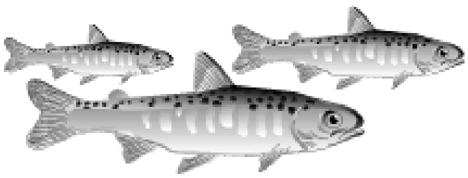
Lower Snake River Juvenile Salmon Migration Feasibility Study

Final Feasibility Report/ Environmental Impact Statement

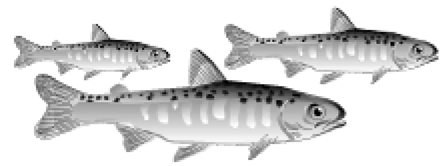
Part II
Chapters 5 through 13

February 2002



Chapter 5

Environmental Effects of Alternatives



5. Environmental Effects of Alternatives

5.1 Introduction

Section 5 discusses the potential direct and indirect effects of the alternatives on each of the following resource areas: geology and soils (Section 5.2); air quality (Section 5.3); water resources (Section 5.4); aquatic resources (Section 5.5); terrestrial resources (Section 5.6); cultural resources (Section 5.7); Native American Indians (Section 5.8); transportation (Section 5.9); electric power (Section 5.10); agriculture, municipal, and industrial water uses (Section 5.11); land ownership and use (Section 5.12); recreation and tourism (Section 5.13); social resources (Section 5.14); aesthetics (Section 5.15); and economic resources (Section 5.16). Each of these subsections is tied to analyses/evaluations of the alternatives conducted as part of the feasibility study and to corresponding technical appendices that present the analyses/evaluations in more detail. For the reader's convenience, a table that summarizes the potential effects of each alternative on the resource area is provided at the beginning of each subsection. The discussion of direct and indirect effects covers uncertainties in the analysis, cumulative effects, and short- and long-term effects for the resource area. Overall cumulative effects are discussed in more detail in Section 5.17, and overall short- and long-term effects are discussed in Section 5.18.

5.1.1 Uncertainties in Environmental Effects of Alternatives

Uncertainty is inherent in any planning effort, especially when the period of implementation may span decades, as is likely for this FR/EIS. Many of the potential biological, economic, and social effects of the alternatives are not known with certainty for several reasons. Information might be unavailable, incomprehensive, and scientifically unsound or reflect natural variability in the resource studied. There are also uncertainties in the assumptions and models used to extrapolate this information to future conditions. Uncertainties in environmental effects of each alternative are identified, described, and quantified when possible in the following sections. These uncertainties are also summarized in Chapter 6 and in Appendix J, Plan Formulation.

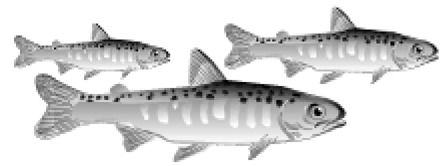
The relative importance of uncertainties will depend on how they influence efforts to compare the potential benefits and costs of the alternative actions.

5.1.2 Cumulative Effects

As appropriate, Section 5 includes discussions of how the proposed action in combination with other regional actions could affect particular resource areas. This discussion follows the groundwork laid in Section 4, Affected Environment, which provides background on how past and present forces have cumulatively contributed to the current status of the resource areas. The National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations require Federal agencies to consider the cumulative impacts of their actions. Cumulative impacts are defined as the incremental impact of the proposed action when added to past, present, and reasonably foreseeable future actions, regardless of what other agency or person undertakes the other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time (40 CFR 1506.7). Section 5.17 discusses overall cumulative effects that could result from implementation of the proposed action from this Lower Snake River Juvenile Salmon Migration Feasibility Study.

5.1.3 Short- and Long-term Effects

Throughout the Section 5 resource analyses, the resource effects are analyzed with respect to short-term and long-term effects. The long-term effects analyses include consideration of the short-term effects analyses. Section 5.18 discusses some of the overall tradeoffs inherent in considering the relationship between short-term uses of humankind's environment and the maintenance and enhancement of long-term productivity.



5.2 Geology and Soils

This section addresses the environmental effects of the alternatives on geologic and soil resources in the project area. See Table 5.2-1 for a summary of potential effects.

Table 5.2-1. Summary of Potential Effects of the Alternatives on Geology and Soils

Alternative 1	Alternative 2	Alternative 3	Alternative 4
• Continued current rate of natural hillslope erosion and wave-induced erosion. • No expected effects to soils.	Same as Alternative 1.	Same as Alternative 1.	• Approximately 13,772 acres of inundated land would be exposed, including mudflats and oversteepened banks that could slough and erode during peak flows. • Roadway and railroad embankments could fail. • Increased total suspended solid concentrations until new flow regime stabilizes.

5.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, natural hillslope erosion and wave-induced erosion on the reservoir banks would continue at the existing rates. There would be no change in adverse effects to soil resources.

5.2.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

The effects under Alternatives 2 and 3 would be essentially the same as under Alternative 1—Existing Conditions because current project operations would continue.

5.2.3 Alternative 4—Dam Breaching

The breaching of dams would lower the levels of the reservoirs such that a near-natural river flow would occur. Approximately 13,772 acres of inundated land would be exposed as a result of the dam breaching in the lower Snake River reach (Table 5.2-2). The lowering of the current water levels by breaching the dams would expose mudflats and oversteepened banks that are susceptible to sloughing and erosion during peak flow events. In addition, as drawdown occurs, areas of the roadway and railroad embankments along the river are anticipated to fail due to steep slopes, saturated soils, and pore pressure increase. During the 1992 drawdown tests in the Lower Granite reservoir, water levels were lowered 33 feet, exposing substantial mudflats along the shoreline of the reservoir. Slope failures observed during the 1992 drawdown occurred along the contact between the structure fill and the natural foundation material. It was estimated that dam breaching could result in 68 potential failure areas on the 140-mile lower Snake River reach. It is anticipated that there could be at least two large failures on both the Little Goose and Lower Granite reservoirs, and one large failure on both Ice Harbor and Lower Monumental reservoirs (see Appendix D, Natural River Drawdown Engineering).

Table 5.2-2. Areas of Current Reservoirs and Exposed Reservoir Bottom

Reservoir	Area of Current Reservoir (acres)	Exposed Reservoir Bottom (acres)
Ice Harbor to Lower Monumental	9,001.8	3,879.8
Lower Monumental to Little Goose	4,960.4	1,443.4
Little Goose to Lower Granite	10,825.2	5,640.2
Lower Granite to the Clearwater River at Spalding and to Asotin on the Snake River	8,448.2	2,808.2
Total	**33,235.6**	**13,771.6**

Source: Walla Walla District Real Estate Database

Total suspended solids (TSS) concentrations could be reasonably expected to be much higher during the proposed drawdown conditions until the new channel bed and banks stabilize and equilibrate with the flow regime (see Section 5.4, Water Resources). In addition, the sediment accumulated on the banks of the reservoir and at the deltas of the streams that discharge into the river would become exposed to soil and rain.

5.2.4 Cumulative Effects

Geologic and soil conditions would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching in the short term (<10 years), exposed shoreline areas would be potential sources of fugitive dust, which may require active management to minimize any adverse effects. Roadway and railroad embankments that could potentially fail would need long-term monitoring and continued maintenance. There also would be increased total suspended solids concentrations until the new flow regime stabilizes. Additional dredging may be required in the McNary reservoir to maintain the navigation channel. Also, additional habitat arrangement considerations may be needed for any expansion of islands or other lands at the mouth of the Snake River that result from sediment deposition. Upslope conditions and land uses would not be expected to change under all alternatives. Therefore, soils and geologic conditions in these areas would be expected to remain similar to existing conditions.

5.2.5 Uncertainties in Potential Geology and Soils Effects

Although the number and severity of slope failures that would result from breaching have been estimated and contingency plans have been developed (Appendix D, Natural River Drawdown Engineering), the actual number and severity could easily differ from these estimates.

Uncertainties in total suspended solids (TSS) concentrations and in concentrations of contaminants that would result from breaching are addressed in Section 5.4, Water Resources.

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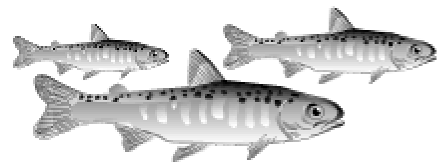


5.3 Air Quality

This section identifies the short-term and long-term effects on air quality of each of the four alternatives in terms of these issues. Table 5.3-1 summarizes these potential effects. Short-term effects are associated with construction- and deconstruction-related activities and newly exposed sediments that are prone to wind erosion. Long-term effects are those that persist after systems have stabilized (e.g., revegetation of exposed sediments, replacement of lost power generation and barge transportation). This section also discusses mitigation measures and cumulative effects. Information provided in this section is described in greater detail in Appendix P, Air Quality.

The analysis of air quality impacts associated with the four Lower Snake River Juvenile Salmon Migration Feasibility Study alternatives addresses four potential impact issues. These issues are: 1) fugitive dust emissions resulting from potential dam breaching activities (i.e., removal of the earthen portion of the dams and other site work); 2) the change in the quantity and distribution of vehicle emissions as commodities are shifted from barges to trains and trucks; 3) fugitive dust emissions resulting from dry exposed lake sediments during high wind events; and 4) atmospheric emissions associated with replacement power generation by thermal power plants.

Table 5.3-1. Summary of Potential Effects of the Alternatives on Air Quality

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Construction-related fugitive emissions	No change from current conditions.	Same as Alternative 1.	Slight increase in emissions from particulate matter associated with mixer trucks and haul roads used for surface bypass collectors (SBC) and other modifications.	Excavation fugitive emissions (PM_{10}) from removal of the core material and from material handling activities.
Emissions associated with loss of barge transportation	No change from current conditions.	Slight increase in emissions from increased barging of juvenile salmon.	Same as Alternative 1.	Increase in some emissions (criteria air pollutants) from the loss of barge transportation.
Fugitive dust from exposed sediments	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	Increase in fugitive dust from exposed reservoir sediments; some mitigation from revegetation.
Emissions associated with replacement power generation	Slight increase in emissions from new power plants that may be built as power demand increases.	Same as Alternative 1.	Same as Alternative 1.	Increase in emissions from replacement power generation.

5.3.1 Study Methods

The study methods used to analyze potential air quality impacts associated with the four alternatives are identified below by issue. Most of the discussion in this section is focused on Alternative 4—Dam Breaching because little or no change in air quality would be expected under the first three alternatives. Additional information on these study methods is provided in Appendix P, Air Quality.

5.3.1.1 Construction-related Fugitive Emissions

In terms of atmospheric emissions, breaching of the lower Snake River dams would be equivalent to a large construction project. U.S. Environmental Protection Agency (EPA) construction-related emission factors were used to estimate fugitive dust emissions related to breaching of the lower Snake River dams (EPA, 2000a). Appendix D, Natural River Drawdown Engineering, provides conceptual designs for breaching the four lower Snake River dams, creating river channelization, and modifying the reservoir. This analysis assumes that all four facilities would be demolished over a span of 4 years (2 years at each pair of dams), but deconstruction would most likely last a number of years. Many of the deconstruction details were approximated; therefore, only a preliminary analysis of fugitive emissions is presented. Deconstruction emissions estimates for Alternative 4—Dam Breaching do not include emissions associated with reservoir modifications. Construction details sufficient for emission estimates of reservoir modifications have not been specified. Details of structural enhancements to improve downstream migration of juvenile salmon (e.g., surface bypass and collection systems) are provided in Appendix E, Existing Systems and Major Systems Improvements Engineering.

5.3.1.2 Emissions Associated with Loss of Barge Transportation

Air emissions resulting from loss of barge traffic were estimated using the number of river, train, and road miles that would be required to transport commodities affected by Alternative 4—Dam Breaching. The transportation-related emissions estimates do not consider tire and brake emissions. Two sources provided data for this analysis. First, the Eastern Washington Intermodal Transportation Study (EWITS) (Lee and Casavant, 1998) conducted a 6-year study funded jointly by the Federal government and the Washington State Department of Transportation that included an examination of transportation-related energy consumption and air emissions associated with breaching of the four lower Snake River dams. The study looked at wheat and barley transportation-related emissions and extrapolated that data to other commodities. Second, the Transportation and Navigation Study (Corps, 1999d) provided the number of train and truck bushel-miles needed to transport the wheat and barley harvest following dam breaching. This data was also extrapolated to other commodities. Transportation-related emissions estimated from the EWITS and Transportation and Navigation Study data produced different values. Because both studies included uncertainty, the emission estimates presented in this section are an average of the emissions provided in the two studies.

5.3.1.3 Fugitive Dust from Exposed Sediments

Windblown fugitive dust emissions were estimated using an EPA method of predicting the amount of particulate matter with aerodynamic diameters less than 10 micrometers (PM_{10}) emitted during a wind erosion event (EPA, 2000a). The analysis used 1984 through 1991 wind data from Pendleton, Oregon; Spokane and Yakima, Washington. Information from related particulate studies at Lake Koocanusa in Montana and Owens Lake in California is also used to supplement results.

5.3.1.4 Replacement of Power Generation

Changes in Pacific Northwest hydropower generation could affect the amount of energy bought and sold, and the number of new generating facilities built throughout an interconnected power system that includes all or part of 14 western states, two Canadian provinces, and a small area of northern Mexico. This area is managed by the Western Systems Coordinating Council (WSCC). This air quality analysis attempts to estimate how air emissions would change in the WSCC-managed region because of the loss of hydropower generated by the four lower Snake River facilities. The analysis is based on the findings of the Technical Report on Hydropower Cost and Benefits that was developed by the Drawdown Regional Economic Workgroup Hydropower Impact Team (DREW HIT, 1999). This report considered existing coal-fired, fuel-oil-fired, and natural gas-fired generating units in the WSCC-managed area. It assumed that new generating units would be natural gas-fired combined cycle units. A power systems model (PROSYM) was used to predict carbon dioxide (CO_2), nitrogen dioxide (NO_x), and sulfur dioxide (SO_2) emissions for new and existing units. These estimates were extrapolated to carbon monoxide (CO), volatile organic compounds (VOCs), PM_{10} and other pollutants using published emission factors.

5.3.2 Impacts of the Alternatives

5.3.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the Snake River facilities would remain in place and barge traffic would continue on the Snake River waterway. No changes from currently planned operations and improvements are planned under this alternative. Emissions estimates presented in this alternative represent existing conditions, or emissions representative of a baseline year.

Construction-related Fugitive Emissions

Other than operation and maintenance and other planned improvements, no new construction and deconstruction activities would take place under Alternative 1—Existing Conditions. Therefore, no new construction- or deconstruction-related atmospheric emissions would result from this alternative.

Emissions Associated with Loss of Barge Transportation

Barge transportation on the navigable portions of the Columbia and Snake Rivers would continue with Alternative 1—Existing Conditions. Although there would not be any air quality impacts, transportation-related emissions estimates for this alternative were used to predict the changes associated with Alternative 4—Dam Breaching.

Fugitive Dust from Exposed Sediments

Under Alternative 1—Existing Conditions, the four lower Snake River reservoirs would not be drained. Therefore, there would be no fugitive emissions from exposed reservoir sediments.

Emissions Associated with Replacement Power Generation

Power generation by the four lower Snake River hydropower facilities would continue under Alternative 1—Existing Conditions, eliminating the need for replacement power. However, the demand for energy would likely continue to grow, resulting in a possible need for additional generating capacity. Emissions from generating units throughout the WSCC-managed area for 2010, representative of Alternative 1—Existing Conditions, are presented in Table 5.3-2. These figures include emissions that would be generated by new natural gas-fired combined cycle units that would go online by 2010, regardless of the continued operation or removal of the four lower Snake River hydropower facilities.

Table 5.3-2. Percent Increase in Year 2010 Electrical Generating Emissions throughout WSCC Region

Scenario	Emissions (thousands of tons per year)				
	CO	CO_2	NO_x	PM_{10}	SO_2
Year 2010 existing conditions	404	414,234	57.8	49.3	457.4
Year 2010 new power plants	408	418,870	58.1	49.5	459.6
Net increase in year 2010 WSCC regional	4	4,636	0.3	0.2	2.2
Percent increase in WSCC regional emission	1.0%	1.1%	0.5%	0.4%	0.4%

Source: DREW HIT, 1999

Summary of Effects for Alternative 1—Existing Conditions

No emission increases are estimated for Alternative 1—Existing Conditions. Therefore, this alternative would have no short-term or long-term air quality effects. Under this alternative, Snake River barge traffic would continue, and new power plants would likely continue to be built as power demand increases. Emissions from these new plants have been factored into the analysis.

5.3.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under Alternative 2—Maximum Transport of Juvenile Salmon, juvenile fishway systems would be operated to maximize fish transport. This would result in an increased number of fish being transported downstream by trucks or barges.

Construction-related Fugitive Emissions

Construction and deconstruction activities would not take place under this alternative. Therefore, no construction or deconstruction related atmospheric emissions would result from this alternative.

Emissions Associated with Barge Transportation

Barge transportation on the navigable portions of the Columbia and Snake Rivers would continue with this alternative. Transportation-related air emissions would likely be slightly higher than the emission estimates presented in Alternative 1—Existing Conditions due to the increased number of trips by trucks and barges needed to achieve maximum transport of juvenile salmon.

Fugitive Dust from Exposed Sediments

Under this alternative, the four lower Snake River reservoirs would remain in their current condition. There would be no fugitive emissions from exposed reservoir sediments.

Emissions Associated with Replacement Power Generation

Power generation by the four lower Snake River hydropower facilities would continue, eliminating the need for replacement power and associated air emissions. Power generation emissions associated with this alternative are projected to be identical to the emissions predicted for Alternative 1—Existing Conditions.

Summary of Effects for Alternative 2—Maximum Transport of Juvenile Salmon

Transportation-related air emissions for this alternative would be slightly higher than emissions under Alternative 1—Existing Conditions due to the increased number of trips made by trucks and barges to achieve maximum transport of juvenile salmon. Only minor long-term air quality effects would result. As with Alternative 1—Existing Conditions, Snake River barge traffic would continue, and new power plants would likely continue to be built as power demand increases. Emission estimates for these new plants are identical to those included in Alternative 1—Existing Conditions.

5.3.2.3 Alternative 3—Major System Improvements

Structural enhancements to improve downstream migration of juvenile salmon would be added to each of the four lower Snake River hydropower facilities under this alternative. The proposed enhancements include optional designs for surface bypass collection (SBC) systems. Details and designs for Alternative 3—Major System Improvements are provided in Appendix E, Existing Systems and Major Systems Improvements Engineering.

Construction-related Fugitive Emissions

System enhancements would consist of SBC systems combined with structural modifications at each project. The SBC structures, consisting mostly of channels, could be built from components constructed offsite, or could be built in-place. Therefore, construction-related air emissions for this alternative would be very small and would include particulate matter emissions from mixer trucks and haul roads. For comparison of alternatives, this analysis conservatively assumed a total of one ton of PM_{10} emissions for structural enhancement at all four facilities. Furthermore, it was assumed that construction would take place in one year.

Emissions Associated with Barge Transportation

Barge transportation on the navigable portions of the Columbia and Snake rivers would continue under this alternative. Transportation-related air emissions would be identical to the emission estimates presented in Alternative 1—Existing Conditions.

Fugitive Dust from Exposed Sediments

For this alternative, the four lower Snake River reservoirs would remain in their current condition. There would be no fugitive emissions from exposed reservoir sediments.

Emissions Associated with Replacement Power Generation

Power generation by the four lower Snake River dams would continue, eliminating the need for replacement power and associated air emissions. Power generation emissions associated with this alternative are projected to be identical to those predicted for Alternative 1—Existing Conditions.

Summary of Effects for Alternative 3—Major System Improvements

Minor construction-related emission increases are anticipated for this alternative. Therefore, only minor short-term air quality effects would result. As with Alternative 1—Existing Conditions, Snake River barge traffic would continue, and new power plants would likely continue to be built as power demand increases. Emission estimates for these new plants are identical to those of Alternative 1—Existing Conditions.

5.3.2.4 Alternative 4—Dam Breaching

Air quality issues associated with Alternative 4—Dam Breaching include impacts from demolition-related emissions, loss of barge transportation, windblown fugitive dust from exposed dry sediments, and emissions from thermal power plants used to replace hydropower.

Construction-related Fugitive Emissions

The steps required to breach each of the four lower Snake River dams include lowering the reservoir, excavating the earthen portion of the dam, removing cofferdams, routing the river around concrete structures, and constructing levees as necessary. Removing the core material of the earthen portion of the dams and constructing levees would produce fugitive dust emissions. PM_{10} emission sources include material handling activities such as hauling, dumping, bulldozing, and grading. Table 5.3-3 presents estimated PM_{10} emissions by hydropower facility and construction activity. Total PM_{10} emissions for the four facilities would be 634 tons per year (TPY). With a 2-year breaching schedule for each dam, the emissions would be spread out over the full 2-year period. Overall, with breaching of 2 dams simultaneously, the total period of effects would be 4 years.

