US Army Corps
of Engineers®
Portland District

Bonneville Configuration and Operation Plan Amendment #1

Juvenile Fish Passage Recommendations

MAY 2008

Executive Summary

The Bonneville Configuration and Operation Plan is a long-term strategic plan to improve the survival of juvenile salmonids passing the U.S. Army Corps of Engineers' (Corps) Bonneville Lock and Dam. This document amends the plan that was developed in 2002 based on research findings and fish passage improvements that have been implemented since then. The 2002 plan recommended the following:

- Bonneville 2nd Powerhouse (B2) is operated as the priority powerhouse
- Construct, operate, and evaluate the B2 Corner Collector
- Continue to evaluate methods to improve the B2 Fish Guidance Efficiency (FGE)
- Defer decision on Bonneville 1st Powerhouse (B1) configuration until critical information is available on
  - B1 sluiceway efficiency and survival
  - B1 DSM spring survival and
  - Adult fallback with high spill

Per the 2002 plan, the following items have been accomplished: B2 has been the priority powerhouse; the B2 Corner Collector has been constructed and evaluated; B2 FGE improvements are being constructed; and additional fish passage survival information has been collected on B1 and the spillway.

Biological data collected to date suggest the following differences in the assumptions made in the original Decision Document:

- B2CC survival is higher than anticipated
- Spillway survival is lower than expected
- B2CC utilization is less than anticipated for Chinook

The biological data has been collected over a limited range of operations and the values may change significantly with different operations. For example B2CC survival may not be 100% without spill. In addition there is between and within year variability that can mask the effect of operational changes, or operational changes may obscure variability in the biological factors.

The following actions are recommended for Bonneville Dam to achieve juvenile fish passage goals. In order of importance:

- Continue to operate B2 as the priority powerhouse
- Evaluate B2 FGE improvements
- Continue evaluating spillway operational improvements and implement permanent spill operation changes if results demonstrate spillway survival increases with test operations. If operational changes do not appreciably increase survival of salmon that pass through the spillway, develop and evaluate structural spillway survival improvements (2009).

- Complete evaluation of a shallow-draft BGS at B2, permanently install if results show that the BGS increases the proportion of chinook salmon that pass through the B2 Corner Collector (2009).
- Implement B1 sluiceway modifications to improve fish passage efficiency (FPE) and reduce forebay delay (2009).
- Conduct a project-wide survival and passage evaluation to verify performance standards have been achieved once B1 MGR installation, B1 sluiceway modifications, spillway survival improvements, B2 FGE improvements, and B2 BGS evaluations are complete (2010).
- Evaluate summer spill to TDG CAP at night versus fixed volume.

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Section 1 - Introduction

Bonneville Configuration and Operation Plan (COP) Amendment Number 1 documents the current long-term strategic plan to improve the survival of juvenile salmonids passing the U.S. Army Corps of Engineers' (Corps) Bonneville Lock and Dam and is amendment number 1 to the Bonneville Decision Document, Juvenile Fish Passage Recommendation published in December of 2002. The COP is to:

- Review and summarize current research on anadromous fish passage at Bonneville Dam
- Develop a framework from which to select future fish passage alternatives and
- Develop a long-term strategic plan to improve the survival of juvenile salmon and steelhead passing Bonneville.

A plan was developed in 2002 and documented in the Bonneville Decision Document, Juvenile Fish Passage Recommendation. The recommendations of that document are:

- B2 will be the priority powerhouse
- Construct, operate, and evaluate the B2 Corner Collector
- Continue to evaluate methods to improve the B2 Fish Guidance Efficiency (FGE)
- Defer decision on B1 configuration until critical information is available on
    - B1 sluiceway efficiency and survival
    - B1 DSM spring survival and
    - Adult fallback with high spill

To date the B2 Corner Collector has been constructed and evaluated, B2 FGE improvements are being constructed and additional information has been collected on B1 and the spillway. Bonneville's COP requires updating with this new information so that additional fish survival improvement alternatives can be developed and evaluated. The results will be a long-term strategic plan for achieving juvenile fish passage performance targets at Bonneville Dam.

Purpose and Need

In the 2000 and 2004 Biological Opinion (BiOp) for the Federal Columbia River Power System (FCRPS), the National Marine Fisheries Service (NMFS) established juvenile and adult fish survival goals for fish passing through the hydrosystem (NMFS 2000, 2004). In 2006, Judge Redden remanded the 2004 FCRPS BiOp and NMFS reinitiated consultation. It is anticipated that the revised BiOp will include dam-specific juvenile fish survival standards. For the purpose of this COP, tentative targets are; a dam passage survival value of 96% for Yearling Chinook and Steelhead, and a dam passage survival value of 93% for Subyearling Chinook. Dam passage survival includes passage beginning at the face of the dam through all routes of passage (turbines, spillway, juvenile bypass systems (JBS), and powerhouse surface bypass) and through the immediate tailrace to approximately 1 mile below the dam. When only route-specific survival estimates are available, or for the purpose of modeling, dam survival is calculated as the sum of the route specific survival estimates weighted by the proportion of fish passing through each route.

Decision Framework

The decision framework describes the criteria used to evaluate passage improvement alternatives at Bonneville. These criteria include fish passage survival, water quality, effects of configuration and operation changes on other species, life histories, cost (capital and operation and maintenance (O&M)), economic impacts, total dissolved gas (TDG), implementation timing and data uncertainty.

Fish Survival Modeling

Studies conducted at Bonneville have provided passage behavior and survival estimates for all routes of passage as well as for the dam as a whole over a range of project operations. These studies have provided information specific to the current configuration of Bonneville. However, for the purpose of this configuration and operation plan study it is necessary to use a model that provides an estimate of dam passage survival for the proposed alternatives.

