US Army Corps
Of Engineers
Portland District

The Dalles
Configuration and Operation Plan

November 2008

Executive Summary

This Configuration and Operation Plan (COP) documents the long-term strategic plan to improve the survival of juvenile salmonids passing the U.S. Army Corps of Engineers' (COE) The Dalles Lock and Dam (TDA). The purpose of this COP is to summarize the current knowledge about anadromous fish passage at TDA; to develop a decision framework identifying potential fish passage survival improvement alternatives; and to develop a comprehensive strategic plan to improve the survival of ESA-listed salmonids passing TDA. The overarching plan is to meet targeted biological performance standards established in the National Marine Fisheries Service's (NMFS) Biological Opinion (BiOp). These targeted standards include 96% and 93% total dam passage survival rate for ESA-listed springtime and summertime juvenile salmonid migrants passing TDA, respectively (NMFS 2008).

Herein, baseline conditions are defined as with the existing bay 6/7 spillwall in place. Under these conditions targeted performance standards are not being met and additional improvements are needed. The decision framework used the following criteria to evaluate passage improvement alternatives at TDA; juvenile fish survival, water quality, effects on other species, cost (capital and operation and maintenance (O&M)), economic impacts, total dissolved gas (TDG), implementation timing and data uncertainty.

This TDA COP identifies the following alternatives as having the highest potential to meet the targeted performance objectives

- Improved spillway egress conditions
- Sluiceway improvements
- Increased turbine-passage survival

The strategic plan developed for TDA consists of Phase I – and if necessary – Phase II actions. Phase I actions include:

(1) Spillwall from between bays 8/9 to near the thalweg

(2) Initiate a feasibility report on sluiceway improvements modifying gate entrance configurations and/or increasing overall sluiceway capacity

(3) Evaluate turbine operation and geometry as means to increase turbine-passage survival

(4) Design, construction and biological testing of selected alternative(s).

Decision points and evaluation loops are part of the overall strategy to facilitate input and direction from Portland District and regional fish managers.

The Dalles
Configuration and Operation Plan

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Section 1 - Introduction

The Dalles Configuration and Operation Plan (COP) documents the strategic plan to improve the survival of juvenile salmonids passing the U.S. Army Corps of Engineers' (COE) The Dalles Lock and Dam (TDA). Located at the head of Lake Bonneville, TDA is approximately 192 miles upstream of the mouth of the Columbia River. Construction of TDA began in 1952, and water was first impounded in 1957.

Purpose and Need

The purpose of this COP is to determine how fish passage survival at TDA can be improved. In the Biological Opinion (BiOp) for operation of the federal Columbia River power system (FCRPS), the National Marine Fisheries Service (NMFS) establishes juvenile and adult fish survival standards for fish passing through the FCRPS (NMFS 2008). Biological performance standards from the BiOp for juvenile salmonids passing TDA include; a 96% total dam passage survival rate for juvenile spring salmonids and a 93% total dam passage survival rate for summer salmonids. Dam passage survival includes all routes of passage [turbine, spillway, and sluiceway] and through the immediate tailrace to approximately 0.5 mile below the dam (Peven et al. 2005).

Currently, juvenile survival rates for a specific passage route at TDA are estimated to range from 80% to 98%. The variability in survival rates are due to a variety of reasons including different species, different routes that fish pass through the dam, and year to year variability (Section 3). An example of the passage route distributions and commensurate survival rates of yearling Chinook salmon are available in Figure 1.1. In this particular example dam passage survival is 93%.

Some inherent assumptions within this strategic plan include, but are not limited to, that increases in dam passage survival should be accomplished with a cost-effective approach, should not negatively affect other salmonid life histories, other aquatic species, or water quality. It has been assumed that TDG water quality waivers would be in place in the future and spill is the preferred passage route for juvenile salmonids. In addition, improvements must be consistent with the authorized uses of the project; navigation, hydropower, and recreation. Finally, the survival improvement(s) need to be implemented in a time-frame that is responsive to the Biological Opinion.

Specific study objectives of the COP include:

- Define the baseline condition (survival and fish distribution through different passage routes) for anadromous fish passage at TDA.
- Identify and prioritize the fish passage alternatives to be evaluated.
- Develop a decision framework from which the most promising alternative(s) will be evaluated.
- Identify critical information gaps needed to make decision on biological and/or hydraulic information for future fish passage improvements.

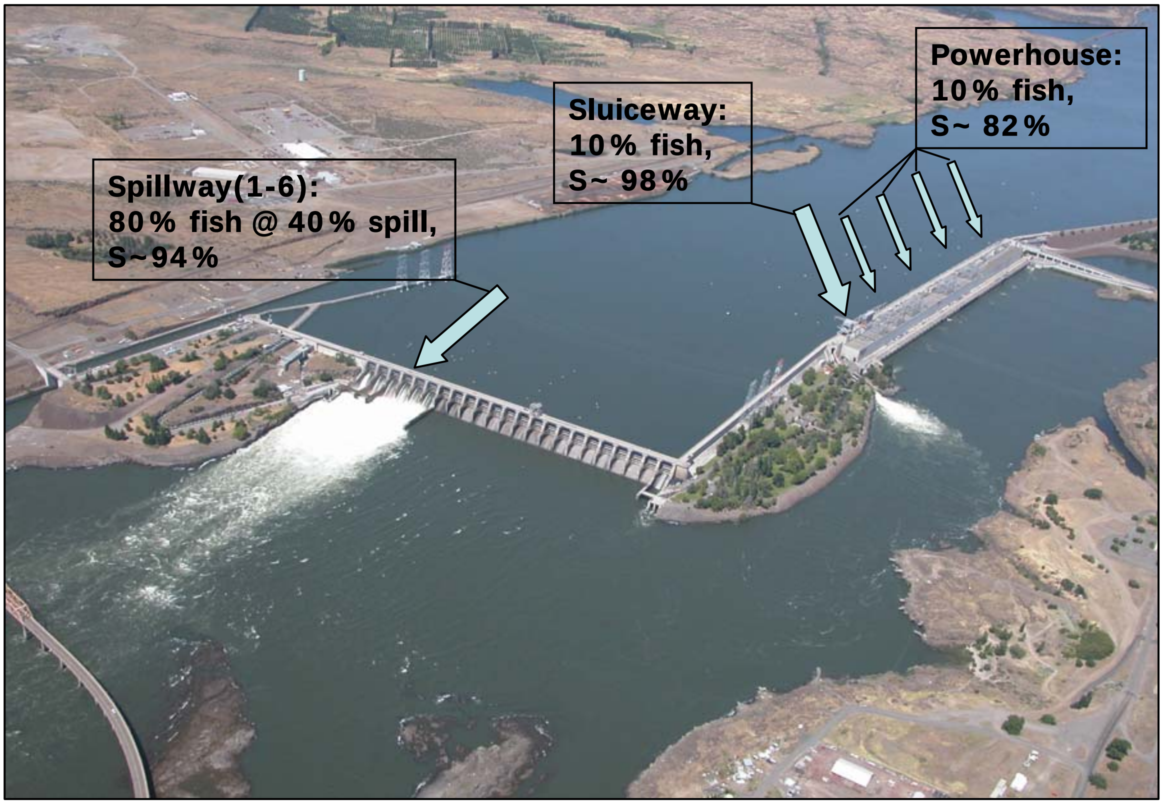

Figure 1-1 Yearling Chinook Distribution and Survival

Fish Survival Modeling

Studies conducted at TDA have provided passage behavior and survival estimates for all routes of passage as well as for the dam as whole over a range of project operations. These studies have provided good information for the current configuration of TDA. Development of the strategic plan decision framework used data from these survival studies to numerically model dam passage survival for the proposed alternative(s).

The model used for this purpose is the Simulated Passage Model (SIMPAS). The spreadsheet version of SIMPAS was developed by NMFS and uses water flow level, passage distribution data (e.g., spill passage efficiency, fish guidance efficiency) and route specific survival estimates to derive total juvenile survival of ESA-listed species during downstream migration through different passage routes and hydropower projects. The SIMPAS model was applied to predicatively illustrate the numerical consequences of alternative(s) implementation. As with all models, the results are only as good as the input parameters. Therefore, a key part of the effort in developing this report was using regionally agreed-upon input parameters for SIMPAS. In addition to SIMPAS modeling, other effects on juvenile fish passage were considered as they may influence fish survival. These include forebay behavior, tailrace egress, dam passage times, and fish condition.