Table 5.3-3. Estimated Deconstruction PM_{10} Emissions

Operation	Emissions (tons per year)			
	Ice Harbor	**Lower Monumental**	**Little Goose**	**Lower Granite**
Bulldozing	3.54	2.61	2.60	3.12
Hauling	150.5	183.7	67.7	63.4
Dumping	0.9	1.1	0.4	0.4
Grading	46.5	34.3	31.5	41.0
Total	**201.5**	**221.7**	**102.1**	**108.2**

Source: Appendix P, Air Quality

Breaching of the dams would incorporate standard construction practices to suppress fugitive dust, such as spraying haul roads with water. Some of the dam core material would be saturated with water to reduce the potential for fugitive dust emissions.

Emissions Associated with Loss of Barge Transportation

Barge transportation on the navigable portions of the Snake River would cease under Alternative 4—Dam Breaching. Grain quantities normally trucked to river ports on the Snake River would be trucked to elevators located on rail lines, or to river ports at or below the Tri-Cities area for barge shipment. According to EWITS, elevator to river port shipments would decrease 21 percent, while elevator to Portland rail shipments would increase by the same amount. About 28 million bushels of wheat would switch from barges to trains. About 62 percent of the barley harvest is trucked to non-Snake River ports and then barged to Portland. The volume of barley barged to Portland would decrease only slightly without barging on the lower Snake River. Additional transportation information is provided in Sections 4.9 and 5.9 (Transportation).

Under Alternative 4—Dam Breaching, the EWITS data suggest that NO_x, PM_{10}, and VOC emissions would increase; CO emissions would remain about the same; and SO_2 emissions would decrease. The Transportation and Navigation Study data indicate that CO, NO_x, PM_{10}, and VOC emissions would increase and SO_2 emissions would stay about the same. The averages of the two total emissions estimates are presented in Table 5.3-4.

Table 5.3-4. Transportation-Related Emissions[1/] (tons per year)

Alternative	CO	VOC	NO_x	PM_{10}	SO_2
Alternative 1—Existing Conditions	235	285	1,705	52	266
Alternative 4—Dam Breaching	227	383	1,759	63	198

[1/] Emissions estimates are an average of the estimates from the EWITS and Transportation and Navigation Study Data.
Sources: Corps, 1999d; Lee and Casavant, 1998

Fugitive Dust from Exposed Sediments

During and after dam breaching construction activities, exposed reservoir sediments would dry and become subject to wind erosion. Because large areas of dry sediments would be exposed, total PM_{10} emissions could be large. The estimated annual average PM_{10} emissions under Alternative 4—Dam Breaching for the four reservoirs, based on data from Pendleton, Oregon; Spokane, Washington; and Yakima, Washington are presented in Table 5.3-5. Residences along the river would be most susceptible to windblown dust from exposed sediments. Because the Snake River valley would channel the winds, residences located where the river bends would be most susceptible to windblown dust.

Table 5.3-5. Annual Average PM_{10} Emissions by Reservoir under Alternative 4—Dam Breaching (tons per year)

Reservoir	PM_{10} Emissions
Ice Harbor	1,555
Lower Monumental	1,224
Little Goose	1,861
Lower Granite	1,652
Total	**6,292**

Source: Appendix P, Air Quality

The Revegetation Plan in Appendix D, Natural River Drawdown Engineering calls for seeding the exposed bottom sediments as the water recedes, and restricting access to the dry reservoirs, thereby minimizing the amount of available erodible material. This analysis assumes that mitigation efforts would reduce emissions by 50 percent. Rain often accompanies strong winds. This analysis did not screen out occasions of precipitation with strong winds, but it did reduce the annual emission estimates to account for the number of days of precipitation.

Emissions Associated with Replacement Power Generation

Hydropower generation does not result in air pollutant emissions. The loss of generation from the four lower Snake River hydropower facilities would require replacement of power-generating capacity, which could result in an increase of criteria air pollutants, toxic air pollutants (TAPs), and greenhouse gases (GHGs). The Technical Report on Hydropower Costs and Benefits (DREW HIT, 1999) concluded that it would not be necessary to replace all 3,500 megawatts (MW) of the four lower Snake River facilities' capacity.

The PROSYM model was used to predict air emissions under Alternative 4—Dam Breaching for 2010. The analysis considered all generating units in the WCSS-managed area, new natural gas-fired combined cycle units that would be constructed regardless of the fate of the four lower Snake River facilities, and 1,550 MW of replacement power that would be constructed in the Pacific Northwest.

With Alternative 4—Dam Breaching, CO and CO_2 emissions are predicted to increase by 8 and 4,636 TPY, respectively. About 65 percent of this increase would be from the new combined cycle plants. SO_2 emissions are predicted to increase by 2.2 TPY, mostly as a result of an increase in Pacific Northwest coal plants. NO_x and PM_{10} are predicted to increase because of Pacific Northwest coal and natural gas combustion. Emissions from the combustion of Alberta, Arizona, and New Mexico coal and emissions from some of the California Independent Power Producers (IPPs) are predicted to decrease.

The analysis indicates that total emissions throughout the WCSS-managed region would increase from about 0.39 to 1.1 percent, depending on the individual pollutant. Percentage increases in emissions above existing conditions are presented in Table 5.3-2.

Summary of Effects for Alternative 4—Dam Breaching

Alternative 4—Dam Breaching would result in demolition fugitive emissions (PM_{10}), emissions associated with the loss of barge transportation (criteria air pollutants), fugitive dust from exposed reservoir sediments, and emissions associated with replacement power generation (criteria and hazardous air pollutants, and GHGs).

5.3.3 Cumulative Effects

Emission increases above those estimated for Alternative 1—Existing Conditions are presented in Table 5.3-6. Emissions under Alternatives 2 and 3 would be essentially the same as those estimated for Alternative 1—Existing Conditions.

Transportation-related air emissions would be slightly higher under Alternative 2—Maximum Transport of Juvenile Salmon due to the increased number of trips made by trucks and barges to maximize juvenile salmon transportation. Minor construction-related emissions are anticipated under Alternative 3—Major System Improvements.

No cumulative effects are anticipated under the first three alternatives. The magnitude of the cumulative effects under Alternative 4—Dam Breaching would depend on the dam breaching schedule. Maximum emissions would occur if all four dams were removed at once, as was assumed for the emission estimates. In this scenario, the deconstruction and fugitive windblown emissions would occur in the same year. The increase in transportation and power generation emissions would take place as the commerce and power systems adjust to the loss of the lower Snake River hydropower facilities and as new thermal power plants come on line.

Emissions associated with increases in truck and rail transportation would be distributed in five states (Idaho, Montana, Washington, Oregon, and North Dakota). Most of the emission increases would be in southeastern Washington.

Emissions associated with replacement power would be distributed over the entire WCSS-managed area, covering the western United States.

Unavoidable adverse effects under the first three alternatives are limited to emissions from new power plants required to meet anticipated growth in demand. The different types of air emissions associated with Alternative 4—Dam Breaching are all unavoidable if this alternative is selected.

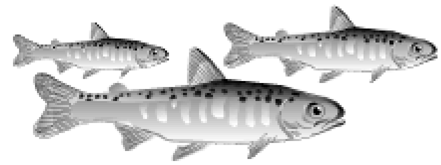
Table 5.3-6. Summary of Emissions (tons per year)

	CO	CO_2	NO_x	PM_{10}	SO_2	VOC	Benzene	Formaldehyde
Alternative 1—Existing Conditions								
Demolition								
Transportation	235	20,680	1,705	52	266	285	1	1
Windblown Dust								
Power Generation	403,624	414,233,886	57,757	49,267	457,383	1,132	4	45
Total	***403,859***	***414,254,566***	***59,462***	***49,319***	***457,649***	***1,417***	***5***	***46***
Alternative 4—Dam Breaching								
Demolition				1,193				
Transportation	227	19,976	1,759	63	198	383	1	1
Windblown Dust				6,292				
Power Generation	407,758	418,870,000	58,100	49,463	459,600	1,134	4	45
Total	***407,985***	***418,889,976***	***59,859***	***57,011***	***459,798***	***1,517***	***5***	***46***
Change from Alt. 1	**4,126**	**4,635,410**	**397**	**7,692**	**2,149**	**101**	**0**	**0**

Source: Appendix P, Air Quality

5.3.4 Uncertainties in Potential Air Quality Effects

Estimates of potential emissions from construction, loss of barge transportation, exposed sediments, and replacement power generation that would result from dam breaching are somewhat uncertain due to uncertainties in data and differences in modeling assumptions (see, for example, Section 5.2.1.2). In all cases, however, these uncertainties would not change the overall assessment that the estimated increases (or decreases) in emissions are small fractions of existing regional emissions (Table 5.2-1).



5.4 Water Resources

A summary of the potential effects of the alternatives on water resources is presented in Table 5.4-1.

5.4.1 Hydrology

5.4.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the river hydrograph would remain the same as the existing conditions described in Section 4.4.1 (Hydrology) and in the 1995 and 1998 Biological Opinions, and would follow the flow augmentation schedule to meet the 85 to 100 thousand cubic feet per second (kcfs) flow target for the lower Snake River. The Corps signed a Record of Consultation and Statement of Decision (ROCASOD) on the NMFS 2000 Biological Opinion (see Section 1.1). Flow depths would remain relatively constant throughout the year and range from about 20 feet in the tailwater areas to over 100 feet at the dams. The surface area of the lower Snake River of approximately 33,236 acres would remain the same. The four dams on the lower Snake River do not provide flood control downstream. Therefore, continuation of current operations would not affect flood control.

5.4.1.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Under these alternatives, the volume of water moving through the lower Snake River would not change from Alternative 1—Existing Conditions, which is based on the 1995 and 1998 Biological Opinions and would follow the flow augmentation schedule to

Table 5.4-1. Summary of Potential Effects of the Alternatives on Water Resources

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Hydrology	No change from current conditions.	No changes from current conditions except slight decrease in water travel time or slight increase in water velocity.	Same as Alternative 2.	• Increase in water velocities. • Reduced surface area. • Flow depths would vary seasonally. • Increase in amount of overbank areas available for flood water storage. • Increase in sediment transport due to higher velocities for first 5 years until scouring stabilizes.
Water Quality—Sediment	No change from current conditions	Same as Alternative 1.	Same as Alternative 1.	• 50 to 75 million cubic yards of material could move downstream. Redeposited, materials could affect water withdrawal intakes and cause a short-term disruption in the food supply for bottom-feeding aquatic organisms. • Suspended sediment from moving materials could result in TSS concentrations that could adversely affect aquatic organisms and other beneficial uses during the first 2 years after dam breaching.
Water Quality—Temperature	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Water temperatures would likely warm up faster early in the season, have greater daily fluctuations, and reach higher daily maximums but cool down faster in early fall (Table 5.4-2 through 5.4-4).
Water Quality—Contaminants	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Manganese would exceed its criteria for thresholds in the water column. • Un-ionized ammonia concentrations may exceed EPA water quality criteria for the protection of aquatic life.
Water Quality—Dissolved Gases	Planned improvements under Alternative 1 should result in reduced TDG levels.	TDG levels should decrease due to decreased voluntary spill.	TDG levels should decrease slightly due to additional planned improvements.	• There would be no spill, so TDG levels would be considerably lower and should remain stable and under the 110 percent threshold.

meet the 85 to 100 kcfs flow target for the lower Snake River. The slight difference between Alternatives 2—Maximum Transport of Juvenile Salmon and 3—Major System Improvements would be the travel time of the water due to minimal spill under the Alternative 2 management for maximum smolt collection and transport. Large voluntary spill for fish passage could continue under Alternative 3, especially during the short term of the next 10 years.

The relative reservoir refill times that reflect water travel times are displayed in several charts in Appendix F, Hydrology/Hydraulics and Sedimentation.

5.4.1.3 Alternative 4—Dam Breaching

Breaching the four lower Snake River dams would return this reach of the river to an unimpounded state. Because the four lower Snake River hydropower facilities are currently operated as run-of-river, the volume of water flowing through the system would not change. However, water velocities through the lower Snake River reach would be greatest under this alternative. Water depths and surface area would be significantly different under Alternative 4—Dam Breaching compared to Alternative 1—Existing Conditions. As a result of dam breaching, the surface area of the Snake River would be reduced from 33,236 acres to 19,464 acres, or almost half of the existing conditions. Flow depths would vary seasonally. During a typical spring runoff period (120 kcfs), average flow depth over a cross section would be about 25 feet compared to being generally less than 15 feet during a typical flow condition. The long-term indirect effects of higher velocities include the greater sediment transport capability. The greater velocities and lesser flow area would result in greater suspended sediment concentrations until the reservoir bed deposits have scoured downstream during the first 5 years following breaching, with about half of the effects occurring in the first 2 years. The effects of sedimentation from this alternative are described in Section 5.4.2 (Water Quality).

5.4.2 Water Quality

The discussion of potential impacts to water quality parameters focuses primarily on those parameters that are most likely to be affected by Alternative 4—Dam Breaching. The primary water quality parameters discussed include sediment; dissolved gases; water temperature; and contaminants such as manganese, dioxin toxic equivalency quotient (TEQ), and total DDT. These parameters are the most significantly affected by the alternatives and are most relevant to the beneficial uses of the water (see Appendix C, Water Quality for additional details). In addition, the breaching and decommissioning of the dams would result in the removal of hazardous materials, substances, and chemicals that are used for current maintenance of the dams. Those materials would be removed in ways to minimize any potential hazards to the river and all waste would be disposed following regulatory requirements for the disposal of those materials.

Under current reservoir conditions, compounds are either bound to sediment and organic matter, are present in the pore water (water between sediment particles), or occur in open water. The release of impounded water and sediment during the drawdown would disrupt existing conditions in the reservoirs and the lower Snake River and Columbia River. Changes in water quality parameters such as temperature, pH, hardness, alkalinity, and salinity can alter the toxicity and degradation rate of some of the compounds that are currently in the water and sediments. Also, organic compounds can become biologically available when sediments are disturbed. Once liberated, it is unknown what the interdependent and interrelated reactions of multiple contaminants would be. Effects on the Columbia-Snake River System would change as the physical and chemical properties of water and sediment change following drawdown.

5.4.2.1 Sediment (Turbidity and Total Suspended Solids)

Alternatives 1, 2, and 3

Under Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements, the Lower Granite reservoir would continue to capture the current average annual sediment load of 3 to 4 million cubic yards per year that the lower Snake River is carrying due to various basin runoff processes. Lower Granite would continue to collect the majority of the annual inflowing sediment load carried by the Snake River. In addition, all four Lower Snake Projects would continue to collect sediments carried into them by the Snake River's tributaries such as the Palouse and Tucannon Rivers as well as by numerous other minor sources of local runoff.

Alternative 4—Dam Breaching

Breaching of the four lower Snake River dams would allow the annual sediment load of 3 to 4 million cubic yards to be carried downstream to the McNary reservior, where the majority of incoming sediment would likely be deposited. The very finest silts and clays would be carried as suspended sediment downstream through Lake Wallula, with their ultimate destination likely being the lower Columbia River estuary or the Pacific Ocean.

Recent sediment volume estimates developed by the Corps, Walla Walla District, indicate that approximately 100 to 150 million cubic yards of sediment have accumulated behind the four lower Snake River dams. In addition, approximately 50 percent of this previously deposited sediment is expected to erode and move downstream within the first few years following dam breaching, particularly during peak flow periods (Corps, 1998a). This translates to about 50 to 75 million cubic yards of material that could move downstream. Approximately one-half of this eroded material is expected to settle out downstream in the McNary reservoir following dam breaching. This reservoir, created by McNary Dam, is the first dam downstream on the Columbia from the Snake River confluence.

The eroded material would most likely be redeposited in the McNary reservoir between the mouth of the Snake River and Wallula Gap. Appendix F, Hydrology/Hydraulics and Sedimentation (Plates 8-12) shows the qualitative predictions of sediment inundation in the reservoir. Because the reservoir extends to Ice Harbor, the very coarsest cobble materials could be initially deposited in the vicinity of Ice Harbor Dam, although they could later be subject to re-suspension and further transport downstream into the McNary reservior. Since these materials were previously able to be deposited behind the lower Snake River dams, and since the flow velocities in the McNary reservoir are generally slower than the Snake River's velocity, it is very likely that most of these sediments would also be deposited in the McNary reservoir rather than being transported downstream of McNary Dam. The sediment exposed on the reservoir bottom after dam breaching would be subject to erosion from wind and precipitation and could eventually be transported downstream to the McNary reservoir.

It is difficult to estimate the volumes and locations to which the various sized particles that make up the accumulated sediment would be redistributed downstream. The McNary reservoir is nearly twice the size of the largest reservoir in the lower Snake River. More-recent analyses indicate that sediment is expected to accumulate mainly on the eastern shore of the McNary reservoir between the Snake River confluence and Wallula Gap. Smaller areas of deposition are anticipated on the opposite shoreline, on the western shore immediately downstream of Wallula Gap, and just upstream of McNary Dam (Appendix F, Hydrology/Hydraulics and Sedimentation).

As a rough estimate, the average depth of sediment deposited in the McNary reservoir could range between 1.7 and 2.5 feet, assuming the sediment is equally distributed throughout the impoundment. Realistically, the eroded sediment would not be equally distributed throughout the waterbody and would most likely be contained and deposited within the main river channel within the impoundment or along the eastern shoreline downriver to the area upstream of the mouth of the Walla Walla River, where most sediment currently accumulates. Assuming that one-third of the area in the McNary reservoir represents the primary deposition zone, the depth of the new sediment could be as much as 4.2 feet. This potential depth of material would not likely present navigation problems because most of the sediment would re-deposit in coves near the shoreline and not near the center where most of the McNary reservoir is greater than 65 feet deep. However, this could present problems with existing water withdrawal intakes, including those used for drinking water supply. In addition, redeposited sediment would likely cover large areas of benthic habitat, which could cause a short-term disruption in the primary productivity and food supply for benthivores and other bottom feeders.

Alternative 4—Dam Breaching calls for the two upstream dams to be breached the first year and the two downstream dams to be breached the following year. With initial breaching, presumably in the late summer low-flow period, velocities would immediately increase to the point that the accumulations of sediment in the Lower Granite and Little Goose reservoirs would be mobilized first at the upper end of the reservoirs, then progress downstream as the energy gradient permits. Although it would remain high, it is possible that the suspended sediment load would decline somewhat within a few weeks/months following initial breaching. However, as flows increase in the October/November time frame, the suspended sediment concentration would increase dramatically. Very heavy sediment loads as a result of breaching the two upstream dams would probably be present throughout the following year until August when the two downstream dams are breached. The timing of sediment movement from breaching Lower Monumental and Ice Harbor Dams would be about the same as described for the upstream dams.

Suspended sediment, turbidity, and the downstream aggradation of the sediment stored in the lower Snake River reservoir beds are primary water quality concerns associated with drawdown. Potential mobilization of these stored sediments during the initial drawdown period may result in total suspended solids (TSS) concentrations that could adversely affect aquatic biota and other beneficial uses. For example, the increased turbidity can adversely affect both primary food production (i.e., phytoplankton and attached benthic algae growth) and fish feeding efficiency. In addition, depending on the magnitude of the TSS concentrations, impairments to other biological functions such as respiration (i.e., gill clogging) and reproduction are possible.

Modeling efforts for SOR to predict suspended sediment and turbidity used 25 milligrams per liter (mg/l) TSS as a threshold for protection of fish (BPA et al., 1995). During the 1997 sampling season, field observations of turbidity levels throughout the lower Snake River were typically below 10 NTUs, except for occasional peak levels of 15 to 20 NTUs during the spring freshet.

During the 1992 drawdown test conducted in the Lower Granite reservoir, suspended sediment concentrations were observed to be as high as 2,000 mg/l (Corps, 1992) during a time when peak flow conditions and rainfall events were not encountered. During the tests, water levels were lowered 33 feet, which exposed substantial mudflats along the shoreline of the reservoir. Under the proposed drawdown, a more extensive series of mudflats would be exposed, vulnerable to erosion and transport downstream, especially during peak flow periods. The HEC5-Q model was used in a previous study in 1994 to predict TSS concentrations after breaching of the dams. The HEC5-Q model predicted that TSS concentrations as high as 9,000 mg/l could be expected at Ice Harbor due to breaching until the new channel bed and banks stabilize and equilibrate with the flow regime.