The model used is the Simulated Passage Model (SIMPAS). The spreadsheet version of the model was developed by NMFS and was used in the 2000 and 2004 BiOp. As with all models, the results are dependent on the quality of the input parameters. Therefore, a key part of the effort in developing this report was using regionally agreed-upon input parameters. The baseline conditions were taken from the July 31st 2006 Remand Coordination Group and are consistent with the input for Comprehensive Fish Passage Model (COMPASS). In addition to SIMPAS modeling, other factors effecting passage survival estimates were considered as they may influence the estimates in ways that cannot or have not been measured. These include forebay behavior, tailrace egress, passage times and fish condition.

Section 2 - Background

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 the 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.

Location and Major Project Features

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 (B1) and Navigation Lock are between the Oregon shore and Bradford Island. The Spillway is between Bradford Island and Cascade Island. The Bonneville Second Powerhouse (B2) is between Cascade Island and the Washington shore.

Fish Passage Facilities

Four species of Pacific Salmon annually migrate past Bonneville: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*O. mykiss*), coho salmon (*O. kisutch*) and sockeye salmon (*O. nerka*). Yearling downstream migrants, including spring and summer Chinook salmon, steelhead, sockeye salmon and coho salmon pass Bonneville Dam from mid April through early June. Subyearling fall Chinook salmon outmigrants pass the dam from mid-June through August. Adult upstream migration occurs throughout the year, although the number of adult fish that pass during the winter months is relatively low. Visual fish counting at Bonneville occurs from April 1st through October 31st with video counts being done the remainder of the year.

Bonneville Dam fish passage facilities include:

- Adult fish ladders
- Bonneville 2nd Powerhouse (B2) Juvenile Bypass System
- B2 Corner Collector System
- Bonneville 1st Powerhouse (B1) Sluiceway (with the B1 screens pulled)
- Spillway

Figure 2-1 Bonneville Lock and Dam

Project Operations

Operational guidelines for Bonneville, as described in the 2004 FCRPS BiOp (NMFS 2004) and in the annual Fish Passage Plan developed by the Corps' Northwestern Division, are based upon many different factors that affect juvenile and adult passage at the dam. Factors include seasonal operation, turbine unit operation priority, turbine operations within 1% of peak efficiency, Bonneville Power Administration (BPA) power requirements, spillway patterns, scheduled maintenance, unplanned outages and other factors.

Flow distribution or operational rules, as described in the BiOp and the Fish Passage Plan, are:

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

Additional limitations or guidelines are:

- ✓ Maximum flow at B1 is 120 Kcfs (operating within 1%).
- ✓ Maximum flow at B2 is 144 Kcfs (operating within 1%).

River Flows at Bonneville

River flows at Bonneville can vary significantly throughout the year and during the juvenile fish passage season. Figure 2.2 shows the hydrograph that represents the lower Columbia River for a period of October 1973 through September 1999 . Peak flows generally occur at the end of May or first part of June and drop significantly by the start of July.

Spillway Operations

In the 2002 Bonneville Decision Document a key variable was spillway operations. Five spill flows were evaluated: 0 Kcfs, 50 Kcfs, 75 Kcfs, 125 Kcfs and 150 Kcfs. In this amendment several spill scenarios were evaluated. The new spill volumes are: 0 Kcfs, 75 Kcfs, 100 Kcfs, and 120 Kcfs.

Total Dissolved Gas

Total dissolved gas (TDG) supersaturation results when spillway discharge and entrained air plunge to depth in the stilling basin. Research shows that prolonged exposure to TDG levels above 120% is harmful to juvenile salmonids and other aquatic organisms. Currently, state and federal water quality criteria limit the saturation of TDG to 110% of atmospheric pressure. Oregon and Washington grant waivers applied for by the Corps that allow the Corps to exceed this limitation at Bonneville, up to a TDG level of 120% below the spillway and 115% measured downstream. Due to these limits spill at Bonneville can be limited. Special TDG restrictions are also placed on Bonneville to keep TDG levels at or below 105% when chum fry are emerging downstream of the project.