Report History and Outline

The development of the TDA COP was initiated during the period the 6/7 spillwall was under construction. Emphasis was on forebay improvements and the ability to reduce spill while maintaining or enhancing high spillway passage efficiencies. While a primary goal of the 6/7 spillwall was attained (i.e., reducing lateral flow), biological expectations (i.e., performance standards) were not achieved and additional spillway improvements became a priority. Several Feasibility Reports and Design Documentation Reports (DDR) were developed for alternatives that have since been shelved or eliminated from consideration. A list of these alternatives and their current status are available in Appendix A. For example, a DDR was developed for a behavioral guidance structure (BGS); however, the concept put-forth in that DDR has been shelved for the time being since this design and alignment negatively impacts navigation.

The baseline configuration for TDA is with the 6/7 spillwall and the spill level is set at 40% during the spill season. Under such a water flow allocation spillway improvements have been shown to provide the best opportunity to reach targeted performance standards. To that end – a DDR for a full length 8/9 spillwall – was developed and construction has been initiated.

The TDA project and current operations are described in Section 2. A summary of current biotic data are available in Section 3. The baseline conditions are presented in Section 4 - which uses the information documented in Section 3 - to provide dam passage survival estimates and identify dam passage survival gaps that exist at TDA. The structural alternatives developed to close these survival gaps are presented in Section 5. A discussion of the potential benefits associated with the differing alternatives is also presented in Section 5. Finally, the recommendations from this strategic plan are identified in Section 6; including, a flow chart identifying critical decision points.

An earlier draft version of the COP is presented in Appendix B. This COP was initiated and sent out for Regional review in 2004/2005 during the period when the 6/7 spillwall was being constructed. At that time it was thought that the 6/7 spillwall would improve spillway survival sufficiently that the next goal at TDA would be to reduce turbine entrainment. Biological results from post-construction spillwall and several hydraulic/design studies later substantially more data is available and has been factored into the current COP. Regardless, Appendix B has been included because of some of the decisions that were identified during the development of that document are pertinent to the decisions and the path presented in this document.

Section 2 - Background

Location and Major Project Features

The Dalles Lock and Dam (TDA) is located at the head of Lake Bonneville, approximately 192 miles upstream of the mouth of the Columbia River.

Features

The project includes a navigation lock, spillway, powerhouse, fish passage facilities, ice and trash sluiceway, and the non-overflow dam, see Figure 2-1. The fish passage facilities for the migration of adult anadromous fish consist of two fish ladders, powerhouse fish collection systems and a transportation channel. The powerhouse has 22 main turbine units, two fish turbine units and two station service units. The fish turbine units provide the attraction flow water for the fish ladders. The powerhouse and the non-overflow dam are at right angles to the main river flow. The spillway contains 23 spillway bays. Each 50-foot wide bay is controlled with a tainter gate (47-foot radius) and is separated from adjoining bays with a 10-foot wide pier.

Figure 2-1 The Dalles Project

Several operational and structural changes have been implemented over time at TDA to improve juvenile fish passage. The key items are:

- Use of the Powerhouse ice and trash sluiceway as a fish passage route.
- Development of spill patterns and spilling a percentage of the river.
- Modified the spillway with a spillwall in 2004 between bays 6 and 7.

Unique Characteristics

The bathymetry at TDA is very irregular, Figure 2-2. In the forebay the thalweg creates a narrow, deep canyon in the middle of the river (Figure 2-2). The minimum elevation is the thalweg is about –120 feet mean sea level (msl). The width of the canyon created by the thalweg expands rapidly about 1,500 feet upstream of the powerhouse. This depression covers almost the entire width of the river a distance of 1,100 feet upstream of the powerhouse. The geometry of this depression influences the bathymetry significantly more on the eastern side of the river close to powerhouse unit 22. The bathymetry in the immediate vicinity of the powerhouse is relatively smooth. The invert level of the powerhouse units is at 58 feet msl, and the river bed elevation increases away from the powerhouse. Near the spillway, the bathymetry of the river is relatively flat, with the bed elevation varying from 80 feet msl to 100 feet msl.

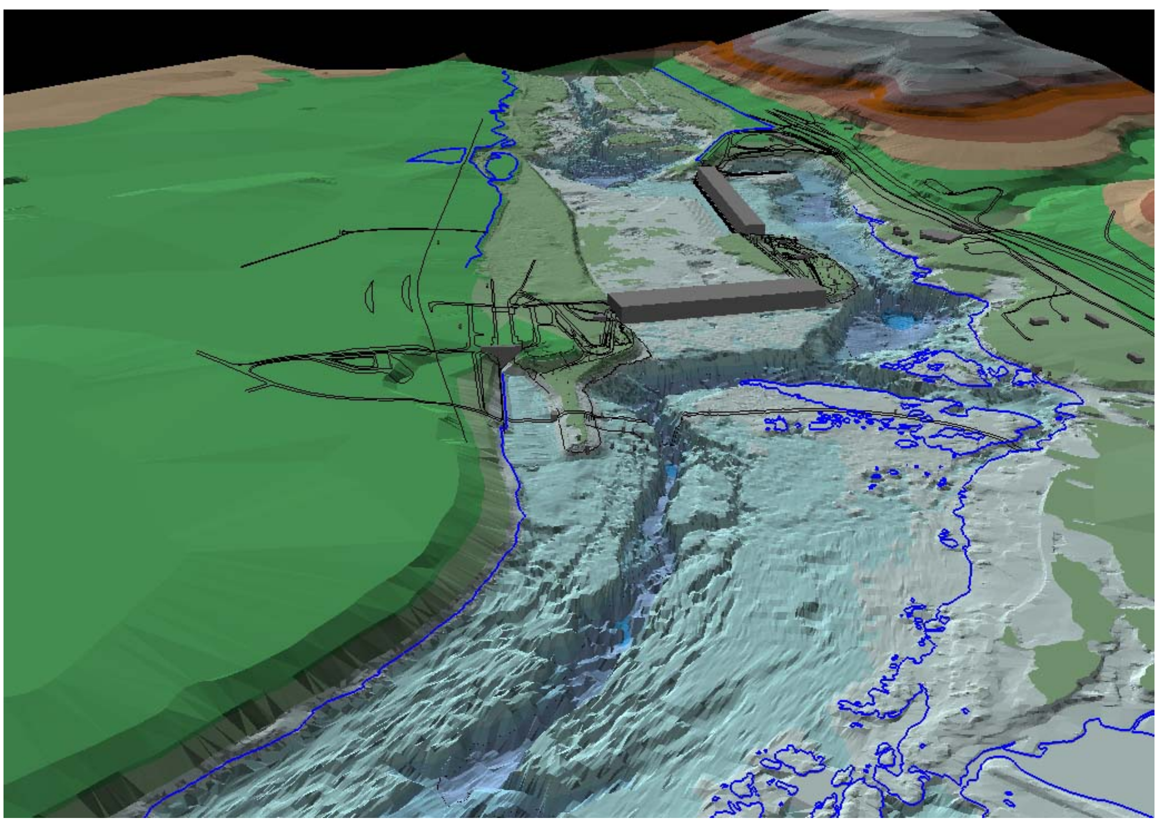

Figure 2-2 The Dalles Bathymetry

The bathymetry downstream of the powerhouse is quite complex, with flow exiting the draft tubes between elevations 5.75 feet msl and 31 feet msl. After exiting the draft tubes the flow is immediately directed upward and over a sill with a crest elevation at 40 feet msl. Then the powerhouse flow turns downstream (west) through the narrow deep thalweg. The thalweg then opens up it turns north with the spillway shelf to the east and the bridge islands to the west. The thalweg downstream of the spillway shelf reaches depths of –200 feet msl.

The overall length of the spillway is 1447 feet, with its crest elevation at 121 feet msl. The stilling basin is the shallowest on the Lower Columbia River and Snake River Projects. The bottom of the stilling basin is at elevation 55 feet msl and the downstream shelf rises up to 68 feet msl. Downstream of Bays 1-15, the basalt shelf extends approximately 700 feet before a shear drop off leading to the thalweg. Downstream of bays 15-23, the basalt shelf tapers back towards the spillway, and the length of the basalt shelf is much less (approximately 200 feet downstream of bay 23). Baffle blocks were constructed approximately 197 feet downstream of the crest to dissipate energy and force a hydraulic jump in the stilling basin. A 13-foot high vertical wall (end sill) marks the downstream end of the stilling basin. A concrete apron then extends 52 feet downstream from the end sill.