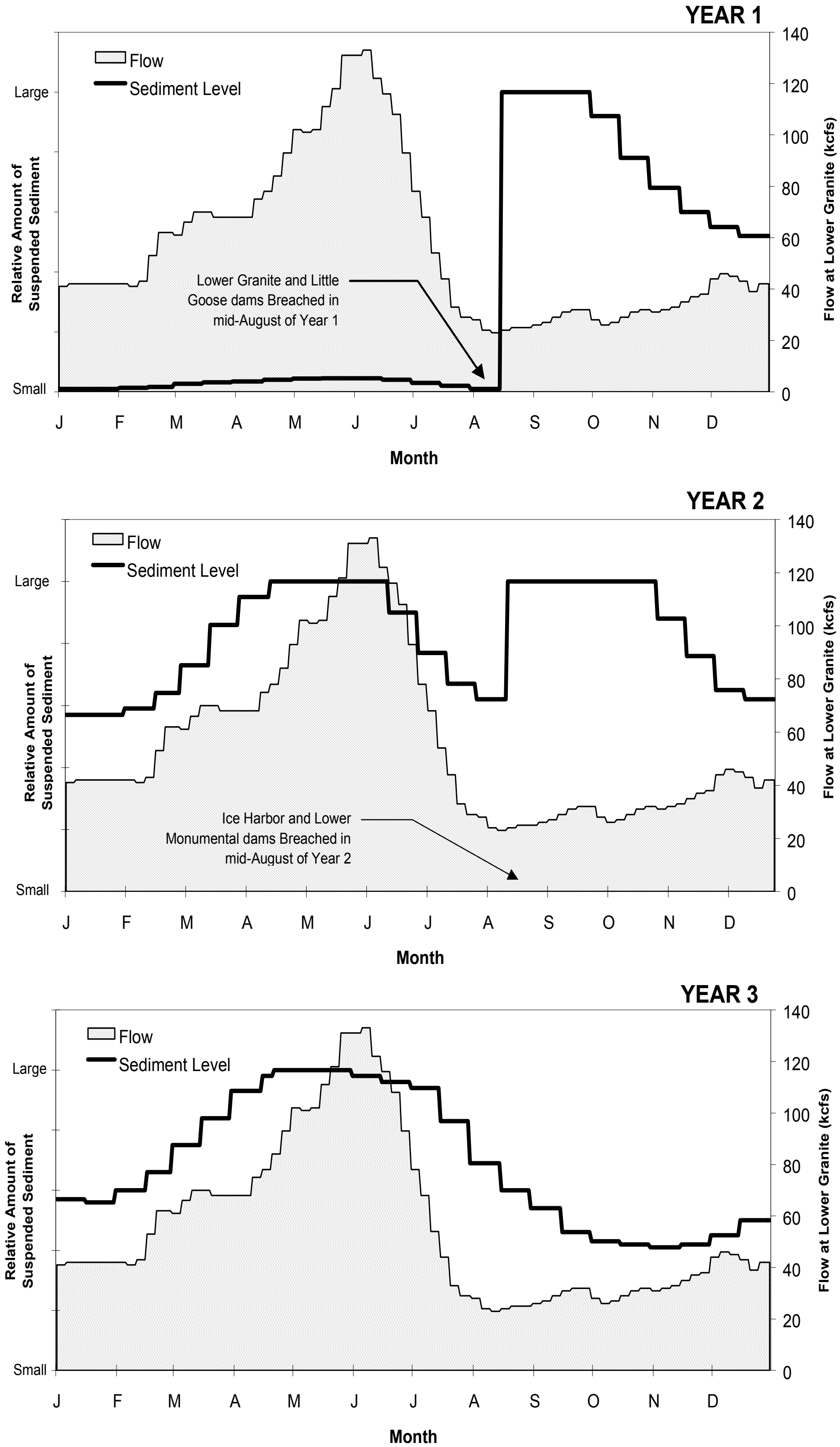
Effects of elevated sediment on anadromous fish are discussed in Section 5.5.1.4. Figure 5.4-1 shows approximately when extreme levels of suspended sediment would be present in the downstream reaches of the lower Snake River if the dams were breached.

5.4.2.2 Water Temperature

Three models were used to analyze the impacts of the alternatives on water temperature in the lower Snake River: EPA's RBM-10 model, the WQRRS model, and the MASS1. This section provides a summary of each model and the impacts of each alternative on temperature.

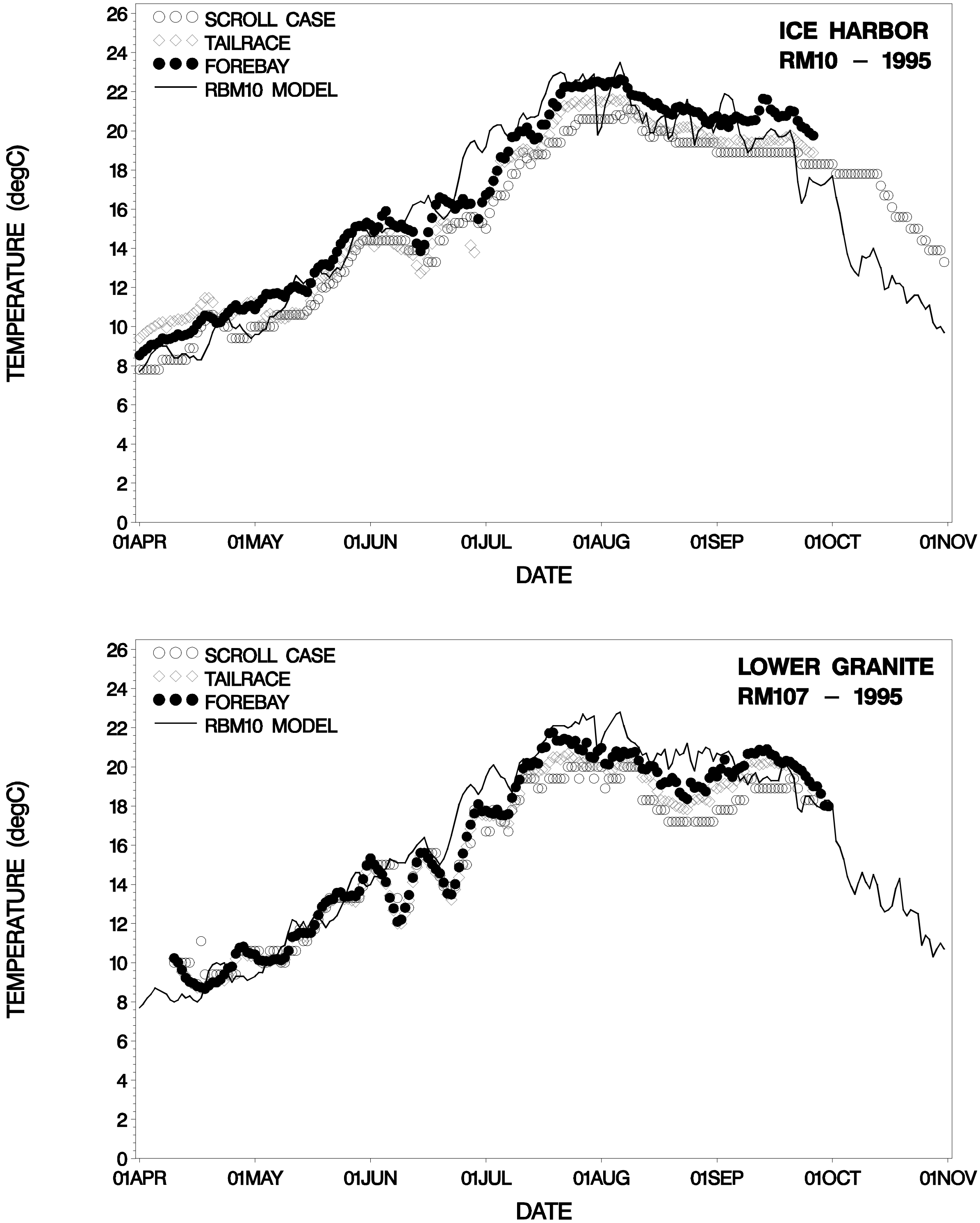
The EPA developed a water temperature model of the Columbia System to support a total maximum daily load (TMDL) for temperature as required under Section 303(d) of the Clean Water Act (Yearsley, 1999). The EPA cooperated with the Corps and provided their temperature modeling expertise and resources to assist the Corps in evaluating the effects of the dams and impoundments on lower Snake River temperature. In this endeavor, EPA used the RBM-10 model calibrated with USFWS 1950s temperature data from Lake Sacajawea and meteorological data for "without dam" simulations. In addition, EPA used the Corps' TDGMS tailrace temperature data as the benchmark for "with dams" predictions. A comparison of RBM-10 results with monitoring results is presented in Figure 5.4-2. The Corps feels that the calibration results show that the RBM-10 model is an effective tool for modeling temperature effects. As a result, the Corps has relied primarily on empirical data and the RBM-10 model results in the temperature analysis.

Four primary scenarios were examined with the RBM-10 model for the lower Snake River portion of the system: with and without dams and with and without Dworshak augmentation. Results from this modeling effort at RM 10 are presented in Figures 5.4-3 and 5.4-4. The years chosen for presentation span a range of hydrometeorologic conditions prior to the augmentation of the lower Snake River with water from Dworshak (1980, 1984, and 1988) and after the augmentation began (1994, 1995, and 1997). The latter group of years are the same years that were simulated during the



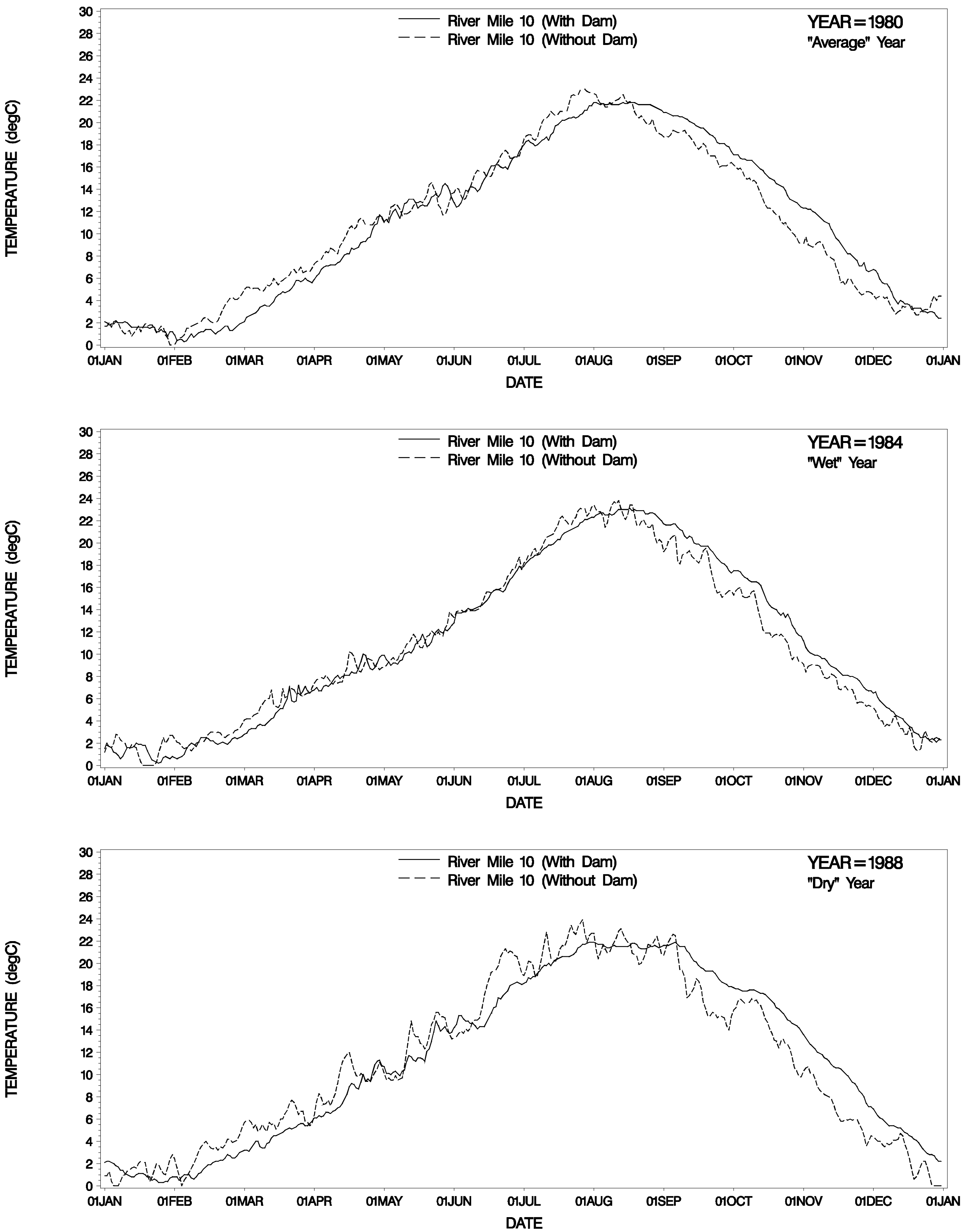
Source: Appendix C, Water Quality

Figure 5.4-1. Estimated Timing of Sediment Transport Resulting from Breaching of the Lower Snake River Dams



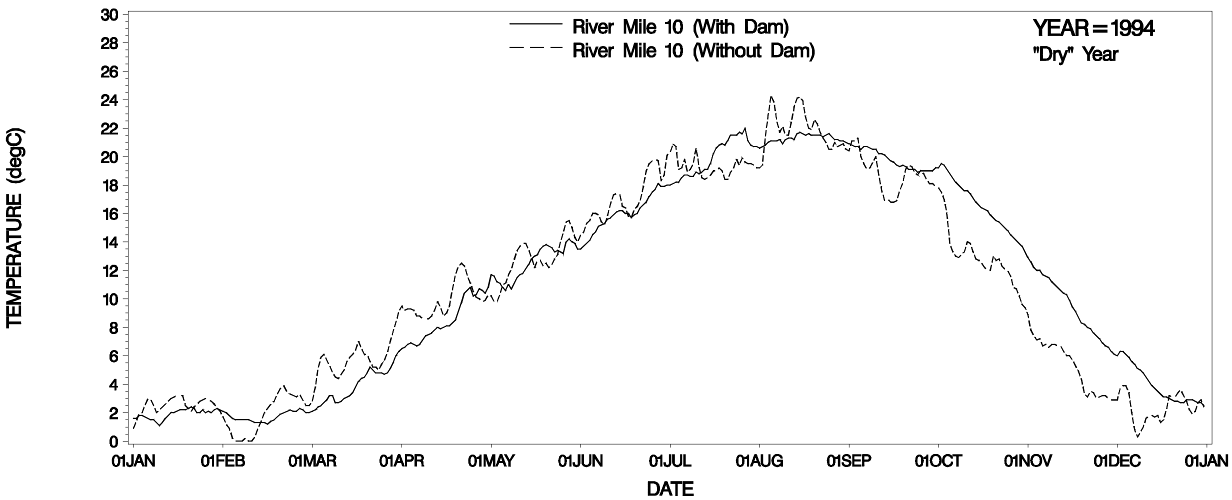
Source: Appendix C, Water Quality

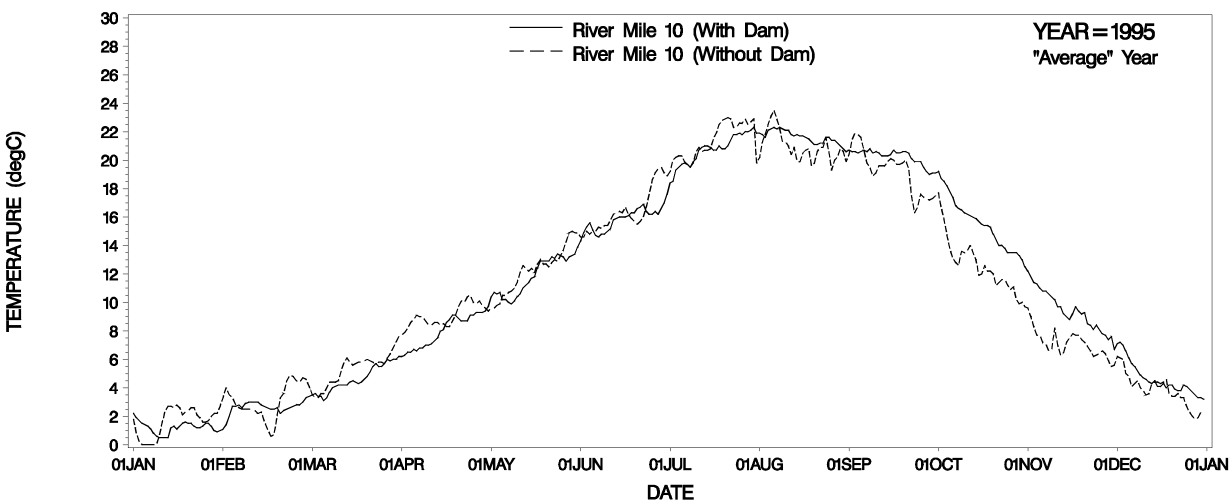
Figure 5.4-2. 1995 RBM10 Temperature Modeling Results and 1995 Temperature Monitoring Data

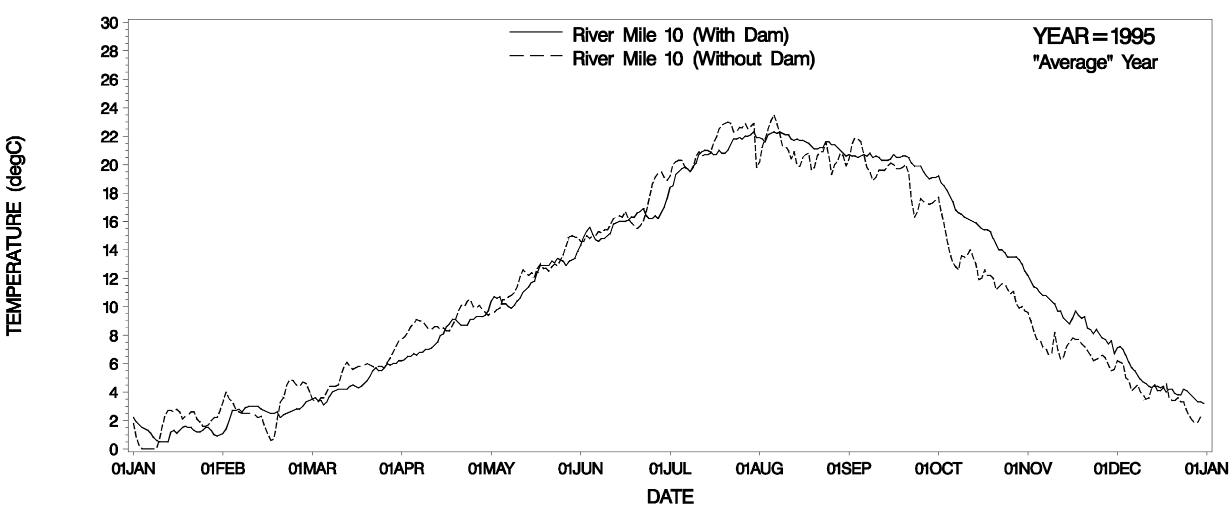


Source: Appendix C, Water Quality

Figure 5.4-3. Temperatures Predicted by RBM10 at RM 10 with and without Lower Snake River Dams for Years Prior to Dworshak Flow Augmentation







Source: Appendix C, Water Quality

Figure 5.4-4. Temperatures Predicted by RBM10 at RM 10 with and without Lower Snake River Dams for Years Since Dworshak Flow Augmentation

WQRRS modeling effort discussed below. 1984 and 1997 have been characterized as wet years. 1988 and 1994 have been characterized as dry years. 1980 and 1995 have been characterized as average years. These results are discussed further in subsequent sections.

The WQRRS model was used to simulate future changes to biological productivity as well as temperature and water quality under the proposed near-natural condition. The WQRRS model of the drawdown alternative was built and calibrated using bathymetric and hydraulics data from 1934 and temperature data from the 1950s prior to damming. Although flow regulation through storage capacity and release schedules are much different, the model assumes that the post-breaching river would have physical characteristics similar to the river in 1934. The hydraulic computations for the model provide a stable solution even with high water velocities. This model was applied to calendar years 1994, 1995, and 1997 using the actual hydrologic, meteorologic, and inflow water quality data from those years as input. Data from 1994 were used to represent a dry year, 1995 to represent an average year, and 1997 to represent a wet year.