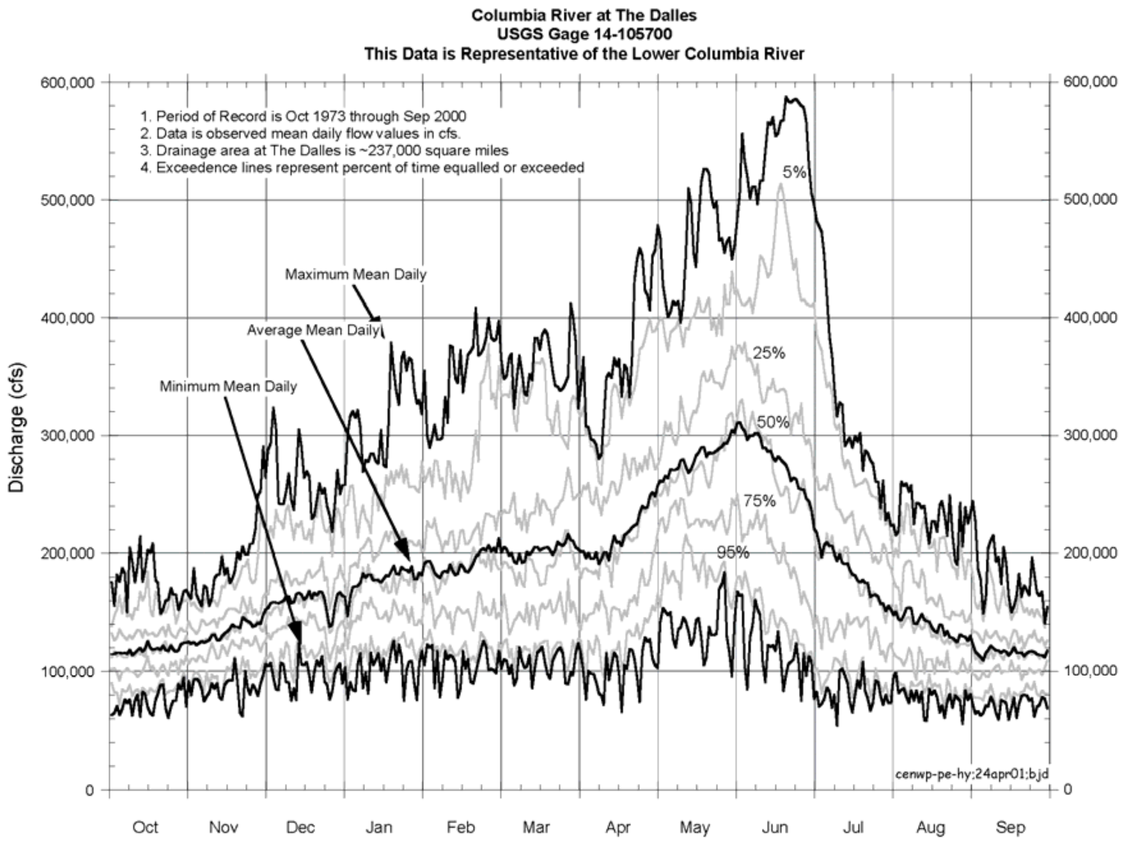

Figure 2.2 Lower Columbia River Hydrograph (October 1973 – September 1999)

Section 3 – Changes Since 2002

In 2002 the recommendations for improving juvenile fish passage at Bonneville were:

- B2 the priority powerhouse
- Construct and evaluate the B2 Corner Collector
- Continue to evaluate methods to improve the B2 FGE
- Defer decision on B1 configuration until critical information is available on
    - B1 sluiceway efficiency and survival
    - B1 DSM spring survival and
    - Adult fallback with high spill

The B2 Corner Collector has been constructed and evaluated, B2 FGE improvements are being implemented and additional information has been collected on B1 and the spillway. This section will highlight the changes since 2002 pertinent to juvenile fish passage at Bonneville, and will identify fish passage information that has become available since the original Decision Document was written, as well as update passage distribution and survival estimates that resulted from configuration changes and/or new information.

Biological Evaluations

Juvenile fish passage studies conducted at Bonneville Dam since 2001 are listed in Table 3.1. These studies were identified by the FCRPS BiOp Remand Collaborative Work Group as the best available information sources for updating fish passage efficiency and route-specific survival estimates at Bonneville Dam. Data from these studies are being used to evaluate alternatives in the Action Agencies Proposed Action, and will be used in this document in a similar manner.

Table 3.1. Passage Distribution and Survival Studies Conducted Since the 2002 Bonneville Decision Document.

Study Year	Citation	Metrics
2005	Adams 2005	Passage Distribution and Behavior
2005	Counihan et al. 2006a	Survival
2005	Ploskey et al. 2006	Passage Distribution
2004	Counihan et al. 2006b	Survival
2004	Reagan et al. 2006	Passage Distribution, Yearling Chinook and Steelhead
2004	Evans et al. 2006	Passage Distribution, Subyearling Chinook
2004	Ploskey et al. 2005	Passage Distribution
2003	Counihan et al. 2003a	Survival
2002	Evans et al. 2003	Passage Distribution and Behavior
2002	Counihan et al. 2003b	Survival
2002	Ploskey et al. 2003	Passage Distribution

Configuration Changes

Bonneville 1st Powerhouse Turbine Rehabilitation

Progress is being made in modifying the turbine units at B1 to the Minimum Gap Runner (MGR) units. As of 15 January 2008, units 1-6, 8 and 10 have been upgraded to MGR units. Unit 7 rehab is scheduled for completion by September 2008, and Unit 9 will be upgraded to an MGR unit by July 2010, completing the upgrade of all Powerhouse 1 turbines. With the current mix of MGRs and original turbine units, the estimated survival for juvenile migrants passing through the 1st Powerhouse turbines is 97.3% for yearling Chinook, and 95.4% for steelhead trout. Due to the limited operation of Powerhouse 1 during the 2004-05 subyearling Chinook migration seasons, sample sizes were not large enough to estimate turbine survival. Survival estimates are available for Powerhouse 1 sluiceway and turbines combined. The combined Powerhouse 1 survival from the 2004-05 studies is 90.0%.

Bonneville 1st Powerhouse Juvenile Bypass System

Following the 2003 juvenile fish migration season the screens at B1 were pulled. This was based on yearling Chinook survival data which showed that the B1 JBS had lower fish survival than fish passing through the turbine units (Counihan et al. 2003). Dawley et al (1993) had previously demonstrated that subyearling Chinook salmon survival was lower for fish passing the B1 JBS compared to turbine units. Following 2003 removal of the B1 STSs turbine unit priority was given to MGR units and unit priority set to maximize egress conditions from the turbines and the B1 sluiceway outfall.