Tailrace Conditions and Predation

The unique characteristics of the TDA project; including, the orientation of the powerhouse and spillway to the main river and the bathymetric irregularities downstream make egress conditions problematic. Unless juvenile fish are in the main thalweg, where the velocities are high, there is a high probability for predator - prey encounters. Like the whole FCRPS predators at TDA concentrate near major fish passage routes in areas of low water velocities, shallow depth, and near structures. In general, overall predation is high in the powerhouse channel upstream of the ice and trash outfall, on the Spillway Shelf just south of spill and near the BRZ and Bridge Island’s. Avian predation is particularly high on the Spillway Shelf in proximity to the existing bay 6/7 spillwall, in the powerhouse channel, the BRZ Island, and Bridge Island’s.

Project Operations

Flow distribution and operational guidelines for TDA, as described in Biological Opinion and in the annual Fish Passage Plan (FPP) developed by the COE Northwestern Division, are based upon many different factors that affect juvenile and adult passage at the dam. Requirements include seasonal operation, turbine unit operation priority, turbine operations within 1% of peak efficiency, Bonneville Power Administration (BPA) power requirements, scheduled maintenance, unplanned outages and others. All of these factors play a role in the operation of TDA in consideration of juvenile and adult fish migration. These factors are not variables within the context of this study and are assumed to be part of the project operation. The FPP is the approved method of operation of TDA for given conditions.

Flow distribution or operational rules for TDA are:

- Minimal powerhouse flow of 50 Kcfs
- Maximum flow at the powerhouse is 270 Kcfs (operating within 1 percent turbine efficiency and assuming a few units out of service)
- Spill set at 40% of the total river flow (requires water quality waivers to be in place)
- Total river flow of 315 kcfs and less use bays 1-6, as total river increases use bay 7, then bay 8, and finally bay 9.
- Minimize any spill to the south of the spillwall.

River Flows at TDA

River flows at The Dalles can vary significantly throughout the year and during the juvenile fish passage season. The hydrograph that represents the lower Columbia River for a period of October 1973 through September 1999 and representative water flows that will occur at TDA are available in Figure 2-3. Seasonal peak water 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 flow conditions used in the TDA COP are based on the hydrograph (Figure 2-3). The Monthly Representative River Flows for the high, medium and low flow year can be seen in Table 2-1. 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. 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 are based on the typical timing of the spring and summer runs.

Table 2-1 Monthly Representative River Flows During Fish Passage Season

Representative River Flows in Kcfs			
Month	High (15%)	Medium (50%)	Low (85%)
April	300	210	150
May	370	270	220
June	390	280	170
July	260	180	120
August	190	130	100
September	140	120	100
Season			
Spring	380	275	195
Summer	246	170	116

Total Dissolved Gas

Total dissolved gas (TDG) super-saturation 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 State's grant waivers, applied for by the NMFS, which allow the COE to exceed this limitation at TDA, up to a TDG level of 120% below the spillway and 115% measured downstream in the forebay of the Bonneville Lock and Dam.

Spill at TDA has a unique characteristic in that spill in excess of about 3 Kcfs per bay causes and increase in the TDG level to the 120% but tends to stay there as spill per bay is increased even if spill is 21 Kcfs per bay. This unique characteristic helps in that as long as waivers are in place spill is typically not limited at TDA. But if the waivers are not in place any spill is most likely going to violate the 110% TDG water quality standard.

The strategic plan identified in this document was developed in concert with the Action Agencies, States, and regional salmon managers based upon the assumption that these waivers will be in place during the juvenile fish passage season(s).

Section 3 - Historic and Current Fish Passage Conditions

General

This section summarizes the current information base on fish passage at TDA. Juvenile salmonid passage attributes that have been measured at TDA include run timing, passage distribution, predator behavior, tailrace egress, and fish survival. In addition to juvenile salmonids, adult salmonid data and information on other species, such as lamprey, sturgeon, and bull trout are presented in this section. Data summarized in this section provides the basis for assessing the biological benefits of alternatives considered in this report. Johnson (et al. 2006), provides a summary of the dam configuration and operational strategies that were employed from 2000 to 2006; including, a synthesis of the collected biotic data on juvenile fish passage, tailrace egress, and survival. Data from these synthesized studies were used for the purpose of decision framework alternative development through SIMPAS modeling.

Juvenile Salmonid Run Timing

The bulk of the juvenile salmon migration typically occurs from early April to the end of August. Due to a lack of juvenile salmon collection capabilities at TDA, estimates of juvenile salmon run timing and species composition are obtained from John Day Dam. John Day Dam is located approximately 24 river miles above TDA and is configured to monitor juvenile salmon smolt passage. Juvenile Pacific salmon species emigrating past TDA include Chinook, coho, sockeye, and steelhead. Both ocean (subyearlings) and stream-type (yearlings) Chinook salmon pass the project during sea-ward migrations. Roughly, half of all juvenile salmon passing TDA during a migration season are estimated to be subyearling Chinook salmon (Martinson et al. 2005).

Juvenile Fish Passage

Since implementation of the 2000 BiOp, the spillway has been used as the primary fish passage system for TDA. Current data on spill passage efficiency is presented in Figure 3-1. Typically, 40% of the total river discharge is spilled 24-hours per day from April 10 through August 31. This operational strategy was used until 2004. As of 2004, 40% of the river is spilled but concentrated in the northern six bays, thus flow is bounded by the north shore and the tailrace spillwall (between bays six and seven) on the south. The effect of the spillwall is reducing lateral water flows in the tailrace stilling basin, enhancing egress conditions for juvenile salmonids.

Juvenile Salmonid Diel Passage Distributions

Diel trends in passage timing (i.e., day vs. night) are typically dependent upon the specific route of dam passage. For instance, spill and sluiceway passage are usually much higher during the day than at night at TDA, whereas, turbine passage rates are predominately higher at night than during the day. Despite the relation between diel periodicity and passage route, factors such as the species, life history phase, and dam operations can also influence the passage timing of juvenile salmon at TDA.

Predator Distribution and Movement

Disorientation and stunning due to the shear forces and pressure changes associated with dam passage events are known to leave juvenile salmon particularly vulnerable to predators in dam tailrace areas. As such, the presence and behaviors of both northern pikeminnow (*Ptychocheilus oregonensis*) and smallmouth bass (*Micropterus dolomieu*) were evaluated. During these evaluations few northern pikeminnow or smallmouth bass were found in areas that fell outside of the juvenile salmon bypass outfall criteria (developed to minimize predator prey interactions). Tailrace areas identified as having the greatest risk of predation, by either species, included the BRZ and Basin Island's. Flow from spill transports fish towards these areas and is, therefore, considered high risk zones for predator prey encounters.

In summary, data on predator fish distribution at TDA suggest that predatory fishes concentrate near major fish passage routes in areas of low water velocities, shallow depth, and near submerged structures. A summary of locations where northern pikeminnow are most likely to be found in TDA tailrace, based on 1993 – 1994 data, is available in Figure 3-2. These studies indicate that a strategy of guiding water flow and fish north, to the thalweg, would minimize the potential for predator prey encounters.