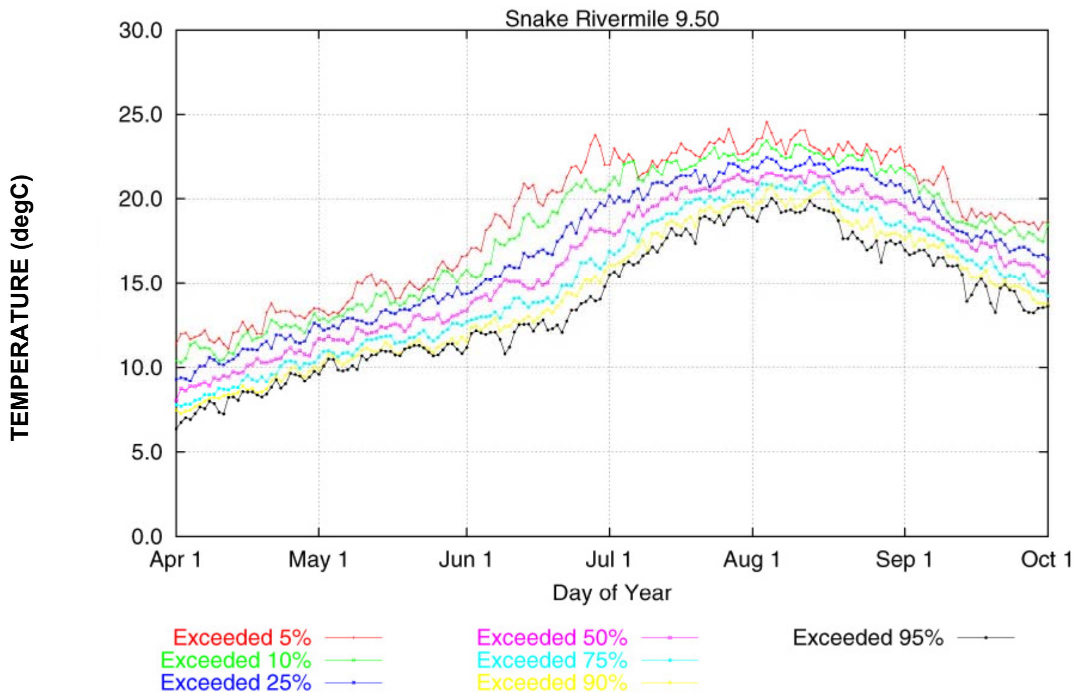
A third modeling study completed by the Pacific Northwest Laboratory (Perkins and Richmond, 1999) used MASS1, a one-dimensional hydrodynamic and water quality model to predict water temperatures on the lower Snake River for the period 1960 through 1995 under near-natural conditions. This long period includes several years prior to the construction of the dams, and several years with all four dams in place. This study can be viewed in its entirety at http://www.nww.usace.army.mil/lsr/products.htm.

The MASS 2 model (Perkins and Richmond, 1999) was used to calculate the temperature multiple times per day and to select the temperature for 3:00 p.m., which is assumed to be the maximum. Results of this model for the lower portion of the Snake River are shown in Figures 5.4-5 and 5.4-6.

Predictions of future water quality conditions are based on the results of water quality and productivity modeling using data collected mainly from 1994 through 1997, as well as two other recent temperature modeling studies (Perkins and Richmond, 1999; Yearsley, 1999). Table 5.4-2 is a summary of productivity and temperature model runs that were available for this study and analysis.

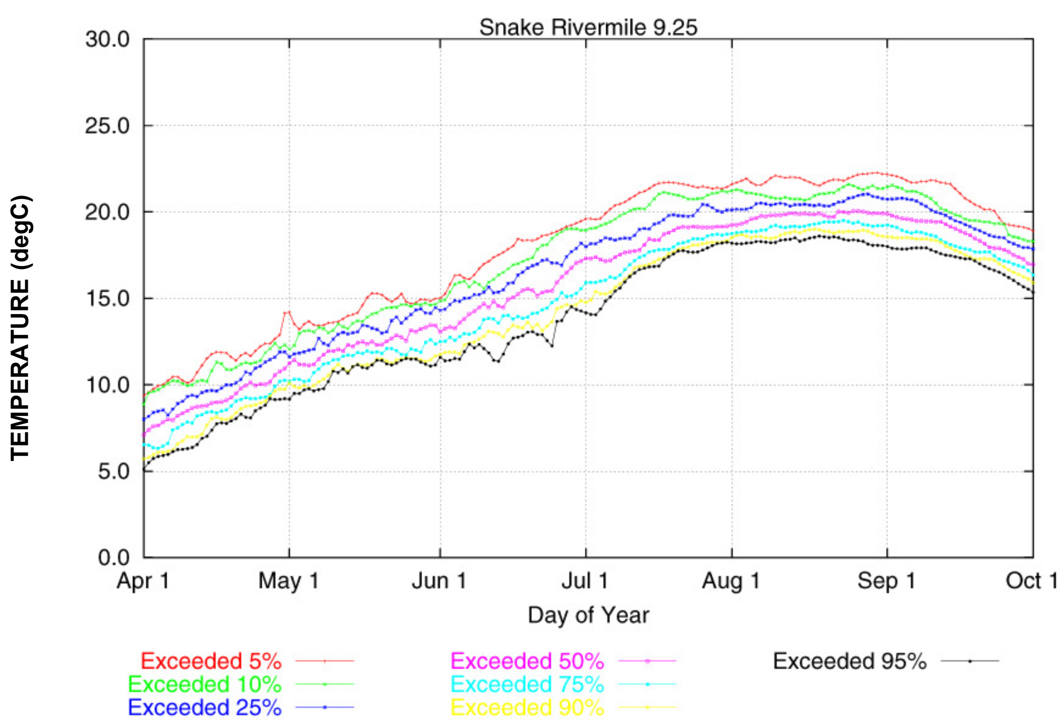
Table 5.4-2. Temperature Modeling Simulations That Were Available for This Analysis

Augmentation	**With Dams**	**Without Dams**
Temperature with Dworshak augmentation	RBM-10 MASS-2	WQRRS RBM-10 MASS-2
Temperature without Dworshak augmentation	RBM-10 MASS-2	RBM-10 MASS-2



Source: Appendix C, Water Quality

Figure 5.4-5. The MASS 2 Simulated Temperatures for Lower Snake River with Near-Natural River Conditions at RM 10 (Perkins and Richmond, 1999)



Source: Appendix C, Water Quality

Figure 5.4-6. The MASS 2 Simulated Temperatures for Lower Snake River with Reservoirs in Place at RM 10 (Perkins and Richmond, 1999)

Alternative 1—Existing Conditions

This alternative represents a continuation of the current system operations as they have been implemented since the issuance of the 1995 Biological Opinion, including flow augmentation up to 427 thousand acre-feet (KAF).

The RBM-10 temperature modeling predicted the average number of days in 1980, 1984, 1988, 1994, 1995, and 1997 exceeding a temperature benchmark of 68°F at three locations under existing conditions, with and without Dworshak augmentation. The predicted number of days exceeding the benchmark are presented in Table 5.4-3.

The historical data presented in Technical Appendix C, Water Quality indicate that water temperatures above 68°F commonly occurred prior to impoundment conditions. The data the Corps has published since the dams became operational show a general lowering of water temperatures in the reservoirs, and a more dramatic decrease since 1992 when cool water releases from Dworshak began. The data also show that the main factor influencing temperatures in the reservoirs is the temperature of inflow from the Clearwater and Snake rivers.

Alternative 2— Maximum Transport of Juvenile Salmon

Since flow operations will remain the same as under Alternative 1—Existing Conditions, this alternative is not expected to produce any discernable changes in water temperatures relative to existing conditions.

Alternative 3—Major System Improvements

Similar to Alternative 2—Maximum Transport of Juvenile Salmon, this alternative is not expected to cause any major changes in water temperature relative to existing conditions. The major fish passage improvements proposed under this alternative are not likely to change water temperatures.

Alternative 4—Dam Breaching

Breaching the dams would produce a major change in the volume and heat storage capacity of open water in the lower Snake River. Three temperature models (RBM-10, WQRRS, and MASS-1) were used to analyze and predict temperatures in the Snake River. From the model simulations it was possible to determine that under natural river conditions temperatures would cool down 5 to 15 days earlier in the fall than they do with the dams in place. The number of days that temperatures exceed 68 degrees is greater under the natural river condition than with the dams in place. The daily variation in temperature is greater under natural river conditions than with the dams in place.

As described by Bennett et al. (1997), maximum temperatures during the summer months of July through August are anticipated to be approximately 4 to 9°F (2 to 5°C) higher under the near-natural system, approaching 79 to 81°F (26 to 27°C). This change is due largely to the cooling effects of releases from Dworshak reservoir.

Table 5.4-3. Comparison of Number of Days Temperature is Expected to Exceed 68°C Benchmark and the Magnitude of Exceedances (Based on RBM-10 model simulations)

Flow Conditions		Dworshak Augmentation	Location	SNAKE RIVER WITHOUT DAMS Days Temp. > 68°F	SNAKE RIVER WITHOUT DAMS Ave. Above 68°F	SNAKE RIVER WITH DAMS Days Temp. > 68°F	SNAKE RIVER WITH DAMS Ave. Above 68°F
High Flows	1984	No	RM 10	56	2.0°	61	2.0°
		No	RM 107	55	1.7°	57	1.8°
		Not Influenced	RM 168[1/]	59	1.3°	59	1.3°
Average Flows	1980	No	RM 10	46	1.6°	57	1.2°
		No	RM 107	44	1.4°	46	1.6°
		Not Influenced	RM 168[1/]	44	1.4°	44	1.4°
Low Flows	1988	No	RM 10	69	1.6°	64	1.3°
		No	RM 107	67	1.4°	67	1.3°
		Not Influenced	RM 168[1/]	70	1.3°	70	1.3°
High Flows	1997	Yes	RM 10	34	0.7°	52	0.7°
		Yes	RM 107	8	0.6°	11	0.5°
Average Flows	1995	Yes	RM 10	55	1.5°	75	1.2°
		Yes	RM 107	59	1.2°	64	1.2°
Low Flows	1994	Yes	RM 10	38	1.8°	60	1.1°
		Yes	RM 107	35	1.8°	31	1.5°

[1/] Anatone site

Source: Appendix C, Water Quality

The WQRRS temperature modeling results also suggest that water temperatures during low-flow years in the lower Snake River could reach higher summer peaks under the near-natural river conditions than under the existing impounded river conditions. Under wet and average hydrometeorlogic conditions, peak summer temperatures are projected to be similar to those observed for the existing system.

Water temperature data collected at both Central Ferry (RM 83.2) and Sacajawea (near RM 0.0) during years before dams were built on the lower Snake River (1956 through 1958) were compared to data collected during 1994, 1995, and 1997 when the projects were in operation. The comparison clearly showed that the existing impounded system tended to warm more slowly in the spring and cool slower in the fall due to the larger volume of water and larger heat capacity of the impoundments compared to the near-natural system. The WQRRS model simulations for the dam breaching alternative were also compared to the measured data for periods of similar hydrometeorological conditions (Corps, 1999e). Measured temperatures in the existing system are similar in magnitude to predicted temperatures except that temperatures in the existing system lagged those predicted for dam breaching. The time lag increased as the year progressed and river flows decreased, apparently related to increased travel times and volumes. Differences between the dam breaching alternative and existing system progressively increased downstream.

Lowering the four impoundments to near-natural river elevations would produce a major change in the volume and heat storage capacity of open water in the lower Snake River. With less open water area and shallower depths, water temperatures over the long term would likely warm up faster early in the season but also cool down faster in early fall. Recent model results predict a more dramatic cooldown under certain hydrometeorologic conditions (Corps, 1999e). Using meteorological and hydrological data recorded during 1994, 1995, and 1997 as WQRRS model input, water temperatures under the near-natural river system were predicted to drop to 59°F (15°C) 15 days earlier than under existing conditions. During a high-flow year, such as in 1997, the difference between the predicted date for water temperatures to drop to 59°F (15°C) and the observed date under existing conditions was closer to 5 days. Thus, the temperature benefit of the dam breaching alternative would occur during low-flow years.

The EPA temperature modeling effort concluded that without flow augmentation from Dworshak Dam, water temperatures would exceed the 68°F (20°C) benchmark in the Snake River more often with the dams in place than with the dams removed. The EPA's temperature model (RBM-10) was calibrated and simulations were generated for a broad array of hydrometeorological conditions with and without Dworshak augmentation and with and without the dams in place. The frequency of exceedence of the 68°F (20°C) benchmark has been reduced in years when there was flow augmentation from Dworshak (1994, 1995, and 1997). The impact of releases from Dworshak is greatest in the upstream reservoirs, decreasing downstream. A comparison of the simulated frequency and magnitude with which water temperatures are predicted to exceed 68°F (20°C) in the existing and near-natural system is presented in Table 5.4-3. Throughout the length of the lower Snake River, the predicted frequency with which average water temperatures are expected to exceed 68°F (20°C) under the existing system than the near-natural system. The difference in predicted exceedence frequency between the existing and near-natural systems increases from upstream (RM

107) to downstream (RM 10). 1998 and 1994 are considered "dry" years, 1980 and 1995 are considered "average" years, while 1984 and 1997 are considered "wet" years. Based on the MASS-2 model, peak daily river temperature would more often peak earlier in the year and be higher under near-natural river conditions than with dams in place (Figure 5.4-5 and 5.4-6).

The RBM-10 model was used to predict the natural daily oscillations in surface water temperature, which is also important in terms of the effects of high temperatures on salmonids. This simulation temperature can be expected to vary about 1 to 2°C within a 24-hour period under near-natural river conditions with maximum temperature occurring about midday, and minimum temperature occurring during the night, compared to 0.5°C with reservoirs (Appendix C).

In general, short-term changes would be expected above and below dams as they are breached. Temperatures would equilibrate rapidly when the flow velocity increases in the reservoir areas as they return to the near-natural river level. Upstream releases from the Dworshak could still be used to moderate temperatures with the near-natural system.

5.4.2.3 Contaminants

Some contaminants are readily attached or adsorbed to sediments by physical or chemical bonding. A sediment contaminant study was conducted to determine the effects of dam breaching on the distribution of organic and inorganic chemical constituents in sediment and the water column (Foster Wheeler Environmental, 1999a). Two organic chemical constituents of concern—dioxin TEQ and total DDT—were found in the sediments. The analysis showed that neither dioxin TEQ or total DDT would exceed their sediment quality criteria under Alternative 4—Dam Breaching.

Manganese was the only inorganic chemical of concern found in the water column in this study. Analytical data exhibited manganese concentrations in excess of odor and taste threshold criteria, but not at levels of concern for toxicity or health effects. The manganese analysis was based on aesthetic values of taste and odor, throughout the lower Snake River, and in the Columbia River upstream of the Port of Hermiston municipal water diversion near McNary Dam to the mouth of the Snake River.

Sediment transport would also release sediment-bound nutrients into the water column, increasing their availability to primary producers. As a result, primary productivity could increase, depending on temperature, dissolved water depth, light, and season. Ammonia, the predominant nitrogen compound, would be resuspended. Certain concentrations of un-ionized ammonia (NH_3) is toxic to fish but the ionized form of ammonia (NH_4^+) is not. However, the concentration of un-ionized ammonia could increase under increased temperature and pH to levels that exceed the EPA's (1986) water quality criteria for protection of aquatic life. Potential ammonia toxicity associated with resuspension of sediments is dependent on seasonal conditions of pH and temperature (see Appendix C, Water Quality, Section 3.3.3.5).

5.4.2.4 Total Dissolved Gas

The regulatory limit for total dissolved gas (TDG) saturation has been modified in recent years by the regional regulatory agencies to allow for spill for juvenile salmonid passage, rather than passage through turbines or collection and transport. It is the Corps' policy to try to meet the 110 percent TDG, but this is difficult to accomplish because of voluntary spill for fish under BiOp operations, involuntary spill during high runoff years, and other constraints.

Alternative 1—Existing Conditions

Under this alternative, current system operations would continue as they have since the issuance of the 1995 Biological Opinion, including flow augmentation up to 427 KAF. The addition of end bay deflectors at Lower Monumental and Little Goose dams is assumed for this alternative. Modified deflectors at Lower Monumental, Little Goose, and Lower Granite are also assumed as part of this base case.

Spills that result in TDG up to 120 percent would be implemented, as defined in the 1995 and 1998 Biological Opinions. Forced spill would likely be similar to operations from 1996 to 1998. Spill caps could remain at current spill volumes or be increased as TDG production is reduced due to spillway improvements. The increases in spill discharge to attain 120 percent TDG are estimated to be from 45 kcfs to 68 kcfs at Lower Granite, from 48 kcfs to 68 kcfs at Little Goose, and from 43 kcfs to 68 kcfs at Lower Monumental, and 45 to 75 kcfs at 1 HR. The gas abatement improvements used with current voluntary spill discharges would result in TDG of 112 to 115 percent. TDG of 130 to 140 percent during times of involuntary spill could occur for extended periods as long as the excess flow continues.

Alternative 2—Maximum Transport of Juvenile Salmon

This alternative assumes that the juvenile fishway systems would be operated to maximize fish transport and that minimal voluntary spill would be used at 1 HR. As a result, elevated dissolved gas concentrations from upstream (the Clearwater River and middle Snake River) would decrease through the lower Snake River. The addition of end bay deflectors at Lower Monumental and Little Goose Dams is assumed for this alternative.

Under this alternative, voluntary spill for fish only remains for non-collected smolts at Ice Harbor. The Corps anticipates, under this alternative, a spill discharge cap of 110 percent or less. Forced spill for peak flow events on the Snake River would likely be similar to 1996 to 1998 operations and could exceed 130 to 140 percent in tailwaters for several weeks system-wide. TDG at Lower Monumental and Little Goose Dams would be reduced somewhat due to the addition of end bay deflectors.

Alternative 3—Major System Improvements

The addition of end bay deflectors at Lower Monumental and Little Goose is assumed for this alternative.

Under this alternative, only a small spill discharge would result from dewatering of the surface bypass collector over a spillway bay. However, this would only lead to small increases in TDG loading to the system. A proportional increase in this source would occur as river flows decrease. Voluntary spill for fish would only remain for non-collected smolts at Ice Harbor under this alternative. Spill would likely be similar to 1996 to 1998 operations. Under this alternative, TDG during involuntary spill conditions during peak flows in the spring could still exceed 130 to 140 percent in tailwaters for several weeks system-wide. TDG at Lower Monumental and Little Goose would be reduced somewhat due to additional end bay deflectors.

Alternative 4—Dam Breaching

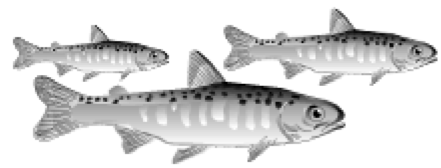
Under this alternative, there would be essentially no more hydraulic head at the four lower Snake River dams and therefore no spill. As plunge pools form during the development of a stable channel morphology under a different flow regime, geographically localized TDG above 110 percent is possible infrequently and for short durations of time.

5.4.3 Cumulative Effects

Hydrologic conditions would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching, there would be increases in water velocities and associated increases in sediment transport until scouring stabilizes in the first five years. Water temperatures would likely warm up faster early in the season and be higher, but cool down faster earlier in the fall as compared to current conditions.

5.4.4 Uncertainties in Potential Water Resources Effects

There will be natural variability in post-breaching temperature, total dissolved gas, dissolved oxygen conditions and productivity. There is, however, considerable uncertainty about the extent and duration of high sediment concentrations and their potential effects on biota, especially on anadromous fish. Similarly there is uncertainty about the extent, duration and effects of elevated concentrations of contaminants released by breaching. These uncertainties were not factored into estimates of population growth/decline conducted as part of the PATH and CRI analyses. Data are currently lacking to address these uncertainties.



5.5 Aquatic Resources

5.5.1 Anadromous Fish

Critical habitats includes Snake River sockeye were listed as endangered on November 20, 1991. Snake River spring/summer chinook were listed as threatened on April 22, 1992. Snake River fall chinook were listed as threatened on April 22, 1992. Snake River steelhead were listed as threatened on August 18, 1999. The Draft Recovery Plan (Schmitten, 1995) defined survival and recovery goals of Snake River salmon species listed under the ESA. In the 1995 Biological Opinion, the National Marine Fisheries Service (NMFS) concluded that major changes in the operation and configuration of the Federal Columbia River Power System (FCRPS) needed to be evaluated with the goal of increasing salmon survival. Actions in this document called for detailed analysis of alternative configurations and operations of the four lower Snake River Corps dams. The direction of the 1995 Biological Opinion was to consider if dam breaching or some other alternative would result in adequate survival and recovery of these Snake River fish. The Corps has responded to the 1995 Biological Opinion by conducting the Lower Snake River Juvenile Salmon Migration Feasibility Study and by preparing this FR/EIS.

Additional biological opinions have been developed on FCRPS operations since the 1995 Biological Opinion, including the Lower Snake River Project. The recent NMFS and USFWS Biological Opinions issued in December 2000 (NMFS and USFWS, 2000) addresses all FCRPS operations (see Section 13.3). Numerous actions addressed in the latest biological opinions are included in the FR/EIS.

This section presents the results of analyses directed at determining both the effectiveness of the alternatives at meeting the goals described in the 1995 Biological Opinion, and overall effects on all potentially affected anadromous fish stocks. A summary of the potential effects of the alternatives on anadromous fish is presented in Table 5.5-1.

While a considerable amount of information and analysis has been developed to assess the alternatives, the bottom line is that no single alternative stands out as the one that would recover the listed stocks. The main reasons for this uncertainty are: 1) limited number of adequate estimates of delayed mortality of transported fish; 2) lack of definitive evidence for the sources of extra mortality; 3) lack of good predictive ability on effects of dam breaching on short-term and long-term effects; and 4) unquantifiable effects of dam breaching on extra mortality and estuarine survival of juvenile anadromous stocks. The selection of an alternative, relative to benefits of anadromous stocks, relies on accurate information in all of these areas and without this information, selection of any alternative will carry risks for the listed anadromous fish stocks of the Snake River.