Bonneville 1st Powerhouse Ice and Trash Sluiceway

There have been no major changes to the B1 sluiceway since 2002, however additional data have been collected on sluiceway passage efficiency and survival estimates. Current survival estimates for fish passing through the B1 sluiceway are 92.8% for yearling Chinook, 95.9% for steelhead and 90.0% (sluiceway and turbines combined) for subyearling Chinook. It should be noted that these estimates were obtained under lower than average flow conditions where few fish were passing through B1. It is likely that different sluiceway survival rates would be obtained under higher flow conditions with more juvenile fish passing through the powerhouse and sluiceway. The BiOp remand collaborative work group suggested applying a sluiceway passage rate of 60% of all B1-passed yearling Chinook and steelhead when B1 flow is less than 20% of the total river flow, and a sluiceway passage rate of 44% for yearling Chinook and steelhead when Powerhouse 1 flow is greater than 20% of the total river flow.

Bonneville 2nd Powerhouse Priority Operation

Adult salmon and steelhead radio-telemetry studies have shown that fallback rates of adult migrants exiting the B1 fish ladders at Bradford Island are substantially higher than for fish passing through the B2 fish ladder (Boggs et al. 2004). With B2 as the priority powerhouse, fewer adult fish are attracted to the B1 fishway entrances, and the result has been reduced fallback rates, particularly during mid to low-flow years. Juvenile fish survival estimates obtained since 2000 have suggested that all juvenile fish passage routes (e.g. turbines, corner collector, JBS) at B2 have higher survival rates than those at B1 (Counihan et al. 2005a; Counihan et al. 2005b). However these studies have been conducted in lower flow years and thus few test fish passed via B1 routes. As a result of this, B1 survival estimates were generated with a smaller sample size and are not as precise. Additionally, during a higher flow year with greater numbers of fish passing through B1, a predator response may result in different survival than those obtained under years with lower flow.

Bonneville 2nd Powerhouse Corner Collector

The B2 Corner Collector (B2CC) was constructed and first used in 2004. Passage efficiency and survival of juvenile salmonids passing through the corner collector was estimated in 2004 and 2005. The survival of juvenile fish that pass through the corner collector was estimated at 100% for yearling Chinook and steelhead and 99.7% for subyearling Chinook. B2CC passage efficiency, expressed as the percent of all fish passing the dam, was 19% for yearling Chinook, 42% for steelhead, and 22% for subyearling Chinook.

Bonneville 2nd Powerhouse Juvenile Bypass System

Improvements to B2 FGE were designed, evaluated and are currently under construction. The modification includes larger, balanced flow vertical barrier screens, screen gap closure devices, and gatewell turning vanes. Prototype testing occurred in 2002. Based on prototype testing, it is anticipated that FGE will be 56% for yearling Chinook and steelhead, and 46% for subyearling Chinook. Full implementation at all units should be completed by 2009. In addition to FGE data additional survival estimates have been obtained since the analysis in the 2002 Decision Document. Based on the best available data, and input from the FCRPS Remand Collaborative Work Group, the current estimates for smolt survival through the B2 JBS is 98% for yearling Chinook, 95.4% for steelhead, and 95.5% for subyearling Chinook.

Spillway

In 2002 spillway flow deflectors were added to bays 2, 3, 16, 17, and 18. In addition, the existing Bay 1 flow deflector was modified. The new configuration has flow deflectors at 7 feet NGVD on bays 1, 2, 3, 16, 17 and 18 and flow deflectors at 14 feet NGVD on bays 4 through 15. New spill patterns were developed and used for the first time in the 2002 spill season. Post-construction evaluation of the new deflectors and spill patterns revealed lower than expected spillway survival rates for juvenile Chinook (Table 3.2). The low spillway survival rates appear to be related to daytime passage, discharge, and deflector elevation. Studies were initiated in 2006 and continue to date, that attempt to separate these variables and isolate the mechanism for the low spillway survival.

	Yearling Chinook 2004		**Steelhead 2004**		**Subyearling Chinook 2004**	
	7' msl	**14' msl**	**7' msl**	**14' msl**	**7' msl**	**14' msl**
75K Day**	0.937 (0.018)	0.773 (0.045)	0.927 (0.046)	0.850 (0.063)	--	--
TDG Night	0.943 (0.026)	0.946 (0.018)	1.010 (0.016)	1.010 (0.015)	--	--
BiOp**	--	--	--	--	0.920 (0.010)	0.803 (0.026)
50K**	--	--	--	--	0.822 (0.033)	0.741 (0.027)
	Yealring Chinook 2005		**Steelhead 2005**		**Subyearling Chinook 2005**	
75K Day	0.946 (0.016)	0.893 (0.031)	0.908 (0.034)	0.861 (0.016)	0.930 (0.015)	0.845 (0.026)
TDG Night	0.949 (0.023)	0.963 (0.019)	1.004 (0.009)	0.989 (0.016)	0.996 (0.019)	1.006 (0.015)

* Daytime spill in 2002 was alternated between 75k (actually 48k) and the TDG cap but was at TDG cap levels the majority of the time. ** In 2004 the 75k spill was actually 48k and the 50k spill was 23k.

Table 3.2. Spillway passage survival estimates (with standard errors) for radio-tagged juvenile salmonids passing through spillbays with deep (7' MSL) and shallow (14' MSL) flow deflectors at Bonneville Dam, 2004 & 2005 (data from Counihan et al. 2006a&b).

In 2004 a discrepancy in the measured gate opening and the actual gate opening became known (measured being larger than the actual gate opening). This discrepancy resulted in smaller gate openings and spill being less than that reported. Reanalysis of spillway passage efficiency did not reveal a substantial difference from what had previously been reported: percent spill to percent fish ratios remain near 1:1.

SpringChinook

$$y = -0.1527x^2 + 1.1793x$$

Steelhead

$$y = -0.0593x^2 + 1.0928x$$

Where x is the percentage of spill and y is the percentage of fish that pass the project through the spillway. Data used to generate the new spill curves are presented in Tables 3.3 – 3.4.