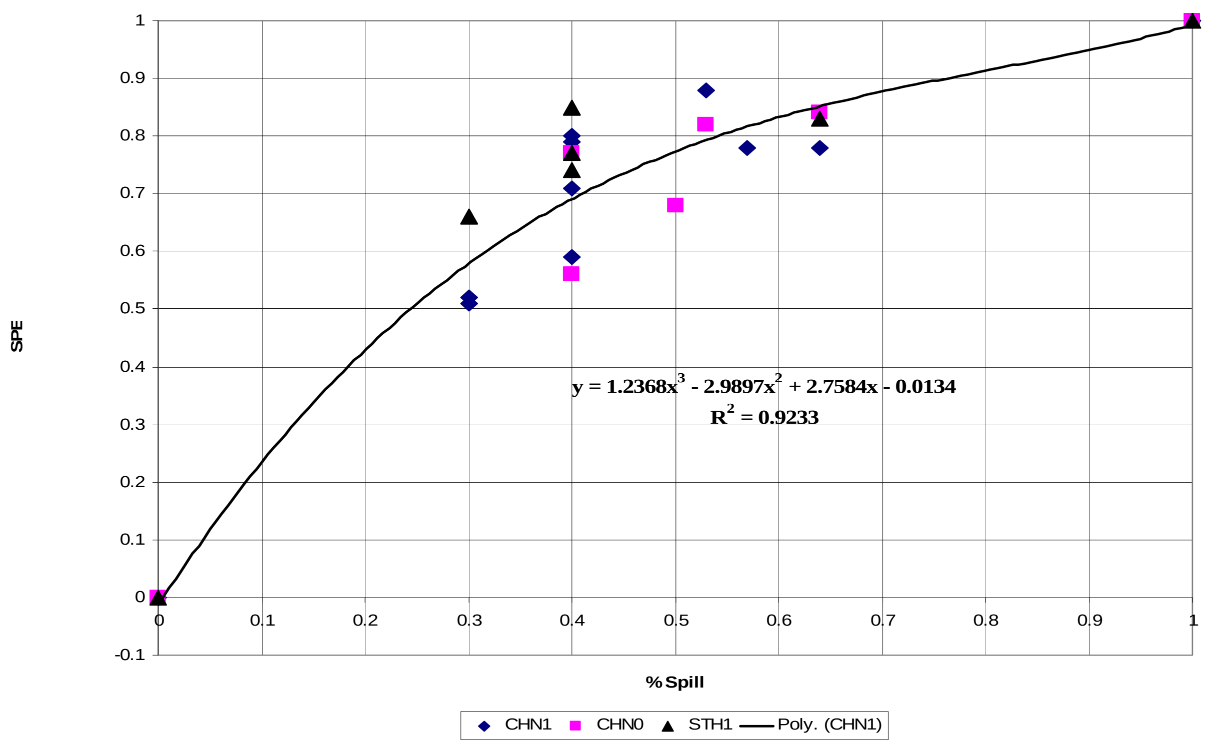

Figure 3-1. Spill efficiency vs. spill percent for yearling Chinook salmon (CHN1), subyearling Chinook salmon (CHN0), and steelhead (STH1) trout (Hansel et al. 2000; Beeman et al. 2001a, 2001b, 2002; Ploskey et al. 2001; and Hansel et al. 2004).

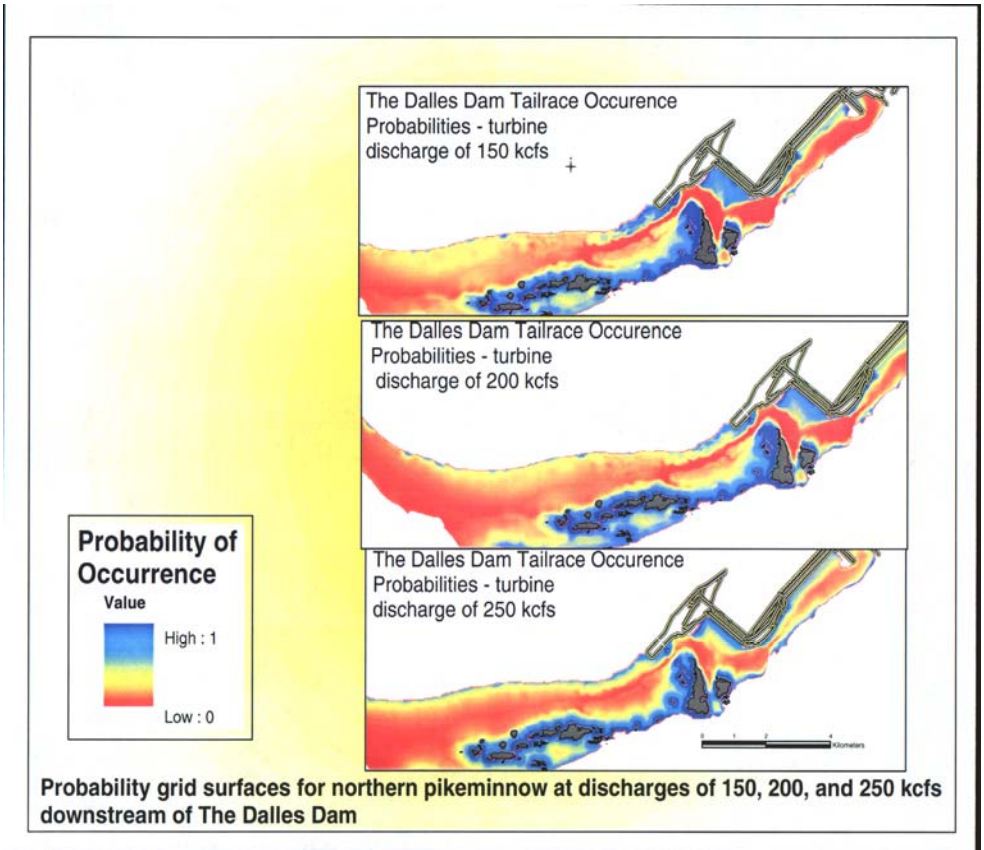

Figure 3-2. Northern pikeminnow distribution at three river discharges in TDA tailrace (Petersen et al. 2001).

Juvenile Pacific Lamprey

Little is known regarding the downstream migratory behaviors of juvenile Pacific lamprey passing hydroelectric facilities. Most juvenile lamprey are believed to travel deep in the water column (Brege et al. 2001). Evaluation of lamprey exposure to intake screens suggested that the plastic mesh and bar screens commonly used in FCRPS turbine intake bypass systems caused a substantial proportion of lamprey to become stuck in the screen material, a condition that ultimately lead to death for these fish. Such screen systems are not deployed within TDA turbine intakes. Like juvenile salmon, data on the downstream run timing of lamprey at TDA are from the John Day Dam SMF (Figure 3.3)

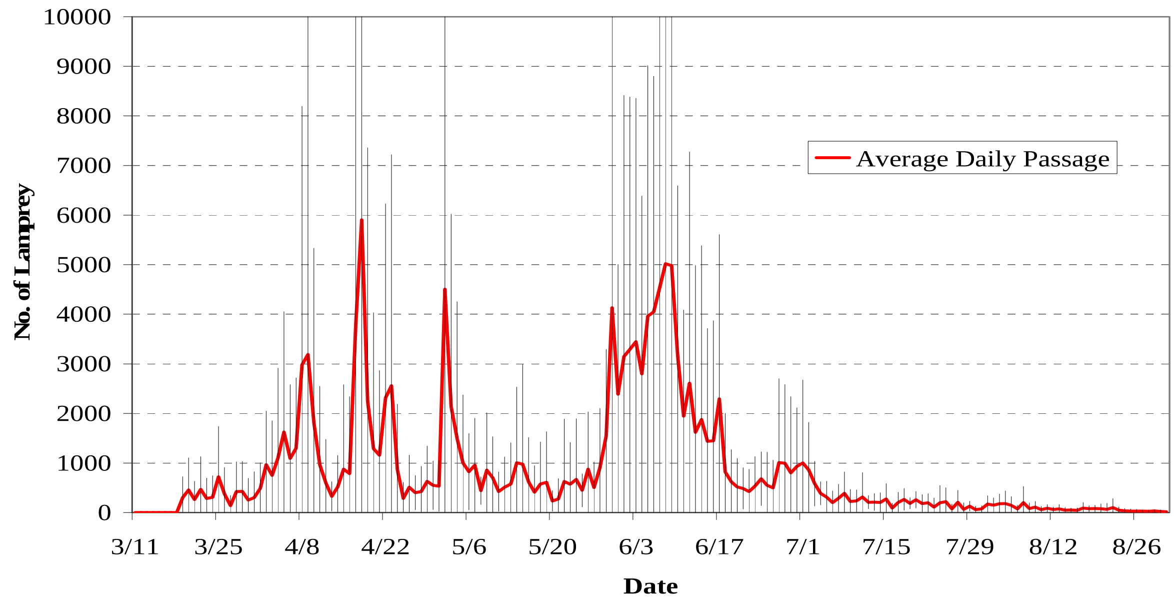

Figure 3-3. Average daily juvenile lamprey passage at John Day Dam. Averages calculated from 1998 to 2003 Smolt Monitoring Program data for John Day Dam (Jeff Kamps, unpublished data).