This section is divided into six parts. Sections 5.5.1.1 through 5.5.1.5 address the effects of each alternative on all anadromous stocks, with emphasis on listed Snake River salmon and steelhead. The analysis in the first four parts is primarily qualitative in nature and does not directly estimate how closely each alternative could achieve the goals of the 1995 Biological Opinion and Draft Recovery Plan (NMFS, 1995; Schmitten, 1995). The qualitative assessment of each specific alternative on the listed Snake River stocks, and on other anadromous fish that could be affected by each alternative, is based on literature and extensively on the Fish and Wildlife Coordination Act Report (Appendix M) and the summary of the Anadromous Fish document provided by NMFS (Appendix A, Anadromous Fish Modeling).

Section 5.5.1.5, Model Analysis of All Alternatives, is a more quantitative evaluation of the likelihood of each alternative meeting the jeopardy standards of the 1995 Biological Opinion for the Snake River listed stocks and is based on the NMFS analysis as presented in Appendix A, Anadromous Fish Modeling. The NMFS analysis, in turn, depended heavily on documents developed by the regional process known as Plan for Analyzing and Testing Hypotheses (PATH) (Marmorek and Peters, 1998a, b; Marmorek et al., 1998a, b; Marmorek et al., 1996) and NMFS' own Cumulative Risk Initiative (CRI) analysis. Section 5.5.1.6 discusses the CRI analysis.

The PATH analysis is based primarily on an extensive review of the best available data prior to 1994, together with modeling of the effects of hydrosystem operation and configuration under each alternative on downstream and upstream passage survival (i.e., lifecycle modeling) and the subsequent effects of that and other factors on the long-term population trend.

NMFS performed additional modeling for use in its evaluations, designated the CRI. The model evaluates the sensitivity of changes in a specific life-history stage and the relative effect of changes in other life-history stages on achieving biological goals and objectives. The analysis determines if one or multiple H combinations (habitat, hatcheries, harvest, and hydropower) exist and are able to achieve the biological objectives related to recovery of ESA-listed species.

Although the NMFS analysis presented in Appendix A, Anadromous Fish Modeling, includes additional alternatives, this section discusses only the four alternatives under evaluation in this FR/EIS. The FR/EIS alternatives are: Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, Alternative 3—Major System Improvements, and Alternative 4—Dam Breaching.

5.5.1.1 Alternative 1—Existing Conditions

The impact assessment for Alternative 1—Existing Conditions emphasizes potential effects on ESA-listed Snake River salmon and steelhead. Potential effects to other Columbia River (non-Snake River) anadromous salmonids and other anadromous stocks are discussed separately and in less detail.

Many factors affect salmon and steelhead in the Snake River System independent of the construction and operation of the four lower Snake River dams. Notably, many other dams constructed upstream of the lower Snake River dams had very significant effects on runs of all of the currently listed species, in many cases reducing the potential for production to a small fraction of the historical levels. Dam construction upstream of Lower Granite Dam has caused the overall loss of about 46 percent of river miles of salmon and steelhead spawning and rearing habitat in the Snake River System, including the mainstem Snake and Clearwater rivers (Appendix A of Corps et al., 1993). The greatest relative loss has been for fall chinook salmon, which is estimated to have lost most of its total historical spawning habitat from construction of the dams from Hells Canyon Dam upstream (Waples et al., 1991).

The construction and operation of dams on the lower Snake River have affected anadromous salmonids in many ways. Dams change the flow rate and water velocity through the reach, affecting migration; present obstacles and sources of injury for fish attempting downstream and upstream passage; affect juvenile fish transported by truck or barge to avoid direct mortality; increase the danger of dissolved gas supersaturation; increase the habitat for predators of juvenile salmonids; alter rearing habitat; modify the seasonal temperature regime; and inundate spawning habitat. Dams have direct, quantifiable effects on salmonids such as direct mortality from turbine passage, as well as indirect effects such as modification of estuary arrival times for juvenile fish (Marmorek et al., 1996). These effects can generally be grouped according to their effects on juvenile or adult Snake River salmon and steelhead.

Snake River Salmon and Steelhead

Effects on Juvenile Salmonids

Direct and indirect effects on salmonids from Alternative 1—Existing Conditions are presented by the primary factors associated with operation of the four lower Snake River dams: flow and water velocity, dam passage, transportation, dissolved gas

Table 5.5-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 1—Existing Conditions
Based on the NMFS Cumulative Risk Initiative (CRI) analysis (see Section 5.5.1.6), all Snake River ESUs are likely to continue declining populations trends under current conditions. However, the chance of extinction is relatively low for Snake River spring/summer chinook index stocks, fall Chinook, and steelhead (less than 5 percent for all) in the short term (24 years). Long-term (within 100 years) chance of extinction increases substantially, assuming no contribution of hatchery fish to returning fish, 0 to 78% for spring/summer chinook index stocks, 40% for fall chinook and 1 and 93% for Runs A and B Snake River steelhead, respectively. Chance of extinction for all stocks would be much greater in the long term if wild spawning hatchery fish currently contribute significantly to returns.
CRI analysis indicates that currently implemented hydrosystem improvements, relative to those in place in the late 1970s, have substantially benefited juvenile and adult salmonid survival and likely prevented the extinction of Snake River spring/summer chinook and possibly other stocks.
PATH analyses (see Section 5.5.1.5) indicate that future salmon escapements of spring/summer chinook would be slightly less than the NMFS 1995 Biological Opinion survival criteria (i.e., minimal acceptable escapement) and just equal to recovery criteria (threshold level escapement for NMFS defined recovery). PATH results are dependent on assumptions about additional mortality including differential delayed transport mortality (i.e., mortality that occurs to transported fish after they are released that does not occur to untransported fish) and extra mortality, which could be related to passage (either in-river or transported) through the hydrosystem after they have left the hydrosystem corridor. Other sources of additional mortality may be caused by factors independent of the hydrosystem, such as reduced stock viability and ocean conditions.
PATH analyses for fall chinook produced varied results that depended on which of four sets of assumptions were considered for delayed transport mortality. Survival criteria were met for all four assumptions used, but recovery criteria were only met for two of the four. Results for steelhead could not be modeled in the same manner, but would likely be similar to, but better than, spring/summer chinook salmon. Sockeye salmon were not modeled but would likely be similar to other species.
PATH results indicated that the chance of meeting NMFS survival and recovery criteria for spring/summer chinook, fall chinook, and steelhead under Alternative 1 would likely be the same or slightly better than Alternatives 2 and 3, but mostly worse than Alternative 4.
Low to moderately high direct (which includes in-river and transport) passage mortality, (lowest for spring/summer chinook; highest for fall chinook) would occur with Alternative 1. Direct mortality would be slightly higher than Alternatives 2 or 3 for all stocks and much lower for at least spring/summer chinook and steelhead than Alternative 4. Results for direct passage mortality for fall chinook are unclear. Overall direct passage mortality is primarily influenced by the portion of fish transported. For example, the estimated direct mortality of transported fish is about 2 percent. Therefore, when the portion of fish transported is higher, the direct passage mortality is lower.
Harmful dissolved gas concentrations effects would be slightly worse under Alternative 1 than Alternatives 2 or 3 and, during peak flows, much worse than Alternative 4 for Snake River ESA-listed salmon and steelhead stocks.

Table 5.5-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 1 (continued)
Survival of adults during upstream migration would remain in the high 90 percent range per facility for spring/summer chinook, sockeye, and steelhead, and would be lower for fall chinook due to straying and fallback. These levels would be similar to Alternatives 2 and 3, but may be the same or lower than Alternative 4.
No change in effects to Columbia River (non-Snake-River) salmon and steelhead stocks would occur, including listed stocks.
Pacific lamprey and American shad would continue to have passage losses in the Snake River.
Alternative 2—Maximum Transport of Juvenile Salmon
The CRI only analyzed for effects for fall chinook (no other ESUs were analyzed) for some of the characteristics of Alternative 2 and 3 (did not distinguish between the two) so findings are assumed to apply to both alternatives. This analysis indicated that maximum transport would slightly reduce the chance of extinction by improving conditions over Alternative 1 for fall chinook. However, this improvement would not be adequate to meet the NMFS-designated threshold risk levels for fall chinook.
PATH model results indicate a slightly lower chance of meeting the NMFS spring/summer chinook and possibly steelhead survival and recovery criteria than under Alternative 1, while fall chinook is the same. Alternative 2 would have a slightly lower chance of meeting the NMFS survival criteria than Alternative 4 for all stocks, and much lower chance for spring/summer and fall chinook (for three of four sets of hypotheses) for recovery criteria than Alternative 4. It should be noted that the PATH results are highly dependent on assumptions about the degree of additional mortality attributed to the hydrosystem after juveniles have left the river.
This alternative would have slightly reduced direct passage mortality (including both in-river passage and transport) relative to Alternative 1 and slightly higher mortality than Alternative 3 because of the relative portion transported. For the same reasons, the results also indicate there would be much lower direct passage mortality, at least for spring/summer chinook and steelhead and possibly fall chinook, than Alternative 4.
Harmful dissolved gas concentrations effects would be similar to Alternative 3, slightly better than Alternative 1, but during peak flow periods, they would be much worse than Alternative 4 for Snake River stocks.
Survival of adult fish during upstream migration would remain in the high 90 percent range per facility for spring/summer chinook, sockeye, and steelhead, and would be lower for fall chinook due to straying and fallback. These levels would be similar to Alternatives 1 and 3, but may be the same or lower than Alternative 4.
No change in effects to other Columbia River salmon and steelhead stocks, including listed stocks is predicted.
Pacific lamprey and American shad would continue to have passage losses in the Snake River.

Table 5.5-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 3—Major System Improvements
CRI analysis did not differentiate between Alternatives 2 and 3 (see Alternative 2) for fall chinook. Because the increased transport showed reduced risk of extinction in the CRI analysis, Alternative 3 should reduce the chance of fall chinook extinctions slightly more than Alternative 2 because more fish would be transported. Other Snake River stocks were not analyzed.
The PATH model results were nearly the same as Alternative 2 indicating a generally similar chance of meeting the survival and recovery criteria for spring/summer chinook (the same for survival, less for recovery) and steelhead than under Alternative 1, but much worse for recovery criteria than Alternative 4. For fall chinook, Alternative 3 would be slightly better than Alternative 2 for recovery criteria, and relatively variable for the survival criteria depending on delayed transport mortality hypothesis used in the models. Results are highly dependent on assumptions about the degree of additional mortality attributed to the hydrosystem after juveniles have left the river.
Under Alternative 3, there would be slightly reduced direct passage mortality (in-river plus transport) relative to Alternative 2 because of the greater portion transported. There would be much lower direct passage mortality, at least for spring/summer chinook and steelhead and possibly fall chinook than Alternative 4 for the same reasons.
Harmful dissolved gas concentrations effects would be similar to Alternative 2, slightly better than Alternative 1, but much worse than Alternative 4 during peak flow periods for Snake River stocks.
Survival of adults during upstream migration would remain in the high 90 percent range per facility for spring/summer chinook, sockeye, and steelhead, and lower for fall chinook due to straying and fallback. These levels would be similar to Alternatives 1 and 2, but slightly better due to increased turbine diversion screening. Survival may be the same or lower than Alternative 4.
No change in effects to other Columbia River salmon and steelhead stocks, including listed stocks.
Pacific lamprey and American shad would continue to have passage losses in the Snake River. Some benefit would occur for Pacific lamprey in the Snake River if new screening facilities increase diversion from turbines.
Alternative 4—Dam Breaching
CRI analysis indicates that dam breaching would not restore Snake River spring/summer chinook runs if the only benefit were to increase direct downstream passage survival, even if it were as high as 100 percent survival for spring/summer chinook. Additional increases in estuarine/early ocean survival of at least 5 to 10% would also be needed. For fall chinook, the risk of extinction may be reduced to threshold levels with this alternative, but only if survival below Bonneville Dam is increased by at least 20 percent as a result of this action. Steelhead and sockeye were not assessed with this analysis but would likely have similar benefits as other stocks.

Table 5.5-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 4 (continued)
The CRI life-stage analysis indicates that large increases in overall survival could result from relatively small reduction in mortality during the first year of life, such as in freshwater juvenile stage or the estuarine/early ocean stage. It is unknown whether these types of changes could be made.
Based on NMFS analysis, Snake River fall chinook could reach acceptable levels of extinction risk with just reduction in harvest rates and no change in the current hydrosystem. Harvest rate reduction alone would not be adequate to restore Snake River steelhead.
PATH analyses indicate that this alternative is more likely than any other alternative to meet survival and recovery criteria of listed species. It would meet NMFS survival and recovery criteria for spring/summer chinook, fall chinook, and steelhead. NMFS has indicated, however, that PATH analyses could not determine if breaching was necessary or sufficient for recovery. The difference between this and other alternatives in meeting the criteria are highly dependent on the assumptions about the effects of delayed transport mortality and extra mortality. Should the relative effect of the hydrosystem on these factors be lower than assumed, then the differences among the alternatives would be reduced and breaching would offer only a slight improvement in survival over current conditions.
Both the CRI and PATH analyses indicate that further improvements in the hydrosystem passage system are unlikely to recover listed Snake River stocks unless there is an improvement in juvenile fish survival downsteam of Bonneville Dam, either through such factors as improved fish conditions or improved timing of entry into the ocean.
Short-term effects would be mostly adverse relative to current conditions for Snake River stocks. Adverse effects would occur from elevated suspended sediment (e.g., reduced feeding, direct mortality of juveniles). There could be impedance of juvenile and adult migration with some extended disruption to adult migration from sediment (for primarily 2 to 3 years). Rearing habitat quality for juvenile fall chinook would be reduced, but there would be some benefit from increased juvenile migration rates and reduced dissolved gas.
There could be some short-term adverse effects on other Columbia River stocks that migrate through the McNary reservoir from increased suspended sediment and burial of rearing habitat. There may also be fall and spring adult migration delays for primarily 2 to 3 years during and following dam breaching. Reduced subyearling chinook salmon rearing habitat quality in the McNary reservoir may occur.
Long-term benefits would likely reduce in-river juvenile passage mortality for all Snake River salmon and steelhead stocks through the Snake River reach. Adult passage mortality may decrease or remain unchanged. Elimination of dam mortality and possible reduced predation in the Snake River reach, and an increased juvenile migration rate may be a benefit for all stocks. Improved river rearing habitat and increased fall chinook river spawning habitat may take more than 2 to 5 years to develop after dam breaching. Reduced adverse effects of dissolved gas supersaturation in the Snake River would occur.

Table 5.5-1. Summary of Potential Effects of the Alternatives on Anadromous Fish

Alternative 4 (continued)
Some long-term potentially adverse effects include the loss of fish transport from the Snake River which would increase the direct passage mortality (in-river plus transport) because of the high direct survival rate (98 percent) of fish in barges, particularly for spring/summer chinook and steelhead. There also is an increased risk of stray Columbia River fall chinook stocks mixing with native stocks and spawning in the Snake River, possibly reducing the native fall chinook stock viability.
Long-term benefits for other Columbia River salmon and steelhead stocks, including Federally listed stocks (mostly for those passing the McNary reservoir) would include reduced dissolved gas supersaturation and increased spring turbidity, which may reduce predation.
Pacific lamprey migration survival in the Snake River would improve, while American shad use may decrease due to loss of reservoirs. Overall effects to Columbia River stocks of these species would be slight unless large positive benefits to the estuarine habitat occur from dam breaching. There is no information indicating at what level, if any, benefits would occur.

supersaturation, predation, and rearing and migratory habitat. Where information on the effects of these factors is not clear, the range of data and interpretations is provided.

Juvenile fish from the Snake River move either to the estuary by passing through all reservoirs and dams (in-river migration) or are collected at one of three dams on the Snake River, or McNary on the mainstem Columbia River, then transported by truck or barge for release below Bonneville Dam. While many individual factors affect overall survival (discussed in the following subsections), a summary of how overall direct in-river passage survival of juvenile spring/summer chinook salmon, steelhead, and fall chinook has changed over time is shown in Figure 5.5-1. Survival estimates for recent years (1994 to 1999) indicate in-river passage survival in the range of 31 to 59 percent for spring/summer chinook and 44 to 53 percent for steelhead in the same reaches (NMFS, 2000b fish passage white paper). This information indicates that current direct passage survival of spring/summer chinook salmon and steelhead has increased in recent years of moderate to high flows (1995 to 2000); survival during years of moderate to high flow can approach as high as it was in the 1960s when only four dams instead of eight dams were in place for Snake River fish to pass on their way to the ocean (NMFS, 2000b). Survival during low flow years is typically less, as illustrated by discussion of the most recent spring 2001 outmigration conditions in the following section. No comparison in survival estimates with historical conditions is available for fall chinook, but it has increased during medium to high flow years from the 1970s, before many of the newer passage facility improvements were constructed or implemented. Under Alternative 1—Existing Conditions, it is expected that in-river passage survival should remain similar to the data from recent years. It should be noted that these passage survival values represent only direct passage survival and do not include any possible delayed effects to fish from passing through the hydro system or survival of transported fish.

When evaluating the overall mortality of juvenile fish, all stages of their life history should be considered. Mortality prior to passage through the first reservoir encountered can often be as high as 95 percent, especially for fall chinook parr. Even though over 90 percent of eggs are fertilized, fry to parr to smolt mortality can make up a large part of the egg to smolt mortality; overall, 99.95 percent of the progeny of two adult spawners will typically die before they spawn, with or without dams. Given 4,000 eggs, assume 3,800 will die, and 200 survive to spawn.

Juvenile Salmonid Survival and Flow During Spring 2001

The Fish Passage Center (FPC) presented preliminary survival estimates of the 2001 spring outmigration of juvenile steelhead and chinook in the Snake and Columbia Rivers as these stocks responded to the low run-off volume, energy deregulation, volatile wholesale power markets, and BPA energy and financial emergencies that occurred in spring 2001 (personal communication, FPC MEMO from M. DeHart to CBFWA Members Group, August 10, 2001). These conditions combined to produce poor migration conditions for juvenile spring/summer chinook, fall chinook, and steelhead. An estimated 80 percent of these Snake River stock smolts were transported by barge during the 2001 outmigration season, so the survivals presented represent about 20 percent of the stock outmigrant populations for those smolts that remained to migrate in-river with low flow and predominantly no spill. Survival of the transported proportion of the population will not be determinable for 2 to 3 years when the adults return, allowing for calculation of differential delatyed mortality, extra mortality, and SAR comparisons.

Low river runoff volume and hydrosystem operation decisions affected the ability to implement the Biological Opinion measures for the 2001 juvenile salmon migration. The July Final Runoff Volume Forecast at The Dalles was 52 percent of average, and at Lower Granite Dam the volume was estimated at 47 percent of average. The power system emergency declared by the Bonneville Power Administration subsequently determined how the hydrosystem operated in 2001 relative to the provision of fish mitigation measures. Reservoir refill was prioritized in order to provide power. As a result, NMFS Biological Opinion flow targets were not achieved. Seasonal average flows for the spring period were 48.9 kcfs at Lower Granite and 126.3 kcfs at McNary compared to the Biological Opinion target flow of 85 kcfs at Lower Granite and 220 kcfs at McNary.

The poor flow year was exacerbated by power peaking operations in the mid-Columbia where flows were highest on weekdays and decreased considerably on weekends. In addition to average flows below the Biological Opinion flow targets, flows were fluctuated on a daily and weekly basis to maximize power production and revenue. Because flows in the Snake River were projected to be less than 85 kcfs, spill was terminated at the Lower Snake River Project and transportation was maximized, including the collection and transport of 50 percent of the spring migrants at McNary Dam.

The FPC estimated survivals of yearling spring/summer chinook and steelhead, in the reach from Lower Granite tailwater to McNary Dam tailwater, using fish that were PIT-tagged above Lower Granite and subsequently detected at Lower Granite Dam. Weekly survival estimates for yearling spring\summer chinook were below 60 percent (about 10 percent to 15 percent below normal) in April and declined from mid-May through the remainder of the migration. Estimates of survival by the end of May were lower than 20 percent. Estimates for both hatchery and wild chinook were very similar. For steelhead, early season survivals were near 20 percent and declined to less than 10 percent for hatchery fish, while the wild steelhead faired slightly better with survivals that remained near 20 percent.

River conditions for 2001 produced the poorest survivals since PIT Tag survivals have been estimated (1993) (Table 5.5-2). Seasonal survival estimates from Lower Granite to McNary Dam for yearling chinook was estimated at 0.57 and for steelhead at 0.16. This steelhead estimate is about 50 percentage points below the lowest seasonal estimate for the last 5 years and probably represents both lower survival as well as increased residualism in smolts desmoltifying back into rearing and overwintering lifestages. Average survival for spring chinook in this reach from 1995 to 2000 was 0.72, and average survival was 0.70 for steelhead.

A comparison of survivals to total discharge using the same wild chinook data showed an increase in survival with increasing flows. Flows in the Lower Snake River in 2000 were considerably higher than those in 2001.