Studies to evaluate the effect of increasing daytime spill on adult salmon and steelhead passage times and fall back rates were also conducted. These studies found that spill levels above 100 Kcfs resulted in longer passage times and increased fallback rates for adults (Caudill et al. 2006; Boggs et al. 2004). Studies have also shown a strong relationship with longer passage times resulting in lower escapement (Keefer et al. 2005).

Table 3.3 Spill Efficiency Estimates for Yearling Chinook Salmon at Bonneville Dam, 1997-2005.

Year	% of Total River Flow	% of Fish Passing Through the Spillway	Reference
1997	52.7%	75.2%	Hensleigh et al. 1999.
1998	40.1%	43.5%	Hensleigh et al. 1998
1999	35.0%	41.0%	Plumb et al. 2001
2000	34.0%	45.0%	Evans et al. 2001a
2001	22.0%	16.0%	Evans et al. 2001b
2001	37.0%	30.0%	Evans et al. 2001b
2001	16.0%	14.0%	Ploskey et al. 2002
2001	37.0%	38.0%	Ploskey et al. 2002
2002	44.3%	57.0%	Evans et al. 2003
2004	32.9%	33.0%	Reagan et al. 2005
2004	24.4%	26.0%	Reagan et al. 2005
2004	49.9%	51.0%	Reagan et al. 2005
2005	39.0%	38.0%	Counihan et al. 2005b

Table 3.4. Spill Efficiency estimates for steelhead trout at Bonneville Dam, 1997-2005.

Year	% of Total River Flow	% of Fish Passing Through the Spillway	Reference
1997	52.7%	71.0%	Hensleigh et al. 1999
1998	40.1%	40.9%	Hensleigh et al. 1998
1999	35.0%	39.0%	Plumb et al. 2001
2000	34.0%	34.0%	Evans et al. 2001a
2001	16.0%	14.0%	Ploskey et al. 2002
2001	37.0%	38.0%	Ploskey et al. 2002
2004	44.3%	55.0%	Evans et al. 2003
2004	32.9%	25.5%	Reagan et al. 2005
2004	24.4%	12.0%	Reagan et al. 2005
2004	49.9%	54.0%	Reagan et al. 2005
2005	39.0%	40.0%	Counihan et al. 2005b

Section 4 - Baseline Conditions

The baseline conditions used during the development of the original Decision Document in 2002, the anticipated benefits of the B2CC and B2 FGE improvements as well as the current baseline conditions are defined in Table 4.1. The numbers in Table 4.1 are consistent with the COMPAS inputs. In 2002 the yearling Chinook and Steelhead data was not split between day and night as it is for the 2006 baseline.

Observations from the table suggest that:

- B2CC survival is higher than anticipated
- Spillway survival is lower than expected
- B2CC utilization is less than anticipated for Chinook

The biological data has been collected over a limited range of operations and the values may change significantly with different operations. For example B2CC survival may not be 100% without spill. In addition there is between and within year variability that can mask the effect of operational changes, or operational changes may obscure variability in the biological factors.

In Table 4.1 the dam project survival numbers were computed for 100 Kcfs spill operations 24 hours a day. This suggests that there has been an improvement in overall dam project survival since 2002 with the addition of the B2CC and the improvements to the B2 FGE. The exception is subyearling Chinook which is being driven by poor spillway survival (74-91%). The screens at B1 were removed and this had a positive impact on dam project survival.

Table 4.1 Bonneville Baseline Survival Information
Dam Project Survival Computed for 100 Kcfs Spill 24 hours a day

		Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse						
	Timing	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	Spillway Survival	Dam Project Survival
Yearling Chinook	2002 - baseline	0.39	0.9	0.9	0.22	0.98	0.48	0.9	0.98	0	0	0.98	96%
Yearling Chinook	2002 - Expectation	0.39	0.9	0.9	0.22	0.98	0.6	0.9	0.98	0.46	0.98	0.98	97%
Yearling Chinook - Day	Nov-06	0	0.943	0	0.6/0.44	0.928	0.33	0.939	0.969	0.43	1	0.969	97%
Yearling Chinook - Night	Nov-06	0	0.953	0	0.6/0.44	0.928	0.33	0.98	1	0.18	1	0.969	98%
Steelhead	2002 - baseline	0.41	0.9	0.9	0.22	0.98	0.48	0.9	0.98	0	0	0.98	96%
Steelhead	2002 - Expectation	0.41	0.9	0.9	0.22	0.98	0.6	0.9	0.98	0.62	0.98	0.98	97%
Steelhead - Day	Nov-06	0	0.927	0	0.6/0.44	0.959	0.35	0.83	0.923	0.6	1	0.888	92%
Steelhead - Night	Nov-06	0	0.941	0	0.6/0.44	0.959	0.35	0.917	0.987	0.6	1	1	98%
Sub-yearling Chinook	2002 - baseline	0.09	0.8	0.82	0.06	0.95	0.28	0.94	0.98	0	0	0.98	97%
Sub-yearling Chinook	2002 - Expectation	0.09	0.8	0.82	0.06	0.95	0.4	0.94	0.98	0.47	0.98	0.98	97%
Sub-yearling Chinook	Nov-06	0	0.904	0	0.6/0.44	0.93	0.28	0.86	0.95	0.3	0.99	0.894	90%

Section 5 – Alternatives

In this section, each fish passage alternative considered is briefly described and an estimated total cost is provided. Existing studies and reports were used to determine the features, costs, and schedules for each alternative. The benefits of each alternative were estimated and included survival improvements.