Adult Fish Passage

The Dalles is currently estimated to have some of the lowest adult upstream fish passage times among the four lower mainstem FCRPS projects (Bjornn et al. 2000; Monan et al. 1976). Fish passage facilities for adult salmon migrating upstream were incorporated into the original construction of the dam. These facilities included a fish ladder on the north shore and east fish ladder, a powerhouse collection channel, and a now defunct fish lock. The north fish ladder has entrances adjacent to the north side of the spillway. The east fish ladder has main entrances on the south side of the spillway, east and west ends of the powerhouse, and smaller entrances along the length of the powerhouse collection channel. The main entrance to the north fish ladder consists of two 15-foot wide openings with a 15-foot auxiliary entrance located in the spillway training wall upstream. Main entrances on the south side of the spillway are similar to the north ladder entrances. The west powerhouse main entrances are 8-foot-8-inches wide and equipped with three telescopic weirs to control entrance depth and head. The east powerhouse main entrance consists of three 8-foot-8-inch wide openings that regulate flow with telescopic weirs. Minimizing delays for adult upstream migrants at TDA has required evaluation and refinement of fishway entrance configuration and operations criteria (Johnson 1978. The current configuration prioritizes use of the main fishway entrances, with all powerhouse collection channel entrances having been closed since 2000.

Steelhead Kelts

Like juvenile salmonids, steelhead kelts (i.e., post-spawn fish that are potential repeat spawners) undergo a mass migration to the Pacific Ocean from April through June of each spring. For example, an estimated 60% of the entire Snake River steelhead Evolutionary Significant Unit (ESU) attempted sea-ward migration as kelts following spawning in 2000 (Evans and Beaty 2001). Route specific dam passage data from kelts suggest that improvements being implemented at FCRPS projects for juvenile salmonids will prove beneficial to steelhead kelts (Wertheimer and Evans 2005; Wertheimer 2007).

Bull Trout

Adult Bull trout are rarely observed ascending TDA. Similarly, less than 20 bull trout have been documented at the John Day Dam since 1998 (Martinson et al. 2005).

Sturgeon

White sturgeon(s) (Acipenser transmontanus) seldom ascend fish ladders at Columbia Basin hydroelectric projects. The lack of sturgeon passage is probably due to the fact that fish ladders at Columbia River basin dams were designed primarily for adult salmonids (North et al. 1995). One exception is the east TDA ladder, where individuals up to 180 cm have been documented passing. Presumably, sturgeon passage is related to the larger orifice size (25-inch by 26–inches) at the east TDA ladder, than at the north TDA ladder (18-inch by 18–inches).

Adult Lamprey

Adult lamprey passage at TDA was evaluated using radio-telemetry methods between 1997 and 2000. Of the three Lower Columbia River Dams operated by Portland District Corps of Engineers, adult lamprey passed TDA fishways most successfully. Passage success for lamprey at TDA ranged from approximately 60% to 80%.

Lamprey are typically observed passing upstream through fish ladders by alternating short bursts of swimming with rest periods during which they attach to the substrate with their mouths. Lamprey have also been shown to use a combination of oral attachment and leaping behavior to navigate through fishway orifices. Mesa et al. (1999) estimated the mean critical swimming speed of adult lamprey to be 1.4 body lengths/s at 15º C. These results suggest that adult lamprey likely encounter difficulty in passing high velocity areas in fish ladders at Columbia River dams.

Section 4 - Baseline Conditions and Dam Passage Survival Gap

The current baseline conditions; including, fish passage distribution and route specific survival estimates for three species: yearling Chinook, steelhead, and subyearling Chinook salmon are defined in Table 4.1. These survival values have been agreed to by regional fish managers and are consistent with the BiOp.

The baseline dam passage survival for all species evaluated (spring Chinook salmon, steelhead, and fall Chinook salmon) does not meet the targeted performance standards for dam passage survival. To identify areas where there are dam passage survival gaps the baseline data was evaluated and the following observations were made:

- Bays 1-4 have higher survival rates than bays 5-6 but the majority of the juvenile fish pass through bays 5-6 (66%) versus bays 1-4 (34%).

- Sluiceway survival is typically high but relatively few fish use the route. Despite high survival rates it is hypothesized that if the number of fish using the sluiceway were to increase that survival would be negatively impacted. For instance, it is plausible that predators would adapt to greater prey availability at the sluiceway outfall and redistribute to take advantage of such a feeding opportunity.

- Survival through the turbines is low with estimates ranging from 80% to 84%. It is not definitively known if the causative mechanism(s) for these low survival rates are from direct injuries obtained while passing through the turbines or indirect mortalities during egress from the turbines downstream to the control point. Data from other projects suggest that direct turbine survival is generally high and most of the survival issues are related to indirect mortality associated with predation related to poor egress conditions. The bathymetry downstream of the project and the geometry is not conducive to good egress conditions without major realignment of the channel (see Figure 2-2). A major realignment of the powerhouse channel is not considered cost effective means of increasing dam passage survival rates due to the small percentage of fish that pass through the turbines (Table 4-1).

Specific alternatives that build off the existing configuration and address dam passage survival gaps are presented in Section 5. Current policy emphasis focuses on the spillway as the primary juvenile salmon passage route; thereby, requiring spillway survival rates that allow for meeting the targeted dam passage survival performance standard(s). Currently, the spillway does not meet such standards; thus, spillway improvements are necessary. Using the spillway as a primarily route of passage requires TDG waivers be in place during the juvenile fish passage season.

Table 4-1 Baseline Conditions											
	Spill %	**SPE**	**Fish Bay 1-4**	**Survival Bay 1-4**	**Fish Bay 5-6**	**Survival Bay 5-6**	**Sluice Eff - Project**	**SBC or Sluice S.**	**Turbine Survival**	**FPE**	**Dam Passage Survival**
Spring Chinook	0.40	0.80	0.29	0.97	0.51	0.93	0.10	0.98	0.84	0.90	0.938
Steelhead	0.40	0.80	0.29	0.97	0.51	0.93	0.10	0.98	0.84	0.90	0.938
Fall Chinook	0.40	0.78	0.28	0.97	0.50	0.91	0.08	0.93	0.8	0.86	0.913

Section 5 – Alternatives

There are three key areas for improvements identified in Section 4 are:

- Spillway egress conditions
- Redistribution of fish at the spillway
- Reduce turbine entrainment

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

- Spillway Improvements
    - Full Length Spillwall
- Spillway Redistribution
    - Surface flow at the spillway
    - BGS
    - Vortex suppression
- Reduce Turbine Entrainment
    - Sluiceway improvements (possible sluiceway outfall relocation)
    - JBS
    - Shallow BGS
    - Turbine Optimization

In this section, each fish passage alternative considered in this document 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 include survival improvements.

The cost estimates for the alternatives were taken from various sources. Some were from previous studies while others were adapted from similar construction contracts for similar types of work. The total cost for implementing each alternative were developed using four primary cost calculations: 1) the design development work that includes model studies, biological testing and engineering design; 2) the construction phase which includes construction costs, supervision and administration, engineering during construction and post construction monitoring, which includes biological testing costs to determine and confirm acceptable project operations; and 4) operational and maintenance (O&M). A brief description of the alternatives follows, with additional details of each alternative listed in Appendix A.

All of the fact sheets for each of the alternatives currently being considered at TDA can be found in Appendix A. The fact sheets contain the following information:

- Purpose
- Description
- Status
- Costs
- Water Quality Impacts

- Timing/Schedule
- Biological Impacts
- Operational Constraints
- References

A list of the alternatives that are being evaluated and general summary information on the alternative (e.g., alternative impacts to juvenile fish passage, other life histories, level of design, average annual cost) and anticipated year implementation could take place are available in Table 5-1.