Table 5.5-2. Season Survival Estimates[a/] for the Reach Lower Granite Tailwater to McNary Tailwater

Migration Year	Yearling Chinook	Steelhead
1995	0.72	0.74
1996	0.65	0.69
1997	0.65	0.73
1998	0.77	0.65
1999	0.79	0.69
2000	0.76[b/]	
2000	0.74[c/]	
2001	0.57[d/]	0.16[d/]

a/ Estimates from NMFS white paper "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams," unless otherwise indicated.
b/ Estimate by Fish Passage Center includes only wild yearling chinook.
c/ Estimate by Fish Passage Center includes only hatchery yearling chinook from CSS study groups.
d/ Estimates by Fish Passage Center includes hatchery fish only (estimates for wild fish were similar. See figures 9 to 12.

A comparison of survivals to total discharge using the same wild chinook data showed an increase in survival with increasing flows. Flows in the lower Snake River in 2000 were considerably higher than those in 2001. The time period of the spring outmigration past Lower Granite Dam in 2001 was not greatly different when compared to historic timing. Run timing for both chinook and steelhead began later and was shorter in 2001 compared to historic timing. The timing of passage for spring migrants at McNary was more delayed compared to the average historic dates for yearling Chinook. For both steelhead and chinook the timing of the 90 percent passage was more than a week later than average. While it is clear low flow contributed to increase travel times, flows in the lower Columbia also fluctuated widely over short periods of time; sometimes these fluctuations represented a change of 30 to 40 percent in total river flow. The mid-Columbia outmigration was shaped by the cyclic peaking of flows that followed the artificial weekly cycle of power needs. It is evident in passage indices that steelhead were more affected by this type of flow fluctuation than chinook. Travel times in 2001 were some of the slowest in the 20 years of travel time calculations. The longer travel times were especially noticeable in the lower Columbia, where flows were near record lows. For yearling chinook over the years 1996 to 2000, travel time from McNary Dam to Bonneville Dam averaged 5.6 days (average and of median daily travel times), while 2001 travel times average 10.8 days. For steelhead over the same reach the 1996 to 2000 average travel time was 5.0 days compared to an average of 10.0 for 2001.

Adult Salmon Returns During Spring 2001

Counts of fall chinook, coho, and summer steelhead crossing Bonneville Dam broke records in 2001, leading biologists to predict that the 2001 total adult fish return from the ocean to the Columbia River would be the highest since 1938. The total count of salmon for the calendar year through September 11 is 1.5 million adult fish with some 762,768 adult chinook counted passing Bonneville Dam with 67,967 jacks in 2001. That total includes a record 391,367 upriver spring chinook salmon, and 14,072 jacks. A summer chinook count of 76,200 was the most since 1969.

The steelhead count at Bonneville increased to 535,226, including 139,731 wild fish, through September 11, according to statistics posted by the FPC. The total far surpasses the previous upriver steelhead mark of 384,000 set in 1986.

The fall chinook count increased above preseason forecasts of 292,300 total returns to the mouth of the Columbia. The most recent TAC estimate predicted a return of 473,900 fall chinook compared to 253,300 last year and a 1995 to 1999 average of 289,000.

When accounting for runs returning to Columbia River tributaries and catches below Bonneville Dam, managers estimated that the total return in 2001 would reach 3.0 million, the largest return to the Columbia River since 1938. Managers estimate about 80 percent of the total return in 2001 originated as hatchery fish. While wild fish constitute only 20 percent of the run, their numbers are the strongest seen in recent years.

The harvest take of fall chinook has been limited as a means of protecting the Snake River portion of the total run. A management agreement between states and tribes, and endorsed by the National Marine Fisheries Service, allowed a maximum take of 31.29 percent of the upriver bright run. The tribes received an allowance of up to 23.04 percent where the non-Indian sport and commercial fishers were allowed 8.25 percent of the catch.

The number of steelhead to pass Lower Granite Dam and enter tributaries in Idaho passed 18,000 on August 27, compared to the 10-year average of 4,100. The count climbed to 37,665 through September 11, including 11,707 wild fish that are ESA-listed. The latest forecast predicted a total run size of about 200,000 steelhead past Lower Granite, compared to the 1975 to 2000 average of 74,000.

The most recent TAC updated projection estimated that the "Group A" summer steelhead run would swell to 521,700, including 374,200 fish of hatchery origin and 147,500 wild fish. The “Group B” steelhead preseason forecast was for 36,000 adults returning, including 8,900 wild adults and 27,100 hatchery adults. A total A-B run of 586,600 steelhead would exceed the previous record. The A-run steelhead, for the most part, arrive earlier and fan out across the Columbia-Snake River Basin. The later arriving B run, generally larger than A steelhead, are bound for Idaho's upper Clearwater and Salmon River subbasins. The latest forecast nearly doubles preseason forecasts. Through August 22, 2001, an estimated 403,763 summer steelhead, including 120,035 wild fish, had been counted at Bonneville Dam. The previous record was 384,000 steelhead in 1986.

Of the 200,000 steelhead expected to cross Lower Granite Dam this summer and fall, 166,000 should make up the early returning A-run fish that swim to the Snake, Salmon, Grande Ronde and Imnaha Rivers. An estimated 36,000 of the returns should be the larger B-run steelhead that return to the Clearwater and Salmon Rivers in Idaho.

The upriver sockeye run past Bonneville Dam (estimated at 116,700) would be the largest recorded run since 1987. A total of 16 adult sockeye salmon have entered the Stanley Basin as of late-August 2001. Biologists expect about 35 adult Snake River sockeye salmon to return to the Stanley Basin before the 2001 run ends. The unofficial count of Snake River sockeye salmon passing Lower Granite Dam through August, 2001, was 50 adults. The 2000 run of 257 adult sockeye salmon returning to the Stanley Basin came from a 1998 downriver smolt run of 143,000 fish released. Only 49,800 juvenile sockeye salmon outmigrated from Idaho releases toward the Pacific ocean in 1999, so the size of the smaller 2001 adult return was predictable to biologists.

Flow and Water Velocity

The development of dams and reservoirs has changed the lower Snake River from a free-flowing stretch to a 140-mile river reach of slack water with run-of-river reservoirs that are wider and deeper than the original river. Upstream storage reservoirs have reduced flow peaks during the spring season. The net effect has been to reduce velocity and increase the time water takes to travel through this reach. Because juvenile salmon and steelhead are primarily passive in their early migration, the change in velocity has affected the rate of downstream migration of juvenile salmonids.

Some records indicate that the rate of migration from the Salmon River in Idaho to below the Bonneville Dam area, under certain conditions, has increased from 22 days (without lower Snake River dams) to 50 days (with lower Snake River dams) (Ebel, 1977). In contrast, while flow may affect movement upstream of Lower Granite Dam, fish that are collected and transported spend only about 2 days traveling from Lower Granite to below Bonneville Dam, independent of flow.

The delay in migration could affect the timing of arrival at the estuary for in-river migrating fish. The ability of juvenile salmonids to acclimate to salt water is dependent on their physiological condition, and these conditions are somewhat time-dependent along with size-dependent. Therefore, this delay in arrival at the estuary could affect their ability to physiologically transition to the marine environment. Also, the delay could subject fish to high water temperatures longer and increase the rate of predation.

The effects of flow were also examined relative to the effects on overall survival. Early studies conducted when the lower Snake River dams were being constructed indicated a positive correlation between downstream passage survival and flow (Sims and Ossiander, 1981; Sims et al., 1983). Other studies indicated that the quantity of flow affects travel time and smolt survival (Sims and Ossiander, 1981; Sims et al., 1983; McConnahan, 1990; Berggren and Filardo, 1993; DeHart, 1991; Petrosky, Unpublished Manuscript). The meaning of these results was clouded by the effects of dissolved gas and spill and also by high levels of debris at the dams that increased mortalities during some of the early study years (Steward, 1994; Williams and Matthews, 1995).

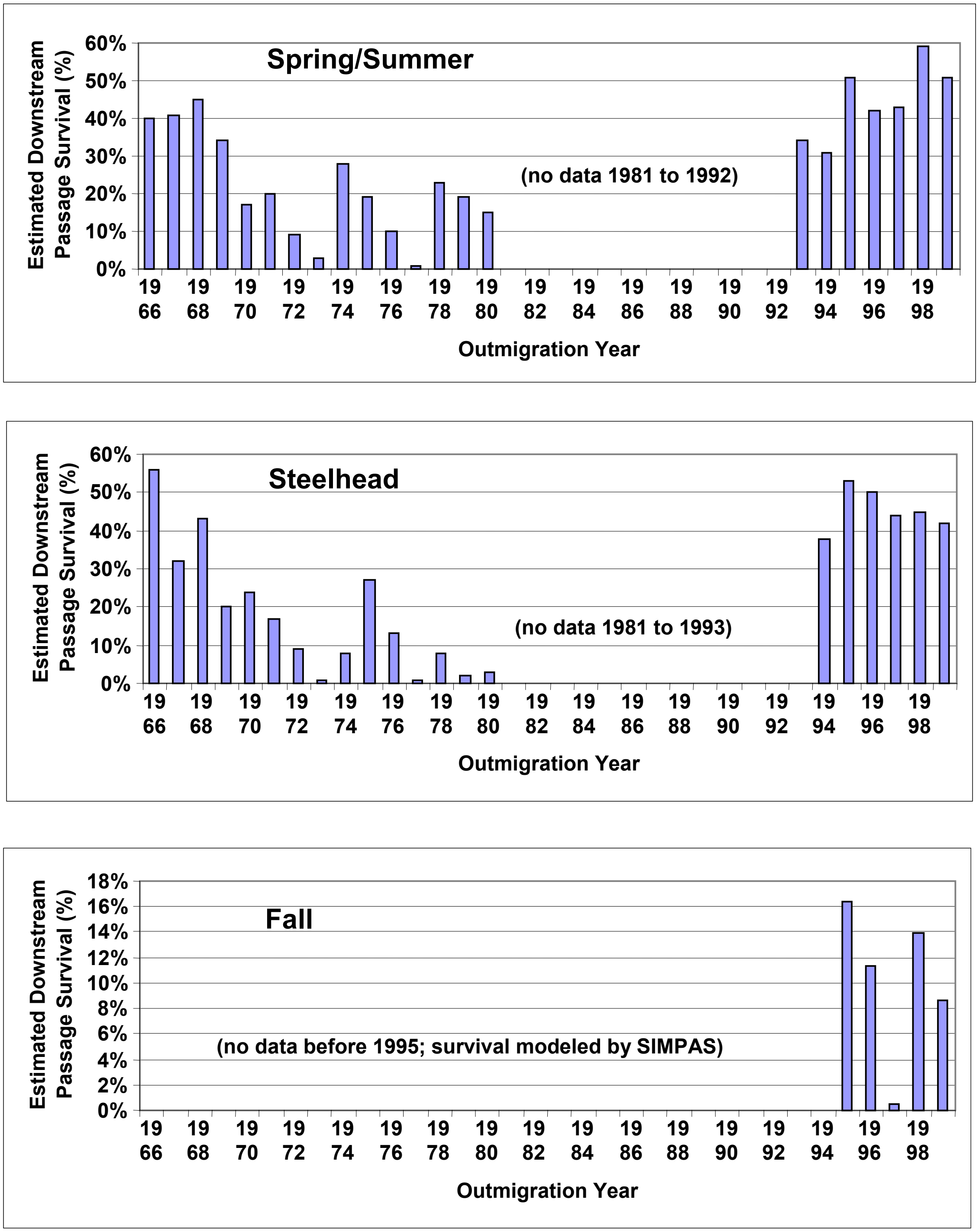


Figure 5.5-1. Estimated Survival (Includes Extrapolation Outside Area Measured) of Juvenile Spring/Summer and Fall Chinook, and Steelhead from the Upper Dam on the Snake River to the Tailrace of Bonneville Dam (no transport fish) (NMFS, 2000, 2000a,b)[1/]

1/ From 1964 to 1967, juveniles passed Ice Harbor, McNary, The Dalles, and Bonneville Dams. Additional dams were added in 1968 (John Day Dam), 1969 (Lower Monumental Dam), 1970 (Little Goose Dam), and 1975 (Lower Granite Dam). Data are from unpublished NMFS analyses (NMFS, 1999a).

Adult returns have also been found to be related to the flow and spill during the season in which they outmigrated as smolts. Raymond (1979) found that the survival of smolts to adults was higher during years of higher flow and spill than during years with lower flows. Petrosky (1991) found a positive survival relationship from smolts to returning adults with increased flow years for some upper Snake River chinook salmon stocks during the 1977 to 1987 period. However, since 1977, the majority of Snake River spring/summer chinook salmon have been transported, so that the effects of flow on survival may be from delayed effects of flows upstream of Lower Granite Dam or below Bonneville Dam (e.g., estuary or ocean plume) (NMFS, 2000b). It should also be noted that the period from 1977 to 1996 was a drought cycle, and that from 1986 through 1995, Snake River flows were below normal for 10 years in a row.

Results of these and other studies have led to general agreement that there is some positive relationship between increased flow and juvenile survival (Cada et al., 1997). However, the relationship is only a general one, and there is disagreement about the exact survival benefits of increased flow, particularly when flows are greater than moderate. While there is a significant flow/survival relationship to summer migrants in the flowing portion of the Snake River upstream of Lower Granite Dam, this relationship is confused by a similar strong relationship to temperature and turbidity, which are also correlated with flow (NMFS, 2000b).

Other studies on effects of flow on survival have been equivocal. A multi-year study using PIT-tagged yearling juvenile chinook salmon and steelhead migrating during the spring freshet found varied effects of flow on survival through the lower Snake River and a portion of the Columbia River (Smith et al., 1998). The results indicated that travel time through the reservoirs was related to flow rate and that spill quantity and temperature also affected movement rate.

The length of time it takes to reach the ocean for juvenile salmonids traveling downstream in spring partly depends on the exact timeframe within the migration period. Fish traveling later appear to migrate faster, possibly due to their larger body size. In addition, results of the study showed a significant relationship between survival of chinook salmon and steelhead and average seasonal flow when all years in the study were combined. However, there was no significant relationship to flow rate and survival within a specific year (i.e., the flow rate individual fish encountered during a single year did not appear to significantly influence survival).

The quantity of flow could influence survival of juvenile Snake River fall chinook salmon, but this too is uncertain. Reservoirs in the system could also have reduced turbidity, which could decrease cover that provides protection from predators for migrating juveniles. Muir et al. (1999) found several factors that appeared to affect both travel time and survival of juvenile Snake River fall chinook salmon. They found that survival of Snake River fall chinook salmon to Lower Granite Dam was significantly related to flow, turbidity, and temperature. Survival was correlated to travel time in only 1 of 3 years of study, and travel time was not correlated with any physical factor in 2 of 3 years. Survival decreased with decreased flow, decreased turbidity, and increased temperature on an annual basis. Because these factors themselves were highly correlated, it is not possible to determine which was the major factor affecting survival.

In the reach from Lower Granite Dam to Lower Monumental Dam, a similar but less strong pattern was identified. Survival was again correlated to flow, temperature, and turbidity, but strong correlations existed only in 1 of 3 years. The year with the highest flow, 1997, actually resulted in lower survival of fish below Lower Granite Dam than the other 2 years; this was thought to be the result of the fish being smaller during migration (Muir et al., 1999).

Under Alternative 1—Existing Conditions, flow augmentation would continue. Flow releases were evaluated in the NMFS 2000 Biological Opinion and will continue as prescribed within that document. However, it was assumed for this FR/EIS that flow augmentation under the 1995 and 1998 Biological Opinions would continue.

As described in Section 2, flow augmentation would be provided during the spring and summer migration period as described in the 1995 and 1998 Biological Opinions, mainly to increase survival of migrating juvenile fish. The 2000 Biological Opinion utilizes a sliding scale for spring and summer flow objectives (April through August) dependant on annual availability of stored water. The timing of flow depends on several factors (e.g., fish abundance, available storage, and river temperature).

The priority of flow augmentation for the Snake River is for summer migrating juvenile fall chinook salmon in July and August, unless doing so would depart markedly from the spring flow objectives. The result is some balance of use for spring and summer flow needs and reservoir refill. Dworshak reservoir has been used as part of the flow augmentation program. Releases from Dworshak result in cooler water downstream. Depending upon timing of flow releases, these releases can both benefit or work to the detriment of life-stage survival of the juvenile Snake River fall chinook salmon stocks in the summer, and could be detrimental to the Clearwater River stocks by extending the period before these fish are ready to migrate (Arnsberg and Statler, 1996; Connor et al., 1996). If increased flow increases survival, then optimized flow augmentation should benefit the Snake River salmonid stocks.

Construction of the Hells Canyon Complex reduced the production potential of the Snake River basin for fall chinook salmon. Spawners were displaced from the historic production area of the Snake River near Marsing, Idaho, which was warmer during egg incubation and rearing than any present-day production area. Consequently, young fall Chinook salmon from present-day production areas emerge, rear, and begin seaward migration later than was observed for fall chinook salmon in the historic production area. Releases of cool reservoir water from the Hells Canyon Complex may also keep water temperatures in the upper and lower reaches of the Snake River cooler longer into the spring and summer than before dam construction, thereby further delaying fry emergence and prolonging shoreline rearing.

Construction of Dworshak Dam and releases of water from the Dworshak reservoir made the lower Clearwater River more suitable for fall chinook salmon. There is no conclusive evidence that the lower Clearwater River ever supported fall chinook salmon, and, based on the early life history timing and growth statistics, it is still marginal habitat even though it is warmer than before construction of Dworshak Dam. In some years, the lower Clearwater River produces juveniles that have a “stream-type” (Healy, 1991) early life history, as opposed to the typical “ocean-type” (Healy, 1991) early life history of inland fall chinook salmon. Rates of residualism as high as 85.7 percent in 1994 may be an unintended result of releasing cool water from the Dworshak reservoir for summer flow augmentation. Large volumes (approximately 609 m^3/s/d) of 46.8°F (8.2°C) water released in July 1994 decreased water temperatures in the lower Clearwater River from 67.1 to 47.8°F (19.5 to 8.8°C). This 51.3°F (10.7°C) drop probably worked in concert with decreasing day length to cause the high rate of residualism by smaller volumes (approximately 381 m^3/s/d) of 51.4°F (10.8°C). Water released from the Dworshak reservoir in July and August of 1995 resulted in a drop from 67.6°F to 55.4°F (19.8°C to 13.0°C), and only 6.3 percent of fish from the lower Clearwater River residualized and completed seaward migration as yearling smolts.

Construction of Lower Granite Dam and the seven other mainstem dams located downstream reduced the production potential of the Snake River basin for fall chinook salmon. To reach the sea, present-day smolts pass from the relatively high-velocity waters of the Snake and Clearwater Rivers into the relatively low-velocity waters of downstream reservoirs. Fall chinook salmon smolts migrate downstream faster in high-velocity water than in low-velocity water. Radio-tagged wild Snake River fall chinook salmon smolts migrated downstream over 26 times faster in the upper end of the Little Goose reservoir, which includes a short reach of high-velocity water, than in the relatively low-velocity water in the forebay of Little Goose Dam (Venditti et al., 2000). Venditti et al. (2000) concluded that the reduction in downstream migration rate was caused by decreased water velocity in the dam forebay.

Dam Passage

Submerged traveling screens (STSs) or extended submerged bar screens (ESBSs) divert migrating fish away from passage through turbines at lower Snake River dams (see Section 3.1.2.1). In recent years, designated spill has been used to bypass fish around turbines in addition to the screen diversions.

Many of the fish diverted and collected from Lower Granite, Little Goose, and Lower Monumental Dams on the Snake River, and McNary Dam on the Columbia River are transported downstream by barge or truck and released below Bonneville Dam. Most diverted fish are transported, except for PIT-tagged research fish that constitute the in-river treatment group. About 88 percent of all diverted fish were transported in 1996 on the Snake and Columbia Rivers (Corps, 1999). The average portion of fish recently transported (about 1994 to 1999) has been 72, 48, and 77 percent of all spring/summer chinook, fall chinook, and steelhead of the Snake River ESUs, respectively (NMFS 2000a Biological Opinion). The remaining portions either pass through the turbines or through the spillways.

Some migrating juvenile fish die in bypass and transport facilities. Recent estimates of direct mortality during passage through collection and bypass facilities on the Snake River dams for all species combined has been less than 1 percent at each facility. Rates could be higher or lower for individual years or species (Corps, 1997; Corps, 1999). One recent study at Little Goose Dam found mortalities during bypass of steelhead to be much higher, at about 5 percent. This value, however, could have included mortality from predation in the tailrace at the outfall site (Muir et al., 1998).