The cost estimates for the alternatives were taken from various sources. The total cost for implementing each alternative was developed using three primary cost calculations: the design development work that includes model studies, biological testing and engineering design; the construction phase which includes costs to develop plans and specifications, construction contract supervision and administration, and engineering during construction (these costs are estimated from percentages of the construction contract and vary based upon the complexity, duration, and unknowns of the job); and operational and maintenance (O&M) and post construction monitoring costs, which includes biological testing costs to determine and confirm acceptable project operations.

The key areas for improvement are:

- Spillway Survival
- Increased utilization of the B2CC
- Increased understanding of the robustness of the B1 survival numbers to determine the best route of passage at B1 for juvenile passage

All alternatives relate to one or more of the key improvement areas and are:

- Spillway Improvements
- B2 BGS
- B1 Sluiceway Improvements if the best B1 juvenile passage route is the sluiceway
    - Sluiceway Improvements
    - BGS
    - Sluiceway Outfall Relocation

Alternative 1 – Spillway Improvements

There is an on-going effort to understand cause of lower than expected spillway survival. The likely factors are related to gate opening size, deflector elevation or a combination of the two. Data suggest that increases in spill volume also increases depth over the deflectors and spillway survival. The goal is to identify operational changes (spill patterns and minimum spill levels) that provide the highest survival and still meet water quality requirements. To meet the minimum gate opening and egress conditions spill levels could be high enough to exceed the TDG requirements downstream. At this time no construction dollars are associated with this alternative and dollars are limited to hydraulic and biological studies. There is a potential for hydropower impacts if the minimum spill volume for good survival is changed from 50 Kcfs to 75 or 100 Kcfs.

Alternative 2 – B2 BGS

The Corps is investigating the use of a shallow draft behavioral guidance system (trash shear boom) as a way to increase the proportion of salmon that pass B2 through the Corner Collector. It is assumed that the BGS will increase the Corner Collector efficiency for yearling and subyearling Chinook by 15% and 5% for steelhead. These increases in efficiency would result in dam passage survival increases of 0.2% for yearling Chinook, subyearling Chinook, and steelhead. The shallow draft BGS is also expected to reduce forebay residence times for juvenile salmonid migrants. The cost of the shallow draft BGS was approximately $3,000,000.

Alternative 3 – B1 Sluiceway Improvements

B1 turbine survival is higher than sluiceway survival; thus the biological benefits associated with sluiceway improvements are limited. Although there is a general belief that sluiceway passage may provide long term survival benefits since a surface passage route tends to reduce forebay retention time. The inference afforded by biological data collected at B1 is limited by small sample sizes causing concerns with making critical decisions regarding improvements to the B1 sluiceway.

Sluiceway Improvements

Sluiceway improvements fall into three categories: improvements to the sluiceway entrance and channel, improvements in the forebay to guide fish to the sluiceway (BGS) and relocation of the sluiceway outfall.

An engineering study is nearing completion that evaluated different sluiceway alternatives. The alternatives included a do nothing alternative; an alternative to put automatic gates on select sluiceway entrances; and an alternative that includes automatic gates and improvements to the sluiceway channel. The costs for each alternative range from 2 to 9 million and are detailed in Bonneville First Powerhouse Sluiceway Modification for Fish Passage.

The biological benefits associated with the B1 Sluiceway Improvement are to increase sluiceway passage efficiency to 60% of the B1 juvenile fish.

Section 6 –Evaluation

Section 5 discussed the alternatives being studied and Table 6.1 shows the anticipated biological benefit associated with each alternative. The guidance and dam passage survival estimates were determined by SIMPAS, a spreadsheet model developed by NMFS. SIMPAS assumes that the fish arriving at the project are distributed between the primary features (Spillway, B2 and B1) based on flow percentage.

Estimates are computed for:

- 3 Species
  - Spring Chinook
  - Steelhead
  - Fall Chinook
- High, Medium and Low Flows
  - Weighted Average of Flows
- Day and night passage estimates were computed for Spring Chinook and Steelhead
- Baseline and Alternatives presented in Section 5

The guidance and dam passage survival estimates for baseline information is presented in Table 4.1 and in Table 6.1. SIMPAS results are presented in Table 6.2. The following observations can be made from the results presented in Table 6.2:

- Spring Chinook Dam Passage Survival numbers exceed the target value of 95% day and night without any additional improvements. There is a 0.4% improvement if spillway survival can be increased to 98%.
- Steelhead Dam Passage Survival numbers exceed the target value of 95% during the night without any additional improvements.
- Steelhead Dam Passage Survival numbers do not meet the target value of 95% during the day and spillway survival improvements are necessary to get to the 95% target level.
- Subyearling Chinook Dam Passage Survival numbers do not meet the target value of 93% and spillway improvements achieve the 93% target level. The B2CC BGS also achieves 93% dam passage survival with zero spill.
- B1 sluiceway improvements produce no discernable increase in overall Project survival.
- Relocating the B1 outfall does increase overall Project survival for all species under all conditions.

Discussion

The observations identify the following:

- The most important alternative for improving dam passage survival is improving spillway survival.
- The key data gap is the robustness of the survival numbers given the range of operations evaluated.

Table 6.2 results are based on a 24 hour spill volume not the current operation of a set spill volume during the day and gas cap at night. The SIMPAS results suggest that a 24 hour spill volume would achieve the target survival levels.