Table 5-1 Alternative Summary Information - The Dalles Configuration and Operation Plan

Alternative		Impacts on Juvenile Fish Passage	Impact on other Life Histories	Level of Design	Average Annual Cost ($1000/yr)	First Year of Implementation
A	Spillway Redistribution	Spillway Survival	minimal			
A1	Vortex Suppression			20%	$126	2007
A2	Surface Flow (TSW, RSW & ASW)			0%	$1,056	
A3	Log Boom			0%	$84	
B	Spillway Improvements	Spillway Survival	minimal			
B1	Full Length Spillwall			100%	$45,000	2010
C	BGS to the Spillway	Spillway Eff.	minimal	50%		
C1	40 Ft Draft BGS To Spillway				$5,321	
C2	Fuff Shallow BGS to Spillway				$288	
C3	BGS To Sluiceway Entrance				$5,321	
D	Sluiceway Entrance Improvements	Sluice Eff.	minimal	0%	$703	
E	Sluiceway Outfall Relocation	Sluice Survival	minimal	15%	$3,088	
F	Powerhouse Surface Bypass	PH Guidance and Survival	minimal	5%		
F1	Surface Collection Full Flow Bypass				$19,711	
F2	Venturi Sluiceway Collector				$17,726	
F3	VBS Sluiceway Collector				$10,757	
F4	Option A: Prototype 3 yrs				$58,674	
F5	Option C: Prototype 3 yrs				$45,084	
G	JBS	PH Guidance and Survival	minimal	30%	$11,765	
H	Turbine Improvements	PH Survival	minimal	5%	$8,073	

1. Level of Design is based on 0% if no reports have been developed, 10% if a Feasibility Report has been developed, 25% if a DDR has
2. Hydropower impacts are contingent on a change in precent spill and turbine efficiency change, see Section 6

The Fact Sheets (Appendix A) were originally developed in 2004 and have been updated over time. As Feasibility Reports and Design Document Reports have been developed details in the Fact Sheets have changed or some alternatives have been eliminated. Section 5 has been updated but some information in Appendix A is outdated but is still part of the report for completeness.

The Spillway Improvement Alternative (Alternative B) has progressed to the point that a full length spillwall between spillbays 8 and 9 is currently under construction and should be available for the 2010 juvenile fish passage season. The cost estimated is based on the construction contract.

Alternative A – Spillway Redistribution

The purpose of the spillway redistribution alternative is to direct juveniles to portions of the spillway that provide higher survival.

There are several alternatives identified that could redistribute juvenile fish.

> Alternative A1 – Vortex Suppression
> Alternative A2 – Surface Flow
> Alternative A3 – Log Boom to Sluiceway to Spillway or U/S of PH to Spillway (discussed further as Alt C2)

Alternative A1 - Vortex Suppression: Current spill operations create a large vortex at the outside spillbays being used for spill, typically Bays 1 and 6. The vortex is caused by flow moving parallel to the spillway and abruptly turning 90 degrees around the pier nose. Many juvenile fish that pass by the powerhouse and those headed directly to the spillway appear to be drawn to the surface flow created by the large vortex that forms in Bay 6. Several biological tests have documented that 66% of the fish pass through Bays 5&6 and may be drawn into the vortex. The location of this vortex places the fish in a poor egress position due to predator zones downstream. Alternative A1 suppresses this vortex in an effort to redistribute fish to more northern bays where egress is better and survival is higher. This is one of the lower cost methods to redistribute the fish within the spillway. With the full length 8/9 spillwall moving fish north is not anticipated but it moving fish to different bays may be beneficial this alternative might meet future objectives.

Alternative A-2 – Surface Flow: If suppressing the vortex does not provide sufficient spillway redistribution, Alternative A2, surface flow could be developed to create a large surface spill, which should draw the fish to this bay. This could be done by several methods, a top spillway weir (TSW), removable spillway weir (RSW) or and adjustable spillway weir (ASW). A TSW is shaped crest which is placed upon the uppermost stoplog in a slot to provide for surface spill. This type of device provides for a free falling jet of water from this weir onto the concrete ogee and would need to be designed to minimize fish impact and injury on the ogee. If good egress conditions are problematic under low flow conditions a surface flow alternative could be used to reduce spill percentage by strategically using surface flow.

An RSW is an ogee-shaped overflow weir with no spillgate control that provides a surface passage route at the spillway. The Dalles Dam RSW concept would be used to relocate fish passage distribution at the spillway from bays having poor egress and survival to a bay(s) that have good egress and survival. The direct passage of surface water should provide greater juvenile attraction.

An ASW is a device that could provide adjustable surface spill. This will allow optimal stilling basin conditions for juvenile fish survival while meeting the percentage spill requirements mandated in the BiOp.

Alternative A3 – Log Boom: Many fish travel along the face of the powerhouse, but do not pass through either the turbines or the ice and trash sluiceway. These fish then go to the southern region of the spillway and traverse to the north and pass through bays 5 and 6. Alternative A3, a log boom type structure from the downstream end of the powerhouse, to the Bay 3-4 area of the spillway, and may provide guidance for these fish to keep them from passing through Bay 6. With the full length 8/9 spillwall moving fish north is not anticipated but if moving fish to different bays may be beneficial this alternative might meet future objectives.

Alternative B – Additional Spillway Improvements

Various methods of further improving stilling basin conditions related to juvenile survival including removing structure that juvenile fish may impact, shortening retention time in the stilling basin and providing better downstream egress – minimizing predation were evaluated and documented in – The Dalles Lock and Dam Spillway Improvement Study (SIS) Alternative Study Report, Columbia River, Oregon-Washington, February 2007. The recommendation from this report is to construct a full length spillwall from the spillway ogee, over the spillway shelf, to the thalweg. During the development of the DDR for the full length spillwall the wall location was identified as between spill bays 8 and 9. This location maximized juvenile fish passage and minimized negative impacts to adult utilization of the north fish ladder and TDG generation.

Alternative C – Behavior Guidance System

The purpose of the behavior guidance system (BGS) is to guide fish away from poor fish passage locations, through altering the behavioral and sensory stimuli fish are reacting to (e.g., forebay hydraulic conditions), in order to enhance the efficiency of a desired fish passage location such as the spillway.

The BGS would be located in the forebay to maximize juvenile guidance to the spillway while reducing the amount of spillway discharge. There are two primary objectives: increase dam passage survival for juvenile salmonids and increase the cost-effectiveness of operating the spillway as a bypass system. As most of the juvenile fish travel in the upper portion of the water column, current design concepts revolve around a floating structure with a submerged curtain to alter the hydraulic characteristics, and guide the juvenile fish to the desired fish passage location. The Alternatives include:

Alternative C1 – Tethered BGS to the spillway
Alternative C2 – Shallow Draft BGS to the spillway
Alternative C3 – BGS to Sluiceway Entrance

Alternative C1, tethered BGS to the spillway is documented in a DDR completed May 2006 and consists of a 40 foot draft steel barge like segments to guide fish away from the turbines and to the spillway at reduced spill. This alternative was put on hold because the alignment that provided the best biological benefit created unsafe conditions for vessels exiting or entering the navigation lock.

Alternative C2, shallow draft BGS to the spillway would be an off the shelf type log or debris screen with the maximum draft available, probably around 10'. These types of systems are documented in the BGS Feasibility Report completed May 2005. This alternative could provide a low cost way of testing fish behavior around a shallow draft floating structure at The Dalles.

Alternative C3, BGS to the sluiceway entrance has not been studied, but would be a device that would direct the juveniles to the sluiceway, if chosen as the route of passage.

Alternative D – Sluiceway Entrance Improvements

Geometry of existing sluiceway entrances would be modified to provide entrance hydraulics that are more conducive to juvenile fish attraction.

At this time the actual changes are not know, but the concept could be simply modifying the overflow weirs or as complex as and entrance horn, similar to an RSW. Entrance operations may be modified to accommodate different approach patterns between spring and summer migrants (west vs. east entrances). The objective is to reduce turbine entrainment, thereby increasing dam survival for juvenile fish migrants.

Alternative E - Sluiceway Outfall Relocation

This alternative would relocate the sluiceway outfall site to provide better egress and lower predation.

The current sluiceway outfall location is just west of the powerhouse. It is thought that better egress would exist if the outfall was relocated to join more with the spillway flow and combine with the bulk river flow into the thalweg downstream of the spillway. This would require some sort of channel that could go through the existing park area near the Westrick Center then across the spillway shelf to the middle of the spillway. The design would have to take into account passing large flood events since the channel structure might protrude out into the spillway shelf. The costs shown are the lower limit for this alternative from the DDR on Outfall Relocation. The DDR could not recommend construction due to unsatisfactory egress conditions at several river flows but this work was done prior to the spillwall construction and the new spill patterns.