Recent PIT-tag studies have suggested that the higher numbers of bypass systems that fish pass through, the lower their overall survival as a group (Appendix A, Anadromous Fish Modeling; NMFS, 2000). Currently, mortality of juvenile fish is usually about 1 percent at each Snake River dam, and up to 3 percent at each of the lower river facilities (Appendix A of Marmorek and Peters, 1998a). Recent values are presented by Corps, 1999. Mortality has ranged from about 1 to 5 percent and 2 to 7 percent for yearling chinook salmon and steelhead at collection channels at Snake River dams (Muir et al., 1995, 1996, 1998). Direct mortality of transported fish is estimated to be about 2 percent (Marmorek and Peters, 1998a). As discussed under Section 5.5.1.5, Model Analysis of All Alternatives, there is disagreement on the level of any latent mortality (i.e., mortality that could occur after release below Bonneville Dam) resulting from fish being transported (see Transportation on page 5.5-15). It is likely that under Alternative 1—Existing Conditions, direct mortality from collection and transport would remain relatively low. However, these mortalities could decrease as systems continue to be improved.

The other major source of mortality of juvenile fish at dams is through turbines or spillways. Turbine mortality may result from fish being caught in the narrow opening between turbine blades and the hub or walls, and then being directly struck by the turbine blade; from rapid changes in hydraulic pressure; from shear forces; or from cavitation (Wittinger et al., 1995). Overall, total mortality is affected by the proportion of fish passing through turbines and the efficiency of turbine operations. Slightly higher mortality may occur as turbine operation varies from peak efficiency. The 1995 and 1998 Biological Opinions (NMFS, 1995; NMFS, 1998) require turbines to operate within 1 percent of peak efficiency. Current operation is nearly always within 1 percent of peak efficiency. Estimates of turbine passage mortality vary from 2 to 32 percent over a wide range of current and historic conditions (Mathur et al., 1996; Ledgerwood et al., 1990; Weber, 1954; Long et al., 1968; Iwamoto and Williams, 1993; Muir et al., 1996 and 1998; Iwamoto et al., 1994; Schoeneman et al., 1961; Raymond and Sims, 1980; Gilbreath et al., 1993; Normandeau Associates Inc. et al., 1997). Some of these estimates of turbine passage mortality (e.g., 32 percent) include secondary mortality as a result of additional fish loss from factors such as predation that may occur between the time fish pass through the turbine and when they are later collected.

In 1996, the PATH Hydro Work Group concluded that turbine survival of spring/summer chinook salmon under current conditions is $\geq$ 90 percent and adopted a value of 90 percent survival at all facilities for modeling (Marmorek and Peters, 1998a). Most of the more recent turbine survival estimates have been higher (NMFS, 2000b fish passage white paper). For example, turbine survival at Lower Granite and Little Goose Dams, estimates range from 92 to 93 percent, with similar values observed at other Columbia River dams (Normandeau Associates et al., 1996; Normandeau Associates and Skalski, 1997; RMC et al., 1994; RMC and Skalski, 1994a and b; NMFS, 1999b). Some have remained lower, such as at Lower Monumental where yearling chinook salmon have a survival rate of about 87 percent (NMFS, 2000e).

Direct mortality due to passage through a spillway results primarily from abrasion, but juveniles could die later through indirect means such as descaling, stress, predation, or reduced viability due to dissolved gas supersaturation. Accurate data on delayed mortality from this passage route are not available, although limited data suggest it is likely low and likely related, to some degree, to low residence time in the tailwaters (Muir et al., 1999). Ten of 13 juvenile fish passage studies conducted prior to 1995 found low mortality rates of 0 to 2.2 percent (most studies involved steelhead and yearling chinook salmon) for spillway passage at each dam (ISG, 1996; Marmorek and Peters, 1998a; NMFS, 1999b). However, three studies have indicated mortality can be as high as 4 to 27.5 percent (Long, 1968; Marmorek and Peters, 1998a). PATH considers these higher mortality values to be suspect (Marmorek and Peters, 1998a). Of six recent studies at Snake River dams, all but one had spill survival greater than 97 percent (NMFS, 1999b).

If spill volume is very high, survival could be negatively affected at some projects, as indicated by results at The Dalles Dam. Dawley et al. (1998) found survival of only 76 to 92 percent at spill of 64 percent, but survival of 92 to 96 percent for spill of 30 percent. However, preliminary 1999 results found survival similar at both 64 and 30 percent spill, with all tests resulting in survival greater than 93 percent (NMFS, 1999b). Depending upon specific spill volumes and resultant hydraulics, the addition of spillway flow deflectors has been found to either increase or decrease mortality in some studies to above 3 percent (Muir et al., 1995 and 1998; ISAB, 2001). Modeling efforts have generally used a direct mortality estimate of 2 percent for all species due to passage through a spillway (Marmorek and Peters, 1998a). Spillway passage direct mortality rates (about 2 percent) would likely remain within the range of those considered for models for Alternative 1—Existing Conditions (see Section 5.4.1.5, Model Analysis of All Alternatives). However, direct or indirect mortality associated with alterations of spill in the future (e.g., possible increased spill for passage and additional spillway flow deflectors) could alter mortality of fish passing through spillways.

The overall measure of the effectiveness of spill as a juvenile fish bypass method lies in the effect on survival during passage through the entire system, not just survival at each dam. Although fish passed through the spillway may survive dam passage at 98 percent, they continue their migration in the next reservoir at about 96 percent survival. Then, they may pass through another spillway at 96 percent survival into another reservoir at 94 percent survival. Recent estimates by NMFS indicate that average survival for in-river migrating spring/summer chinook is about 41 to 63 percent due to the compounding factors of dam and reservoir passage losses from the Lower Granite reservoir to below Bonneville Dam (NMFS 2000a Biological Opinion). However, fish that are collected and transported have minimal direct mortality, surviving at 98 percent (plus additional mortality for passage through Lower Granite reservoir) to below Bonneville Dam. NMFS estimated that average system survival, considering the portion transported and those passing through the hydroelectric system without transport, results in an average overall system passage survival of 80 percent. However, if delayed transport mortality is considered high, as was done by PATH, overall system survival is then estimated to be much lower, at about 19 to 39 percent (in the PATH 1998 report). But, if it is considered to be in the range assumed by NMFS (63 or 73 percent) system survival is still higher (average 54 to 61 percent), than direct survival of fish passing through all eight reservoirs and dams without transport.

Transportation

The collection of juvenile salmonids and their transport downstream by trucks or barges for release below Bonneville Dam has been an integral part of the FCRPS since the 1970s. One of the main goals of transporting fish is to avoid mortality from passage through dams and reservoirs at projects downstream. Since 1976, at least one million fish have been transported annually from the Snake River to below Bonneville Dam, with significant numbers being transported beginning in 1981 (Ward et al., 1997). For example, in 1999, about 16 million fish were collected and transported from the Snake River for release below Bonneville Dam. Currently, Snake River spring migrating fish, primarily spring and summer chinook salmon yearlings and steelhead, are collected at Lower Granite, Little Goose, and Lower Monumental Dams. Summer migrants, primarily underyearling fall and summer chinook salmon (Columbia River only), are collected at these same dams plus McNary Dam. Research on the effect of transporting fish on their survival began in 1968 and continued through 1989, with recent studies occurring in 1995, 1996, 1998, and 1999.

Concerns about the effectiveness of transportation compared to other forms of passage (e.g., through turbines, over spillways) emerged in the 1990s and have not been resolved to date (NMFS, 2000a). Studies related to this issue have been conducted since the late 1960s (Ebel, 1970; Ebel et al., 1971-74; Ebel, 1974; Park and Ebel, 1975; Park et al., 1976-86; Park, 1980; Park and Athearn, 1985; Park, 1993; Matthews et al., 1985-92; Matthews, 1999; Achord et al., 1992; Harmon et al., 1989-96; Marsh et al., 1996; Marsh et al., 1997a and b).

Direct mortality during transport has generally been determined to be low, typically considered to be on average less than 2 percent. Therefore, emphasis has been placed on examining other effects of transport on fish survival (NMFS, 1999c). Indirect mortality has been evaluated primarily by examining the ratio of returns of transported fish to those that remained in-river (i.e., not transported). The results of these analyses have been referred to in several ways, but have most recently been evaluated using the term “transport to in-river ratio” (TIR). The TIR is a ratio of the number of adults returning to a given location from a transported group of marked juveniles, to the number of adults returning to the same location from the group of marked juveniles released to migrate downstream in-river. If the TIR is greater than 1, it indicates that the test showed greater overall survival for transported fish than for those not transported.

Over 25 years of experimental results for spring/summer chinook salmon and steelhead have indicated that the vast majority of these studies resulted in TIRs greater than 1, with most ranging from 2.5 to 3 (Corps et al., 1999). For example, spring/summer chinook salmon had TIRs of 1.6 and 2.3 (Ward et al., 1997) and steelhead had similar TIRs of 2.0 and 2.1 in 1986 and 1989, respectively. The first studies conducted after 1989 were in 1995. Although the 1995 results were not completed, the initial TIR values for Snake River spring/summer chinook salmon were 2.0 and 2.1 for hatchery and wild fish, respectively. The TIR results for 1996 are incomplete but values are similar—1.4 and 2.7 for Snake River hatchery and wild spring/summer chinook salmon. Jack salmon (precociously mature salmon, usually males, that return one year earlier than most adults) returns for the 1998 study show similar trends (NMFS, 2000b). Data are not available for Snake River subyearling chinook salmon transported from any lower Snake River dam (mostly due to lack of sample fish to tag), but studies on the Columbia River from McNary Dam have subyearlings TIR ranging from 1.8 to 8.

No data are available for sockeye salmon from the Snake River, and results from studies involving the Columbia River sockeye salmon collected and released at Priest Rapids Dam indicate that the TIR was less than 1 for studies conducted in 1984 and 1986. Because of the differences in conditions and methods at Priest Rapids, these studies may not be representative of Corps dams (Chapman et al., 1997). However, later studies showed increased survival from transport (Carlson and Matthews, 1992; Mundy, 1994).

The data from years 1986, 1989, 1995, and 1996 appear to be closer to meeting the assumptions desired for a true measure of the overall transport survival. While studies in 1986 and 1989 were not intended to measure survival to spawning grounds, collections of returning tagged fish from spawning grounds did not indicate as great a benefit from transportation because TIR values were lower compared to values at dams (Olney et al., 1992). The total number of tagged fish found in these spawning areas was low, making interpretation of these results somewhat questionable.

Because of concerns that the controls used in the TIR studies were not true controls (Mundy, 1994; Ward et al., 1997), another method of evaluating the effects of transport was conducted. These studies incorporated the use of fish marked with PIT tags. From these studies, NMFS found that about twice as many fish that were transported returned as adults than did those released to the river. These results were similar to many of the earlier studies. However, the route fish took in passing through the system affected the relative survival; some tag groups that passed untransported had greater survival than some transported fish.

As discussed in Section 5.5.1.5, Model Analysis of All Alternatives, there is some concern that additional mortality from an undetermined cause occurs to fish that are transported; this is known as "differential delayed transport mortality." The ratio of survival to adult return of transported fish below Bonneville Dam to the estimated survival to adult return of in-river migrant fish to below Bonneville Dam is an index of the relative post Bonneville Dam additional mortality of transported fish. This value is referred to as a D-value in the NMFS analysis and is described in more detail in Section 5.5.1.5 and in Appendix A, Anadromous Fish Modeling. This D-value is not a measured value. Instead, it is the calculated difference between the estimate of survival for fish migrating in-river and for those that are transported.

A D-value of 1 would indicate no differential delayed mortality of transported fish, while values less than 1 suggest additional mortality occurs to transported fish compared to in-river migrants. All models to date have indicated that the average D-value is less than 1, which indicates that some additional delayed transport mortality is occurring.

Recent information is not clear on whether barging has any initial effects on lower river (below Bonneville Dam) mortality relative to fish that are not barged (in-river fish). Recent tracking of radio-tagged spring chinook salmon has found no significant difference in overall survival or susceptibility to bird predation between barged and in-river fish in the reach below Bonneville Dam to the start of the estuary (Schreck and Stahl, 1999). In the Shreck and Stahl study, radio-tagged barged fish had survivals ranging from 74 to 100 percent, while radio-tagged in-river fish had survivals ranging from 65 to 96 percent during spring 1998. Average bird predation, based on recovery of all radio tags, was 17 percent. But some PIT-tag recovery information, used to evaluate Caspian tern predation, has suggested that barged spring chinook salmon may have been more susceptible and barged steelhead less susceptible to bird predation during 1998. In contrast, information from the same study in 1997 found no difference in susceptibility to predation of barged fish of either species (Collis et al., 1999).

Possible causes of differential delayed transport mortality have been postulated to be the result of natural mortality or increased stress or disease. Delayed natural mortality may occur because fish transported are protected from many natural conditions (e.g., predation, ability to find food over an extended period, proper migrating ability) that would have resulted in their death during migration had they not been in a barge. Surviving in-river fish have already undergone the "natural" mortality process; many of the fish less well-suited to survival in the wild would have died upstream before passing Bonneville Dam. The result is that the barged fish population would contain a higher portion of fish less well-suited to survive in the wild. The effect would be that some of the barged fish would suffer a higher rate of mortality at some point after they are released from the barge than those that migrated in-river.

Stressful environments for extended periods decrease survival. The process of collection and loading fish increases stress for some stocks, although studies have documented that stress is reduced by the time fish are released from the barge, except possibly during peak migration (Schreck et al., 1998; Schreck and Stahl, 1999).

Disease is thought to possibly increase during barging because fish are confined to a small area in close proximity to other fish during transport. Some studies have found spring chinook salmon have lower resistance to general infections under extended crowded conditions (Schreck and Congleton, 1994). However, Elliott and Pascho (1993 and 1994) have demonstrated that at least for one disease, bacterial kidney disease (BKD), the caustive organisms are prevalent in-river as well as in the collection and transportation system. The majority of fish, both hatchery and wild, are infected with BKD by the time they reach the first collection and transport facilities at Lower Granite Dam. NMFS (1999d) concluded that while BKD is highly prevalent in Snake River smolts, the effect of fish transport on disease-caused mortality of these fish remains unknown.

In comparison to collection and transportation, it is important to emphasize that in-river migration is also stressful for fish. Passing eight dams and reservoirs, which could include migration through spillways or turbines, can cause stress. Exposures of fish to elevated dissolved gas concentrations also subjects fish to stress, especially during periods of high system-wide spill.

Other issues relative to transport include effects of transport on adult homing, effectiveness of transport by trucks compared to barges, and survival of trucked fish compared to in-river migration. NMFS (2000b) indicates there has been no documentation of straying of transported Snake River fish to other streams at rates that deviate from natural straying rates. Limited effects of trucking vs. barging have been conducted. Of five paired tests, only one showed significantly lower survival of trucked fish than barged fish (NMFS, 2000b). Release procedures have changed from earlier studies to try to reduce the effects of release locations on survival. Recent data using the new mid-channel release procedures indicate that trucked fish survive at significantly higher rates than those migrating in-river (Matthews, 1999).

Under Alternative 1—Existing Conditions, transportation would continue for all fish collected at the three dams on the Snake River and for summer migrants only at McNary Dam. This approach is based on the 1998 Biological Opinion (NMFS, 1998). Spill would be used, to the extent possible, under the "spread the risk" policy (see Section 2) to bypass fish at all dams where fish are not either collected and transported or passed through turbines. This would mean about 70 to 80 percent of the spring/summer chinook salmon and steelhead, possibly sockeye salmon, and a lesser portion of fall chinook salmon (about 30 to 60 percent), would be transported around dams and released below Bonneville Dam. This would continue until sufficient data are gathered from tagging studies to determine if the transport program should be altered.

Dissolved Gas Supersaturation

Gas bubble disease or trauma can result when fish are exposed to dissolved gas that is greater than saturation. Gas bubble disease has been a well-documented source of past mortality in the Columbia River System (Ebel et al., 1975; Weitkamp and Katz, 1980). Factors that contribute to this disease include the percent hydrostatic pressure supersaturation, duration of exposure, water temperature, physical condition of the fish, depth of travel of the fish, and life stage (Ebel and Raymond, 1976; Weitkamp and Katz, 1980; Filder and Miller, 1993). Spillway flow deflectors (see Section 2) constructed at most dams since the late 1970s have helped reduce the production of reach-wide dissolved gas supersaturation that caused significant mortality in the 1970s. These factors make it difficult to determine what amount of exposure above the state standard of 110 percent of total dissolved gas (TDG) is considered safe for aquatic organisms in the Snake and Columbia Rivers.

Most studies on dissolved gas supersaturation have concentrated on direct effects, which have included major changes in the effects of physiological function, physical damage from internal bubble formation, and death. Also, there is evidence of secondary effects of gas bubble disease. Frequently, gas bubble disease has been noted as increasing susceptibility to factors such as bacterial, viral, and fungal infections (Meekin and Turner, 1974; Nebeker et al., 1976; Weitkamp and Katz, 1980; and White et al., 1991). It can also increase susceptibility to predation (White et al., 1991). Information summarized from several studies has documented adverse effects, including either acute or chronic mechanisms of mortality beginning as low as 110 percent saturation (Filder and Miller, 1993; Weitkamp and Katz, 1980). Additionally, some studies suggest gas saturation may affect other aquatic organisms, including invertebrates that could be food for salmonids. Bioassay studies of aquatic mayflies below a hydroelectric project in Montana found that TDG as low as 114 to 118 percent could cause adverse effects to these organisms and concluded that at least these mayfly species were susceptible to negative effects from operation of the hydroelectric project (Brammer, 1991). However, sampling of invertebrates residing below Bonneville Dam did not detect visible signs of effects to invertebrates from dissolved gas concentrations within or somewhat in excess of this range (Toner et al., 1995). However, no bioassays were conducted on organisms in this study to confirm field observations or to determine concentrations that might result in adverse effects.

Interpretation of the dissolved gas saturations that cause significant adverse effects to migrating salmonids differs by source (BPA et al., 1995). The current maximum EPA and Washington State water quality standard for the Columbia-Snake River System is 110 percent. However, under current operations, the state establishes exemptions that allow operations to achieve 115 percent in forebays and 120 percent in tailraces, under specific operating conditions. If natural runoff is high, TDG would exceed the 120 percent concentration, often being greater than 130 percent, even with current gas abatement methods.

There is a dissolved gas monitoring program which includes monitoring and external examinations of migrating fish for signs of gas bubble disease (Fish Passage Center [FPC], 1999). Generally, external signs of gas bubble disease have been low when total dissolved gas was less than 115 percent, and observed symptoms only approached 10 percent occurrence when system-wide TDG in-river was 125 percent. The cause-and-effect relationship of gas bubble disease symptoms is not easily demonstrated (Williams et al., 1997). Bubbles can grow internally in a fish's body, disrupting neurological, cardiovascular, respiratory, osmoregulation, and other physiological functions (Stroud et al., 1975; Weitkamp and Katz, 1980). At some TDG concentrations, external symptoms of gas bubble disease may not be apparent; therefore, assessing the effects on fish populations by external examination could be unreliable and would not reflect behavioral effects. A detailed discussion of the possible effects of gas supersaturation on Columbia River salmon is presented in Appendix C, Water Quality of this FR/EIS. NMFS (1999b) concluded that, even during periods of involuntary spill in recent years, impacts to juvenile salmon and steelhead appeared to be minor except when TDG exceeded 120 percent. These types of results differ from laboratory results and tests, including tests involving caged fish in the Columbia River (Ebel et al., 1975; Toner et al., 1995b; and Schrank et al., 1966, 1997, 1998). These studies suggest much more severe reactions at these higher saturation (i.e., 115 to 120 percent). The meaning of the differences is open to interpretation. Fish in the wild could be able to compensate for elevated TDG by swimming at depth, or they could only encounter the higher TDG for a shorter period of time. It is also argued that the lower observed incidence could be from increased mortality, which eliminates fish affected by the gas supersaturation from the sample. Some additional field data attempt to contradict this theory (FPC, 1999), but the question is not answered with available data. Fish that are transported in barges are not subjected to the elevated gas like those that pass in-river because each barge is equipped with gas stripping equipment that eliminate supersaturated conditions in the barge water.

Under Alternative 1—Existing Conditions, current conditions would likely be maintained with periodic elevations of dissolved gas concentrations that could cause adverse effects to fish. The Corps is evaluating construction of end bay deflectors at Lower Monumental, Little Goose, McNary, and Bonneville Dams to decrease TDG production. The Corps will also evaluate potential modifications to existing spillway flow deflectors at some dams to improve their performance.

Predation

One of the major causes of fish mortality during migration is predation by resident fish (Poe and Rieman, 1988; Rieman et al., 1991). More recently, predation by birds has also become a problem (Petersen et al., 1999; Roby et al., 1998; NMFS, 1999d; Collis et al., 1999). Predation by marine mammals on juvenile salmonids occurs in the marine environment and possibly in the lower river, but the overall impact of this predation is unknown (NMFS, 2000d). Predation is considered by some to cause mortality equal to or greater than that caused by passage at dams (Rieman et al., 1991). The primary predator in much of the Columbia River System is northern pikeminnow (Beamesderfer et al., 1990), but in Snake River reservoirs it appears to be smallmouth bass (Curet, 1993; Bennett et al., 1997; Petersen et al., 1999; NMFS, 1999d). Predation within the Columbia and Snake Rivers occurs throughout the reservoirs, but is often concentrated just below and above dams (Poe and Rieman, 1988; Poe et al., 1991). Additionally, many non-native fish including bass, crappie, yellow perch, walleye, and catfish also contribute to predation of migrating juvenile salmon and steelhead (NMFS, 1999d). The current management of these stocks as "game" fish may contribute to predation on the listed stocks. The Northwest Power Planning Council's Framework Process (see Section 3.0) is considering alternatives to manage these non-native predators for the benefit of the listed stocks.