Table 6.1 SIMPAS Inputs

Spring Chinook Day

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse					
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	Spillway Survival
Baseline	0	0.943	0	0.6/0.44	0.928	0.33	0.939	0.969	0.43	1	0.969
Baseline + Spillway Imp	0	0.943	0	0.6/0.44	0.928	0.33	0.939	0.969	0.43	1	0.98
Baseline + B2 BGS	0	0.943	0	0.6/0.44	0.928	0.33	0.939	0.969	0.55	1	0.969
Baseline + B1 Outfall Relocation	0	0.943	0	0.6/0.44	1	0.33	0.939	0.969	0.43	1	0.969
Baseline + B1 Sluiceway Improvements	0	0.943	0	0.6	0.928	0.33	0.939	0.969	0.43	1	0.969
Baseline + Spillway Imp + B2 BGS	0	0.943	0	0.6/0.44	0.928	0.33	0.939	0.969	0.55	1	0.98
Baseline + All B1	0	0.943	0	0.6	1	0.33	0.939	0.969	0.43	1	0.969

Spring Chinook Night

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse					
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	Spillway Survival
Baseline	0	0.953	0	0.6/0.44	0.928	0.33	0.98	1	0.18	1	0.969
Baseline + Spillway Imp	0	0.953	0	0.6/0.44	0.928	0.33	0.98	1	0.18	1	0.98
Baseline + B2 BGS	0	0.953	0	0.6/0.44	0.928	0.33	0.98	1	0.33	1	0.969
Baseline + B1 Outfall Relocation	0	0.953	0	0.6/0.44	1	0.33	0.98	1	0.18	1	0.969
Baseline + B1 Sluiceway Improvements	0	0.953	0	0.6	0.928	0.33	0.98	1	0.18	1	0.969
Baseline + Spillway Imp + B2 BGS	0	0.953	0	0.6/0.44	0.928	0.33	0.98	1	0.33	1	0.98
Baseline + All B1	0	0.953	0	0.6	1	0.33	0.98	1	0.18	1	0.969

Steelhead Day

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse					
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	Spillway Survival
Baseline	0	0.927	0	0.6/0.44	0.959	0.35	0.83	0.923	0.6	1	0.888
Baseline + Spillway Imp	0	0.927	0	0.6/0.44	0.959	0.35	0.83	0.923	0.6	1	0.98
Baseline + B2 BGS	0	0.927	0	0.6/0.44	0.959	0.35	0.83	0.923	0.65	1	0.888
Baseline + B1 Outfall Relocation	0	0.927	0	0.6/0.44	1	0.35	0.83	0.923	0.6	1	0.888
Baseline + B1 Sluiceway Improvements	0	0.927	0	0.6	0.959	0.35	0.83	0.923	0.6	1	0.888
Baseline + Spillway Imp + B2 BGS	0	0.927	0	0.6/0.44	0.959	0.35	0.83	0.923	0.65	1	0.98
Baseline + All B1	0	0.927	0	0.6	1	0.35	0.83	0.923	0.6	1	0.888

Steelhead Night

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse					
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	Spillway Survival
Baseline	0	0.941	0	0.6/0.44	0.959	0.35	0.917	0.987	0.6	1	1
Baseline + Spillway Imp	0	0.941	0	0.6/0.44	0.959	0.35	0.917	0.987	0.6	1	1
Baseline + B2 BGS	0	0.941	0	0.6/0.44	0.959	0.35	0.917	0.987	0.65	1	1
Baseline + B1 Outfall Relocation	0	0.941	0	0.6/0.44	1	0.35	0.917	0.987	0.6	1	1
Baseline + B1 Sluiceway Improvements	0	0.941	0	0.6	0.959	0.35	0.917	0.987	0.6	1	1
Baseline + Spillway Imp + B2 BGS	0	0.941	0	0.6/0.44	0.959	0.35	0.917	0.987	0.65	1	1
Baseline + All B1	0	0.941	0	0.6	1	0.35	0.917	0.987	0.6	1	1

Sub Yearling Day and Night

	Bonneville 1st Powerhouse					Bonneville 2nd Powerhouse					
	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	FGE	Turbine Survival	Bypass Survival	SBC or Sluice Effectiveness	SBC or Sluice Survival	Spillway Survival
Baseline	0	0.904	0	0.6/0.44	0.93	0.28	0.86	0.95	0.3	0.99	0.894
Baseline + Spillway Imp	0	0.904	0	0.6/0.44	0.93	0.28	0.86	0.95	0.3	0.99	0.98
Baseline + B2 BGS	0	0.904	0	0.6/0.44	0.93	0.28	0.86	0.95	0.45	0.99	0.894
Baseline + B1 Outfall Relocation	0	0.904	0	0.6/0.44	1	0.28	0.86	0.95	0.3	0.99	0.894
Baseline + B1 Sluiceway Improvements	0	0.904	0	0.6	0.93	0.28	0.86	0.95	0.3	0.99	0.894
Baseline + Spillway Imp + B2 BGS	0	0.904	0	0.6/0.44	0.93	0.28	0.86	0.95	0.45	0.99	0.98
Baseline + All B1	0	0.904	0	0.6	1	0.28	0.86	0.95	0.3	0.99	0.894