Alternative F – Powerhouse Surface Bypass System

The purpose of this alternative is to provide a bypass system that passes large numbers of juvenile fish through a low volume discharge through the dam, keeping juvenile fish away from turbines.

Surface bypass alternatives for The Dalles powerhouse were described in a Final Report by Harza published in November 1995. The report included concepts spanning the entire powerhouse as well as alternatives using the existing sluiceway for a substantial length of the surface bypass system. Some concepts include dewatering facilities to reduce the volume of bypass flow. Dewatering of bypass flow would be done using 60-foot deep vertical screens, with the excess water passed through operating turbines by venturi flow. Dewatering of the bypass flow was primarily intended to reduce the size, cost and energy dissipation requirements of the bypass outfall. This would allow the outfall to be positioned in locations considered most advantageous to juvenile fish survival.

Surface bypass concepts covered included:

- Alternative F1 - Surface Collection with Full-Flow Bypass.
- Alternative F2 - Venturi Sluiceway Collector
- Alternative F3 - VBS Sluiceway Collector
- Alternative F4 - Option A – Utilizes the existing sluiceway from units 5-22 of the powerhouse, supplemented by a new surface bypass system at the west end (units FT, 1-5) of the powerhouse, with a slightly relocated 4,500 cfs sluiceway outfall, and a 10,500 cfs bypass to the spillway
- Alternative F5 - Option C – Utilizes the existing sluiceway from units 1-13 of the powerhouse, supplemented by new surface bypass systems at the east end (units 14-22) and west end (Fish Turbine Unit) of the powerhouse, with a slightly relocated 4,500 cfs sluiceway outfall, a 6,000 cfs bypass to the spillway, and a new 4,500 cfs outfall from units 14-22

Alternative G – Screen Juvenile Bypass System (JBS)

The purpose of this alternative is to divert juvenile fish from going through the turbines by collecting them into a channel that bypasses the dam.

A screened juvenile fish bypass system (JBS) diverts a proportion of fish passing through turbine intakes into a collection channel, which then routes and releases them downstream of the dam. The outfall is located at the downstream end of the peninsula below The Dalles Bridge near the main flow of the Columbia River. The objective is to increase smolt survival by reducing the proportion of turbine entrained fish and releasing collected fish in an optimum tailrace location that provides the lowest predation. The main features of the JBS designed for TDA include: extended-length submersible bar-screens, vertical barrier screens, orifices, the existing ice and trash sluiceway used as a collection channel, a control weir, a dissipation channel, a dewatering facility, a transportation flume, a fish sampling facility, and an outfall.

Alternative H – Turbine Improvements and Optimization

The purpose of this alternative is to improve the survival of juvenile fish passing through the turbines at TDA.

The low survival through the turbines can be caused by direct injury, as the fish passes through the turbines or by indirect means as the fish exits the draft tube and encounters the tailrace predator habitat.

To solve the direct survival issues grinding, painting, and removing unnecessary obstructions in the scroll case are one element that might provide increased turbine efficiency and improved juvenile fish survival from smoother blades. Studies are underway to determine the best turbine geometry (wicket gate and turbine blade angles) for fish survival. A potential additional improvement would be the installation of Minimum Gap Runners (MGR).

To solve the indirect survival issues either the flow from the powerhouse needs to better turn the corner as it exits the powerhouse or the tailrace pool needs to be changed to put the predator habitat further away from the powerhouse. To help the flow turn the corner, draft tube guidewalls could be a method to direct the powerhouse flow into the thalweg. To change the predator habitat, the southern edge of the river, directly across from the powerhouse could be moved further to the south, to enable the juvenile fish to turn the corner and entrain in the downstream flow prior to encountering the predator habitat.

Another option to consider is turbine optimization to improve turbine egress. It is possible that specifying unit operations might improve juvenile egress and improve survival.

Stand Alone Alternatives for Additional Consideration

The SIMPAS has been used to estimate the increase in juvenile fish survival given any alternatives. Table 5-2 shows the SIMPAS inputs for all of the alternatives. But another key variable to SIMPAS is fish distribution; Tables 5-3, 5-4 and 5-5 show the distribution of Yearling Chinook, Steelhead and Sub-Yearling Chinook respectively given a range in project operations. The SIMPAS results are shown in Table 5-6.

Based upon the results from analyses presented herein; the following alternatives show merit:

- Spillway Improvements
- Spillway Re-distribution
- Sluiceway Improvements

The three alternatives assume that existing "safe" passage routes are utilized (spillway and sluiceway outfall). These alternatives appear to have the potential to improve dam passage survival at reasonable cost and in a reasonable time frame.

The primary criteria have been dam passage survival improvements and cost but the structural alternatives being considered do not have a significant impact on the other criteria: adult salmon, lamprey, other species, water quality etc. The level of spill could impact the other criteria but will factor into the final operational recommendations for TDA once the final configuration is identified.

Table 5-2 SIMPAS Inputs

Alternative	Spill Eff	Spill Surv	FGE	Turb Surv	Bypass Eff	Sluice Eff	Sluice Surv
Yearling Chinook							
Baseline	0	0.92	0.00	0.82	0.00	0	0.994
A. Spillway Redistribution	0	0.95	0.00	0.82	0.00	0	0.994
B. Spillway Improvements	0	0.98	0.00	0.82	0.00	0	0.994
C. BGS to the Spillway	0.15	0.92	0.00	0.82	0.00	0	0.994
D. Sluiceway Entrance Improvements	0	0.92	0.00	0.82	0.00	0.5	0.994
E. Sluiceway Outfall Relocation	0	0.92	0.00	0.82	0.00	0	0.994
F. Powerhouse Surface Bypass	0	0.92	0.00	0.82	0.80	0	0.994
G. JBS	0	0.92	0.73	0.82	0.00	0	0.994
H. Turbine Improvements	0	0.92	0.00	0.84	0.00	0	0.994
Steelhead							
Baseline	0	0.92	0.00	0.82	0.00	0	0.994
A. Spillway Redistribution	0	0.95	0.00	0.82	0.00	0	0.994
B. Spillway Improvements	0	0.98	0.00	0.82	0.00	0	0.994
C. BGS to the Spillway	0.15	0.92	0.00	0.82	0.00	0	0.994
D. Sluiceway Entrance Improvements	0	0.92	0.00	0.82	0.00	0.5	0.994
E. Sluiceway Outfall Relocation	0	0.92	0.00	0.82	0.00	0	0.994
F. Powerhouse Surface Bypass	0	0.92	0.00	0.82	0.80	0	0.994
G. JBS	0	0.92	0.83	0.82	0.00	0	0.994
H. Turbine Improvements	0	0.92	0.00	0.84	0.00	0	0.994
Subyearling Chinook							
Baseline	0	0.89	0.00	0.80	0.00	0	0.931
A. Spillway Redistribution	0	0.93	0.00	0.80	0.00	0	0.931
B. Spillway Improvements	0	0.98	0.00	0.80	0.00	0	0.931
C. BGS to the Spillway	0.15	0.89	0.00	0.80	0.00	0	0.931
D. Sluiceway Entrance Improvements	0	0.89	0.00	0.80	0.00	0.5	0.931
E. Sluiceway Outfall Relocation	0	0.89	0.00	0.80	0.00	0	0.980
F. Powerhouse Surface Bypass	0	0.89	0.00	0.80	0.80	0	0.931
G. JBS	0	0.89	0.59	0.80	0.00	0	0.931
H. Turbine Improvements	0	0.89	0.00	0.82	0.00	0	0.931

Table 5-3 Yearling Chinook - Fish Distribution							
	Q	0	10	20	30	40	50
	PH	270	270	270	266	228	190
	Spillway	110	110	110	114	152	190
380	%	0.29	0.29	0.29	0.30	0.40	0.50
	PH	270	247.5	220	192.5	165	137.5
	Spillway	5	27.5	55	82.5	110	137.5
275	%	0.00	0.10	0.20	0.30	0.40	0.50
	PH	195	175.5	156	136.5	117	97.5
	Spillway	0	19.5	39	58.5	78	97.5
195	%	0.00	0.10	0.20	0.30	0.40	0.50
No BGS							
	Spill Fish	0.703	0.703	0.703	0.720	0.842	0.900
380	Sluiceway Fish	0.190	0.190	0.190	0.184	0.131	0.087
	Spill Fish	0.000	0.289	0.529	0.720	0.842	0.900
275	Sluiceway Fish	0.406	0.322	0.248	0.184	0.131	0.087
	Spill Fish	0.000	0.289	0.529	0.720	0.842	0.900
195	Sluiceway Fish	0.406	0.322	0.248	0.184	0.131	0.087
BGS							
	Spill Fish	0.853	0.853	0.853	0.870	0.900	0.930
380	Sluiceway Fish	0.115	0.115	0.115	0.110	0.056	0.056
	Spill Fish	0.000	0.439	0.679	0.870	0.900	0.930
275	Sluiceway Fish	0.423	0.247	0.173	0.110	0.056	0.056
	Spill Fish	0.000	0.439	0.679	0.870	0.900	0.930
195	Sluiceway Fish	0.423	0.247	0.173	0.110	0.056	0.056

