make an informed judgment on either option. For the Document, fish guidance had to be estimated using other prototype tests that may or may not represent the actual performance of the shallow collector.

CRITFC believes it is prudent that the Corps conduct further research and study on these potential options and quantify the results of all passage improvements that are moving forward at Bonneville Dam. Any passage solution for the First Powerhouse will involve tens of millions of dollars, and whatever decision the region makes on a final system, that decision, good or bad, will remain for decades into the future. The current list of recommendations and improvements being implemented at Bonneville Second Powerhouse and Spillway could likely reduce the need and importance of further improvements at the First Powerhouse to the point where other Corps' hydroelectric project improvements at upriver dams become a higher priority. Thus, the decision whether or not to implement any passage modifications at the First Powerhouse must take into account the entire FCRPS for all Corps managed dams

[2] Currently fish spill has been limited by dissolved gas caps and adult fish fallback concerns. With the addition of deflectors at the Bonneville Spillway and recent research that indicate that fallback is not significantly increased with increased spill, it is highly likely that fish spill volumes will be substantially increased.

[3] Bonneville Decision Document Table 19, assuming a current daytime spill cap of 75 kcfs, Second Powerhouse operational priority, and the installation of the other recommendations in the document. This difference is well within the errors of the analysis.

Third, the current First Powerhouse outfall has never been evaluated during the spring migration; it has only been evaluated for summer migrants. CRITFC concurs with the Corps' assumption and existing data that the current outfall release site for summer migrants is problematic and less than desirable. However, during the spring migration this may not be the case. The outfall failed for summer migrants due in part to predation. During spring migration, on the other hand, water temperatures are lower than for summer migrants, which is thought to be a major factor in lowering predation rates. Further, turbidity rates are higher during spring flows making predation less successful (NMFS 2000; Junge and Oakley 1966). A spring migrant survival evaluation to test the current First Powerhouse screen system was halted due to low flows for the 2001 spring season. Until research is conducted to obtain survival rates for spring migrants through the existing outfall, it is premature to make a recommendation. In addition, if the current outfall location performs better than the current model estimates used for spring migrants in the Document, the improvement in project survival from a First Powerhouse and screen option, currently modeled at less than 1%, will be even less.[4] This estimate assumes a Second Powerhouse operational priority.

Fourth, the Document prematurely recommends that the First Powerhouse screen system be modified with screen improvements, replacing the existing standard length traveling screens (STSs) with extended length bar screens (ESBSs). There have been documented cases at John Day Dam and at The Dalles where significant numbers of juvenile lamprey have been impinged and killed on ESBS screens (Starke and Dalen 1995). To date, there is no design to rectify these impacts. If the screen spacing is designed to meet fry criteria, the impacts to juvenile lamprey and fry could be diminished. This will need to be studied and documented before a recommendation can be made. Additional concerns have been raised for the new Vertical Barrier Screens (VBSs), which need to be installed with the ESBSs. The current VBS design does not meet fry criteria. Further, juvenile sockeye experience unacceptably high rate of descaling, exceeding 20%, when passing through ESBSs and supporting components of the bypass system (NWPPC 1999;CRITFC 1998).

Finally, before the region allocates a significant portion of the Columbia Basin Juvenile Fish Mitigation Program budget toward a new bypass system at the First Powerhouse, CRITFC believes the region should have a definitive or at least a strong indication with regards to certain critical uncertainties. The effects of multiple bypass and delayed mortality associated with mechanical screen bypass systems are critical uncertainties in which resolution is vital to the region before any decision on future bypass systems at the First Powerhouse can be made. This issue is still under analysis. Recent smolt-to-adult returns have shown that fish that pass through even one bypass have lower return rates than fish that were not detected in any bypass (IDFG 1998; CRITFC 2000).

Summary

CRITFC appreciates the opportunity to offer formal comments on the Bonneville Decision Document. CRITFC recommends that the decision about which long-term passage option to be pursued at the First Powerhouse be postponed until 1) studies are conducted to determine if further First Powerhouse improvements are needed after the regionally agreed-upon improvements at the Bonneville Dam Second Powerhouse and spillway have been implemented, 2) research can be

[4] Estimates of survival improvements this small are well into the uncertainty of the model, in other words, the error bounds around the model parameters could easily be greater than the estimates, making the survival estimates speculative.

APPENDIX F

conducted to determine the relationship between bypass systems, delayed mortality and adult returns, and, 3) the costly decision to implement new passage systems at the First Powerhouse becomes more appropriate considering the need for critical passage projects at upriver Corps dams and extremely limited capital construction budgets. Some of these projects were identified by the Northwest Power Planning Council in their report to Congress (NWPPC 1999), and include water quality improvement projects at Corps' dams that are a high priority for CRITFC and its member tribes. If these issues are resolved and a regional need is identified to implement a new passage system at the First Powerhouse, then the region needs to determine which option at that time is most appropriate. This may require further testing of concepts as additional information becomes available.

CRITFC believes the ongoing fish passage improvements at Bonneville Second Powerhouse and spillway will allow the region time and interim fish protection to better understand the uncertainties and concerns that we have raised in these comments. We look forward to working with the Corps and the region to address these issues. Should you have technical questions regarding these comments please contact Tom Lorz, fisheries hydraulic engineer, at (503) 238-3574.

Sincerely,

Don Sampson
Executive Director

cc: Colonel Fastabend, Bob Willis, Portland District Corps; Tribal Program Managers and Attorneys; Regional Directors of state and federal fisheries agencies; FPAC

APPENDIX F

REFERENCES

CRITFC. 2000. Comments on the NMFS white papers entitled: *Passage of juvenile and adult salmonids past Columbia and Snake River dams* and *Salmonid travel time and survival related to flow management in the Columbia River Basin*. In: CRITFC comments on the Corps of Engineers's draft Lower Snake River Salmon Migration Feasibility Report/Environmental Impact Statement. CRITFC. Portland, Oregon.

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