Table 6.2 Bonneville Configuration and Operation											
Amendment Number 1											
Maximum flow through B2 = 144 Kcfs											
Maximum flow through B1 = 120 Kcfs											
Minimum flow through powerhouse = 30 Kcfs											
	FPE						**Survival**				
	0	50	75	100	120		0	50	75	100	120
Weighted Average Spring Chinook Day											
Alternatives											
Baseline	0.6459	0.6895	0.7250	0.7569	0.7873		0.962	0.964	0.965	0.966	0.967
Baseline + Spillway Imp	0.6459	0.6895	0.7250	0.7569	0.7873		0.964	0.967	0.969	0.970	0.973
Baseline + B2 BGS	0.6913	0.7336	0.7656	0.7942	0.8230		0.965	0.968	0.968	0.968	0.970
Baseline + B1 Outfall Relocation	0.6459	0.6895	0.7250	0.7569	0.7873		0.970	0.970	0.970	0.970	0.970
Baseline + B1 Sluiceway Improvements	0.6855	0.7184	0.7484	0.7717	0.7997		0.961	0.964	0.965	0.965	0.967
Baseline + Spillway Imp + B2 BGS	0.6913	0.7336	0.7656	0.7942	0.8230		0.968	0.970	0.972	0.973	0.975
Baseline + B1 Sluiceway Imp + Spillway	0.6855	0.7184	0.7484	0.7717	0.7997		0.963	0.967	0.969	0.970	0.972
Weighted Average Spring Chinook Night											
Alternatives											
Baseline	0.551	0.598	0.640	0.679	0.713		0.974	0.975	0.975	0.975	0.976
Baseline + Spillway Imp	0.551	0.598	0.640	0.679	0.713		0.976	0.978	0.979	0.979	0.981
Baseline + B2 BGS	0.608	0.653	0.691	0.726	0.758		0.975	0.976	0.976	0.976	0.977
Baseline + B1 Outfall Relocation	0.551	0.598	0.640	0.679	0.713		0.981	0.981	0.980	0.979	0.978
Baseline + B1 Sluiceway Improvements	0.591	0.627	0.664	0.694	0.725		0.974	0.975	0.975	0.975	0.976
Baseline + Spillway Imp + B2 BGS	0.608	0.653	0.691	0.726	0.758		0.977	0.979	0.980	0.980	0.982
Baseline + B1 Sluiceway Imp + Spillway	0.591	0.627	0.664	0.694	0.725		0.981	0.981	0.980	0.979	0.978
Weighted Average Steelhead Day											
Alternatives											
Baseline	0.694	0.740	0.771	0.803	0.834		0.934	0.930	0.925	0.922	0.918
Baseline + Spillway Imp	0.694	0.740	0.771	0.803	0.834		0.950	0.953	0.956	0.958	0.961
Baseline + B2 BGS	0.711	0.757	0.787	0.817	0.849		0.938	0.933	0.929	0.925	0.921
Baseline + B1 Outfall Relocation	0.694	0.740	0.771	0.803	0.834		0.939	0.934	0.929	0.925	0.919
Baseline + B1 Sluiceway Improvements	0.743	0.775	0.800	0.821	0.850		0.936	0.931	0.926	0.923	0.918
Baseline + Spillway Imp + B2 BGS	0.711	0.757	0.787	0.817	0.849		0.953	0.957	0.959	0.962	0.964
Baseline + B1 Sluiceway Imp + Spillway	0.743	0.775	0.800	0.821	0.850		0.951	0.954	0.957	0.959	0.962
Weighted Average Steelhead Night											
Alternatives											
Baseline	0.694	0.740	0.771	0.803	0.834		0.972	0.976	0.979	0.982	0.985
Baseline + Spillway Imp	0.694	0.740	0.771	0.803	0.834		0.972	0.976	0.979	0.982	0.985
Baseline + B2 BGS	0.711	0.757	0.787	0.817	0.849		0.974	0.978	0.981	0.983	0.986
Baseline + B1 Outfall Relocation	0.694	0.740	0.771	0.803	0.834		0.978	0.980	0.983	0.985	0.987
Baseline + B1 Sluiceway Improvements	0.743	0.775	0.800	0.821	0.850		0.973	0.977	0.980	0.982	0.985
Baseline + Spillway Imp + B2 BGS	0.711	0.757	0.787	0.817	0.849		0.974	0.978	0.981	0.983	0.986
Baseline + B1 Sluiceway Imp + Spillway	0.743	0.775	0.800	0.821	0.850		0.973	0.977	0.980	0.982	0.985
Weighted Average SubYearling											
Alternatives											
Baseline	0.495	0.713	0.777	0.793	0.788		0.917	0.907	0.904	0.903	0.904
Baseline + Spillway Imp	0.495	0.713	0.777	0.793	0.788		0.917	0.945	0.952	0.954	0.954
Baseline + B2 BGS	0.583	0.768	0.822	0.837	0.834		0.930	0.915	0.911	0.910	0.910
Baseline + B1 Outfall Relocation	0.495	0.713	0.777	0.793	0.788		0.924	0.909	0.906	0.903	0.904
Baseline + B1 Sluiceway Improvements	0.515	0.723	0.777	0.793	0.788		0.918	0.907	0.904	0.903	0.904
Baseline + Spillway Imp + B2 BGS	0.583	0.768	0.822	0.837	0.834		0.930	0.953	0.959	0.961	0.960
Baseline + B1 Sluiceway Imp + Spillway	0.515	0.723	0.777	0.793	0.788		0.918	0.945	0.952	0.954	0.954

Section 7 – Recommendations

It is recommended that the following actions be implemented at Bonneville Dam to achieve juvenile fish passage goals. In order of importance:

- Continue evaluating spillway operational improvements and implement permanent spill operation changes if results demonstrate spillway survival increases with test operations. If operational changes do not appreciably increase survival of salmon that pass through the spillway, develop and evaluate structural spillway survival improvements (2009).
- Complete evaluation of a shallow-draft BGS at B2, permanently install if results show that the BGS increases the proportion of chinook salmon that pass through the B2 Corner Collector (2009).
- Implement B1 sluiceway modifications to improve fish passage efficiency (FPE) and reduce forebay delay (2009).
- Conduct a project-wide survival and passage evaluation to verify performance standards have been achieved once B1 MGR installation, B1 sluiceway modifications, spillway survival improvements, B2 FGE improvements, and B2 BGS evaluations are complete (2010).
- Evaluate summer spill to TDG CAP at night versus fixed volume.

Section 8 – References

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