Table 5-4 Steelhead Chinook - Fish Distribution							
	Q	0	10	20	30	40	50
	PH	270	270	270	266	228	190
	Spillway	110	110	110	114	152	190
380	%	0.29	0.29	0.29	0.30	0.40	0.50
	PH	270	247.5	220	192.5	165	137.5
	Spillway	5	27.5	55	82.5	110	137.5
275	%	0.00	0.10	0.20	0.30	0.40	0.50
	PH	195	175.5	156	136.5	117	97.5
	Spillway	0	19.5	39	58.5	78	97.5
195	%	0.00	0.10	0.20	0.30	0.40	0.50
No BGS							
	Spill Fish	0.703	0.703	0.703	0.720	0.842	0.900
380	Sluiceway Fish	0.207	0.207	0.207	0.201	0.146	0.099
	Spill Fish	0.000	0.289	0.529	0.720	0.842	0.900
275	Sluiceway Fish	0.423	0.340	0.266	0.201	0.146	0.099
	Spill Fish	0.000	0.289	0.529	0.720	0.842	0.900
195	Sluiceway Fish	0.423	0.340	0.266	0.201	0.146	0.099
BGS							
	Spill Fish	0.853	0.853	0.853	0.870	0.900	0.930
380	Sluiceway Fish	0.132	0.132	0.132	0.126	0.071	0.069
	Spill Fish	0.000	0.439	0.679	0.870	0.900	0.930
275	Sluiceway Fish	0.423	0.265	0.191	0.126	0.071	0.069
	Spill Fish	0.000	0.439	0.679	0.870	0.900	0.930
195	Sluiceway Fish	0.423	0.265	0.191	0.126	0.071	0.069

Table 5-5 Sub-Yearling Chinook - Fish Distribution

	Q	0	10	20	30	40	50
	PH	246	221.4	196.8	172.2	147.6	123
	Spillway	0	24.6	49.2	73.8	98.4	123
246	%	0.00	0.10	0.20	0.30	0.40	0.50
	PH	170	153	136	119	102	85
	Spillway	0	17	34	51	68	85
170	%	0.00	0.10	0.20	0.30	0.40	0.50
	PH	116	104.4	92.8	81.2	69.6	58
	Spillway	0	11.6	23.2	34.8	46.4	58
116	%	0.00	0.10	0.20	0.30	0.40	0.50
No BGS							
	Spill Fish	0.000	0.250	0.470	0.650	0.790	0.850
246	Sluiceway Fish	0.360	0.250	0.160	0.090	0.054	0.030
	Spill Fish	0.000	0.250	0.470	0.650	0.790	0.850
170	Sluiceway Fish	0.360	0.250	0.160	0.090	0.054	0.030
	Spill Fish	0.000	0.250	0.470	0.650	0.790	0.850
116	Sluiceway Fish	0.360	0.250	0.160	0.090	0.054	0.030
BGS							
	Spill Fish	0.000	0.400	0.620	0.800	0.850	0.900
246	Sluiceway Fish	0.360	0.250	0.160	0.090	0.054	0.000
	Spill Fish	0.000	0.400	0.620	0.800	0.850	0.900
170	Sluiceway Fish	0.360	0.250	0.160	0.090	0.054	0.000
	Spill Fish	0.000	0.400	0.620	0.800	0.850	0.900
116	Sluiceway Fish	0.360	0.250	0.160	0.090	0.054	0.000

Table 5-6 Dam Passage Survival for Alternatives by Species

Yearling Chinook	Baseline	A. Spillway Redistributio n	B. Spillway Improvements	C. BGS to the Spillway	D. Sluiceway Entrance Improvements	E. Sluiceway Outfall Relocation	F. Powerhouse Surface Bypass	G. JBS	H. Turbine Improvements	Cutoff
% Spill										
0	0.900	0.906	0.912	0.903	0.940	0.900	0.963	0.958	0.910	0.930
10	0.912	0.922	0.935	0.914	0.938	0.912	0.954	0.951	0.918	0.930
20	0.920	0.935	0.953	0.923	0.937	0.920	0.947	0.944	0.924	0.930
30	0.927	0.945	0.967	0.930	0.935	0.927	0.940	0.939	0.929	0.930
40	0.930	0.952	0.977	0.923	0.933	0.930	0.934	0.934	0.931	0.930
50	0.929	0.952	0.979	0.926	0.930	0.929	0.931	0.930	0.929	0.930

Steelhead	Baseline	A. Spillway Redistributio n	B. Spillway Improvements	C. BGS to the Spillway	D. Sluiceway Entrance Improvements	E. Sluiceway Outfall Relocation	F. Powerhouse Surface Bypass	G. JBS	H. Turbine Improvements	Cutoff
% Spill										
0	0.903	0.909	0.915	0.904	0.941	0.903	0.964	0.959	0.913	0.933
10	0.915	0.925	0.938	0.917	0.940	0.915	0.955	0.951	0.921	0.933
20	0.923	0.938	0.956	0.926	0.938	0.923	0.947	0.945	0.927	0.933
30	0.930	0.948	0.970	0.932	0.937	0.930	0.941	0.940	0.931	0.933
40	0.933	0.955	0.980	0.926	0.934	0.933	0.935	0.934	0.933	0.933
50	0.931	0.954	0.981	0.929	0.931	0.931	0.931	0.931	0.931	0.933

Subyearling Chinook	Baseline	A. Spillway Redistributio n	B. Spillway Improvements	C. BGS to the Spillway	D. Sluiceway Entrance Improvements	E. Sluiceway Outfall Relocation	F. Powerhouse Surface Bypass	G. JBS	H. Turbine Improvements	Cutoff
% Spill										
0	0.847	0.847	0.847	0.847	0.889	0.865	0.914	0.908	0.860	0.878
10	0.855	0.865	0.878	0.869	0.888	0.868	0.908	0.903	0.865	0.878
20	0.863	0.882	0.906	0.877	0.887	0.871	0.902	0.899	0.871	0.878
30	0.870	0.896	0.929	0.884	0.887	0.875	0.898	0.895	0.875	0.878
40	0.878	0.910	0.949	0.884	0.888	0.881	0.895	0.893	0.881	0.878
50	0.880	0.914	0.957	0.881	0.888	0.882	0.893	0.892	0.883	0.878

Section 6 – Recommendations

The spillway improvement alternatives have been reduced to one alternative – a spillwall between bays 8 & 9 extending to the near the river's thalweg. This regionally agreed upon alternative showed a tremendous benefit over existing conditions and should provide good survival for bays from 1 through 8. Construction on this alternative has begun and should be available for the 2010 juvenile fish passage season.

Potential combinations for further enhancing spillway passage efficiency & survival – if necessary – were identified. In particular, alternatives that aid the redistribution of fish to better capitalize on survival benefits provided from spillway survival improvements are considered.

1. Vortex suppression in bays 9 and 10.
2. Surface spill in bays 7 & 8
3. Shallow draft BGS

To complement spillway survival enhancements - through reducing turbine entrainment of fish - this COP recommends initiating a feasibility study on sluiceway improvements to assess:

1. Modifying gate entrance configurations, or
2. Increasing overall sluiceway capacity

Like other alternatives, determination of maximum benefits from these actions – alone or in concert – will be determined through an iterative modeling approach.

Final Phase I actions also include:

1. Evaluating turbine operations and geometry as means to increase turbine-passage survival.

All studies will include decision points and evaluation loops to facilitate input and direction from Portland District and regional fish managers. Design, construction, and biological testing of the selected alternative(s) will provide information to facilitate input and direction from Portland District and regional fish managers.