Estimates of losses due to predation are quite variable by species and location. Spring juvenile salmonid migrants (typically yearling smolts) appear to suffer relatively low mortality in the Snake River System. At Lower Granite, estimates were less than 1 percent mortality loss from northern pikeminnow (Chandler, 1993). Estimates of total losses in reservoirs, exclusive of dam passage losses, through the entire lower Snake River reach for spring migrants (spring/summer chinook salmon and steelhead) was only about 1 percent (Petersen et al., 1999). In the Columbia River, mortality rates due to predation could be higher for spring migrants. Rieman et al., (1991) estimated a mortality rate of about 11 percent in John Day reservoir for spring migrants. However, summer migrants at John Day Dam had much higher mortality rates from resident fish, ranging up to an estimated 61 percent (Rieman et al., 1991). Total estimated loss of smolts in the mainstem Columbia and Snake Rivers to just northern pikeminnow, prior to the current predator removal program was estimated to be about 8 percent of all smolts (NMFS, 1999d). Average estimates of losses due to predation for the entire impounded Snake River reach were modeled to be about 59 percent for summer migrating fall chinook salmon (Petersen et al., 1999).

Piscivorous birds congregate near hydroelectric projects along the river and in the estuary and lower river near man-made structures and islands and consume large numbers of migrating smolts (Roby et al., 1998; Collis et al., 1999; NMFS, 1999d). Recent estimates of consumption in 1997 and 1998 are that 10 to 30 percent (best estimate—17 percent) of all potential smolts that otherwise would be found below Bonneville Dam were consumed by birds (Collis et al., 1999). These estimates indicate predation occurred primarily by Caspian terns, but also by gulls and double-crested cormorants. It was estimated that in 1997, 6 to 25 million smolts—or about 6 to 25 percent of all smolts arriving at the Columbia River estuary—were consumed by Caspian terns alone (Roby et al., 1998). It was estimated that in 1998, Caspian terns consumed 7 to 15 million smolts, or 8 to 16 percent of those arriving at the estuary (Collis et al., 1999). Similar bird predation rates likely occurred again in 1999, although no estimates are available (*Columbia Basin Bulletin*, July 9, 1999). Action was taken in 1999 to attempt to move 90 percent of the existing terns from Rice Island to an island further downstream in the Columbia River where predation on juvenile salmonids would be reduced. However, the results indicate that few terns moved, with 7,300 nests developed in 1999 at Rice Island and only about 10 percent of that number at a downstream island (*Columbia Basin Bulletin*, June 18, 1999).

Predation by birds is influenced by the availability of habitat, species, possibly by fish conditions, and maturity. The presence of a newly formed island in the lower river has helped increase predation by birds. The presence of dams also contributes by allowing birds to congregate and prey on possibly disoriented fish after they pass through the dams. In the lower river, the amount of time fish spend in-river before entering the ocean, depth distribution, and schooling behavior may influence predation. Generally, it has been observed that a greater portion of juvenile steelhead were consumed by Caspian terns, possibly because the juveniles of this species were near the surface. The effects of bird predation on fish transported and released below Bonneville Dam is not clear. Schreck and Stahl (1999) found no difference in predation of spring chinook salmon between fish released from barges or those traveling in-river. Collis et al. (1999) found in 1998 that spring chinook salmon and steelhead that were transported were slightly more and slightly less, respectively, susceptible to predation by birds than were in-river fish during 1998. However, there was no significant difference between these groups in 1997. It is speculated that less mature fish, which may include transported spring chinook salmon, may tend to stay in the fresh water longer before entering the ocean, making them more susceptible to bird predation.

Predation by marine mammals, some of which are present in the Columbia River mouth area, also occurs (NMFS, 2000d). Harbor seals are the most abundant mammal in the lower Columbia at about 2,000 individuals, while California sea lions number about 100 to 200. Juvenile salmon were reported to constitute 19 percent of the diet of harbor seals in the lower Columbia and about 3.6 percent of the diet of California sea lions. Whether the portion of food in marine mammal diets is reflective of consumption in the Columbia River mouth is unknown, because they may forage over a wide range, including in areas outside of the Columbia River mouth. As a result, overall estimates of the loss of total juveniles to marine mammals in the lower Columbia River are not available.

Mortality rates due to predation are affected by many factors including current velocity, turbidity, cover, location, predator abundance, prey abundance, and water temperature. Of these factors, temperature is a major controlling factor for predation by fish (Beamesderfer et al., 1990; Petersen et al., 1999). Cooler temperatures tend to reduce predation rates, because predator consumption rates are less (Beamesderfer et al., 1990; Petersen et al., 1999). As temperatures warm, activity and metabolic rate of predators increase, making them more active predators and increasing their need for food.

The source water for flow augmentation could affect predation rates in the Snake River system. Muir et al. (1998) found that survival of subyearling chinook salmon was lower during a year when water used for flow augmentation was released from the warmer Brownlee reservoir than from the cooler Dworshak reservoir. Cool water from the Dworshak reservoir releases could influence water temperature in the Snake River, which could affect survival by reducing predation rates. However, cooler water releases from the Dworshak reservoir delay emergence and migration timing of Clearwater River fish, which could, in turn, increase mortality rates of those fish as they enter the warmer waters in the Columbia-Snake River System later in the year (Connor et al., 1997). Higher water velocities from flow augmentation could also affect survival rates of juvenile fish migrating through reservoirs by reducing the predation rate. However, many factors affect both migration rate and predation (e.g., temperature, turbidity, and fish size) which greatly influence the overall effectiveness of increased flow on survival from predation.

Alternative 1—Existing Conditions would maintain the level of predation currently occurring in the system. However, the source of water for augmented flows, either from Dworshak or Brownlee reservoirs, would influence predation rate and survival of primarily juvenile fall chinook salmon and some sockeye salmon in the Snake River System. Augmentation flow releases from Dworshak and Brownlee reservoirs would be balanced to some degree to help optimize temperature in the Snake River during the summer juvenile fall chinook salmon migration period.

Rearing/Migratory Habitat

Rearing habitat is important during migration for all stocks, but especially for subyearling chinook salmon, which rely more heavily on mainstem habitat for rearing than other Snake River salmonid stocks. The quality and use of the habitat is affected by species, depth, velocity, substrate, benthic and pelagic food supply, temperature, and turbidity. Backwater and slough habitat is used in the lower Columbia during spring and summer migration (Zimmerman and Rasmussen, 1981; Parente and Smith, 1981). Nearshore areas are primary rearing areas for subyearling chinook salmon in river reach areas of the Columbia River (Venditti et al., 1997b). In the middle Columbia River, they use shallow-water, low-velocity areas (Dauble et al., 1999).

Subyearling fall chinook salmon in Snake River reservoirs prefer low-velocity sandy habitat less than 20 feet deep (Bennett et al., 1983; Curet, 1993). They rear in the Snake River and the Lower Granite reservoir for about 75 to 112 days before they migrate downstream (Curet, 1993). In both the Columbia and Snake Rivers, there is movement offshore before migration begins (Curet, 1993; Venditti et al., 1997a,b).

The rearing period of yearling chinook salmon, steelhead, and probably sockeye salmon is likely no more than a few days in any reservoir. These fish are less oriented to the shallow shoreline, although they probably rely on food sources produced in these areas during their short residence time in the reservoirs.

Under Alternative 1—Existing Conditions, food supply and rearing habitat would remain as they are now, although the source of water for flow augmentation (i.e., the Dworshak reservoir, the Brownlee reservoir, or others) can affect water temperature, which can alter habitat in some areas. Food sources for subyearling fall chinook salmon could already be in short supply in the lower Snake River reservoirs (Curet, 1993). This likely would remain the same under Alternative 1—Existing Conditions.

Altered water temperatures in the early summer could benefit some Snake River subyearling fall chinook salmon. Optimum temperature for salmonids is typically less than 59°F (15°C) and the upper lethal temperature for juvenile salmonid is 77°F (25°C) (Coutant, 1999). Temperatures exceed 59°F but remain below the upper lethal levels during much of the fall chinook salmon rearing and migration periods in the reservoirs.

But temperatures during rearing and migration for fall chinook often exceed upper optimum growth temperature range (63°F to 68°F or 17°C to 20°C) and occasionally the avoidance temperature 70°F (21°C), particularly during the outmigration period and especially in low flow years (Coutant, 1999). Historically, prior to reservoir development, temperatures also likely exceeded optimum values within this region (Appendix C, Water Quality). However, the sequence of temperature occurrence has changed with the addition of upstream reservoirs possibly affecting development and outmigration timing of current Snake River fall chinook juveniles (Coutant, 1999). The release of cool water from Dworshak reservoir could benefit rearing and migratory conditions in the downstream reservoirs, if releases are timed to maintain water temperatures within the optimum growth range of 14 to 17°C. Increased release from

Brownlee reservoir could increase temperature, likely reducing habitat quality during the summer period, but enhancing rearing habitat quality during the spring.

Under Alternative 1—Existing Conditions, rearing habitat could remain similar to the 1996 to 1998 period. During this period, habitat conditions varied, but included some improved rearing habitat over earlier years. During 1996, flow releases from Dworshak Dam did not occur until August, which probably had little benefit to rearing habitat conditions. However, in 1997 and 1998, flow releases were earlier, which contributed to cooling the reservoirs (usually less than 70°F [21°C]) during a larger portion of juvenile fall chinook salmon rearing and passage period. This likely improved rearing habitat quality. But the use of water from Dworshak has conflicting interests (e.g., maintaining reservoir levels for recreation, releasing water earlier to provide lower water temperatures in rearing habitat, flow augmentation for juvenile passage, or releasing cooler water later for adult passage), thus the benefits to rearing habitat may vary from year to year depending on what managers decide for a given year.

Effects on Adult Anadromous Salmon and Steelhead

Survival of adult salmon and steelhead is also affected by passage over dams and through reservoirs as they move upstream to their spawning grounds. The stocks of the Snake River, with few exceptions, need to pass all four lower Columbia and four lower Snake River dams and reservoirs before returning to the natal spawning stream of origin. Conditions in the reservoirs, including water quality and flow conditions, affect migration rate and overall survival. Structures and flow patterns at dams also affect the ability of these fish to find their way successfully upstream without suffering injury or delay in migration.

Upstream Passage

Upstream migration of fish through dams can be related to the ability of fish to find and ascend the fish ladders at each dam and not fall back or be swept downstream through the spillway, through the turbine, or other routes such as navigation locks. Conditions in the reservoirs can affect the ability of adult fish to successfully migrate upstream. Reservoirs also affect the amount of available spawning area in the mainstem reaches of the Columbia and Snake Rivers because lower velocity areas created by the reservoirs are not used. Successful migration through reservoirs is related to water quality, particularly water temperature and dissolved gas, which directly and indirectly affect survival.

Some adult fish die during upstream migration. The causes of the mortality are not completely known, but likely include natural and human-caused factors. The sources of mortality could include delay in migration, fallback through turbines, delayed mortality from marine mammal injuries, gillnet interactions, and disease (NMFS, 1995; NMFS, 2000b). The loss of adult fish as they move upstream varies somewhat by species. Estimates of loss of adult fish passing all eight dams and reservoirs from Bonneville Dam to Lower Granite Dam, independent of fish harvested in-river and others that migrate into intervening tributaries or the upper Columbia, vary by species. Recent estimates based primarily on radio tagging studies suggest that 18, 29, 23, and 14 percent of adult Snake River spring/summer chinook salmon, fall chinook salmon, steelhead, and sockeye salmon, respectively, are lost independent of harvest during upstream migration past these eight hydropower facilities (NMFS 2000a Biological Opinion).

Delays in upstream migration of adults traditionally may have occurred at natural barriers within the Columbia River System (e.g., Celilo Falls) but now may occur at dams. This can result in loss of food reserves in tissues that could contribute to mortality. The amount of spill is one factor that affects upstream migration rates at dams. For example, delay at one Snake River dam was low (about 1 day) when spill was less than 25 kcfs, but up to 7 days when spill was from 25 to 125 kcfs (Turner et al., 1983). Higher spills (greater than 60 kcfs) occasionally make fish ladder entrances difficult to find (Turner et al., 1983). During 1993, the median delay per lower Snake River dam was from 0.6 to 1.2 days during periods of no spill to spill of 40 to 80 kcfs (Bjornn et al., 1994). Voluntary spill used to pass downstream migrants past dams in the spring does not appear to cause delays in upstream passage at dams for adult fish (Bjornn et al., 1998).

Higher spills can also influence fallback (adult fish that successfully pass upstream of a dam but are either swept or swim through the spillway, turbines, or navigation locks to below the dam). Bjornn and Peery (1992) found fallback was less than 10 percent when spill was low, but increased to 40 percent during high spill for spring chinook salmon. The occurrence of fallback for salmon remains low at about 3 to 5 percent during low flow periods (Bjornn et al., 1992 and 1993). Fallback is higher for steelhead. Bjornn et al. (1998) found that fish that fell back one or more times were less likely to find their way back upstream to hatcheries or spawning areas. While some fish are lost in this manner, most re-ascend ladders and continue upstream. However, some fish that fall back are strays that have wandered into the wrong area and need to move back downstream to find their natal location. Bjornn et al. (1998) also found that the incidence of headburn was more common on individuals that fell back over dams multiple times. Maximum fallback mortality rates of fall chinook salmon have been 14 to 26 percent in 1993 and 1994, respectively (NMFS, 1999b). High rates of fallback likely result from a high straying rate of fish from other areas (Mendel and Milks, 1997). But survival to spawning grounds for those fish that ultimately stayed above Lower Granite was likely high, and possibly as much as 95 percent (Mendel and Milks, 1997).

While dam passage is slower than through the reservoirs, it is unlikely that overall passage time—at least on the Snake River—has changed since the four lower Snake River dams were installed (NMFS, 2000b). Bjornn et al. (1998) reported that the overall time for radio-tagged spring/summer chinook salmon to migrate through the lower Snake River (about 6.4 days) was comparable to that of pre-dam conditions. Upstream migrants were slowed at dams, but migration through reservoirs was at a faster rate than through free-flowing rivers. Overall survival of adult spring/summer chinook salmon in 1990 from Ice Harbor to upstream spawning grounds ranged from about 54 to 77 percent, which is comparable to 46 to 55 percent from 1960 to 1980 (NMFS, 2000b).

In general, the rate of migration through lower Snake River reservoirs is faster than through comparable rivers (Bjornn et al., 1992, 1993, and 1998). Some reduction in migration rates has been observed for steelhead during periods of minimal flow in reservoirs, but this could have been related to high water temperatures (Bjornn and

Peery, 1992). Results from other studies during minimal flow periods with lower water temperatures showed no observed delays of steelhead.

Temperature

High water temperature can negatively affect migration of adult salmon and steelhead. Water temperatures in excess of 20°C to 21°C (68°F to 70°F) can occur frequently in the Snake River, particularly during the summer months of adult fall chinook salmon and steelhead upstream migrations. This could impede upstream migration or increase mortalities (EPA and NMFS, 1971; Bjornn et al., 1997; Coutant, 1999). Dauble and Mueller (1993) noted that reducing temperature below 72°F (21°C) would reduce the risk to migrating salmon. But, even when temperatures exceed 20°C (68°F), substantial upstream migration still occurs for fall chinook (NMFS 2000 fish passage white paper). Temperatures in excess of 68 to 70°F have occurred both prior to reservoir construction and since they were formed (Chapman et al., 1991). Prior to dam construction on the lower Snake River during the 1952 to 1956 period, daily temperatures in the Snake River below the confluence of the Clearwater exceeded 70°F (21°C) over 5 percent of the time, and 65°F (18°C) over 17 percent of the time (Appendix F, Hydrology/Hydraulics and Sedimentation). However, the timing of high temperatures has changed with late summer temperatures not cooling as rapidly as they did before dams were built the lower Snake River. During low flow years, the delay to cool water temperatures down to about 59°F (15°C) could be as much as 2 weeks later than under pre-dam conditions (Appendix C, Water Quality).

Since dams have been in place, recent additions of cool water releases from Dworshak Dam in the summer have resulted in reduced periods of high temperature in the Snake River reservoirs below the Clearwater River. During the low flow year of 1994, when flow releases from Dworshak equaled about 50 percent or more of the flow in the Snake River, temperatures were reduced by about 11°F (6°C). However, when flow from Dworshak stopped, temperatures exceeded 70°F (21°C). In 1995 and 1997, when flows were higher, the relative effect of lower water temperature releases from Dworshak was reduced to about 5°F (about 3°C) and 2 to 4°F (about 1°C to 2°C) during the moderate and high flow years, respectively. During these years, temperatures in the reservoirs rarely exceeded 70°F (21°C), partly due to Dworshak flow releases, but also due to total flow and air temperature conditions (Appendix C, Water Quality). Cool water releases from Dworshak should benefit adult fall chinook salmon passage through the lower Snake River reservoir to the Snake River mouth. However, temperatures exceeded 68°F in the Snake River upstream of the Lower Granite reservoir during periods in July and August 1998 (Petersen et al., 1999).

Dworshak flow releases will vary from year to year depending on water availability and management direction. The main purpose of these releases has not been completely resolved among management groups with varied opinions about whether to release Dworshak water to just increase flow for juvenile passage or also release flows to reduce temperatures. Some modeled estimates of water temperature suggest that late summer temperatures in the reservoirs may not cool as rapidly as they did in the past (Appendix C, Water Quality). The exact effect of possible shifting of temperature period on adult fall chinook salmon is not clear, but could influence when spawning occurs and ultimately when juveniles emerge from the gravel relative to what occurred historically. Coutant (1999) estimated that current water temperature conditions resulting from reservoirs upstream on the Snake River likely result in early fry emergence when river conditions would be relatively cool. The effect would be delayed growth, development, and migration of juvenile fall Chinook (Appendix M, Annex D). Again, the Snake River fall chinook salmon stock that currently occupies the Snake River could vary from the original native stock in their outmigration behavior in timing in response to decreased water temperatures and flow regulated through Hells Canyon Dam during late spring and early summer (Waples et al., 1991; Appendix M, Annex D).

Dissolved Gas Supersaturation

As with juvenile fish, excessive dissolved gas supersaturation can cause mortalities of adult salmon and steelhead. During periods of high flow in the 1965 to 1970 period (which was before dam modifications were in place to reduce TDG from spill), it was estimated that from 6 to 60 percent of adult salmon died before spawning as a result of TDG supersaturation (Weitkamp and Katz, 1980). During this period, the TDG often noted as causing adverse effects were in excess of 120 percent. However, concentrations considered acceptable by Oregon's or Washington's water quality standards are still less than 110 percent.

Structures in place on dams (spillway flow deflectors) and flow management (upstream storage facilities and increased flow through turbines) have reduced the higher saturation of gas that occurred frequently in the past. State agencies have allowed waivers in water quality standards that allow TDG concentrations to increase to 115 or 120 percent, depending on specifics of timing and location. Still, involuntary spill (i.e., spill exceeding turbine capacity) has resulted in elevated saturation over 120 percent and over 130 percent during recent years. Even with these high TDG supersaturations, signs of adverse effects on adult salmon have been low. For example, in 1997, a high flow year, only 0.1 percent of adult chinook salmon at Lower Granite Dam showed external physical signs of gas bubble disease. However, during June of that year, signs of gas bubble disease were more common in adult sockeye salmon and steelhead at Bonneville Dam. All of the mortality monitoring data show that gas bubble disease incidence and mortality are related to exposure duration and magnitude of TDG in a dose-accumulation fashion (ISAB, 1998). Mortality occurs in the gills, not the fins, and fish can die without any external bubble signs.

Based on observed external signs of gas bubble disease, concentrations of 115 percent to 120 percent do not appear to cause adverse effects to adults (NMFS, 2000b). These are the concentrations currently allowed under the annually granted water quality waivers. Based on current monitoring, it appears that adult spring/summer chinook salmon are not likely to be adversely affected by gas supersaturation even though they are present during periods of potentially high spill in the spring. High TDG could cause delayed stress, resulting in extra expenditure of energy reserved for spawning, an extra mortality effect. Due to this potential mechanism, bioenergetic and radio-tagged studies were funded by the Corps for implementation in Fiscal Year 2000. Adult sockeye salmon and spring migrating steelhead could be more likely to have some adverse effects. Dissolved gas concentrations are unlikely to affect adult fall chinook salmon because they are in the river during periods of high spill at only Ice Harbor instead of all four lower Snake River dams (spill is 24 hours at Ice Harbor through August and subyearling outmigration peaks in July).

Spawning Habitat

Historically, much of the mainstem Columbia and Snake Rivers contained areas of spawning habitat, primarily for fall chinook salmon (Fulton, 1968). Most of the historical fall chinook salmon spawning habitat was lost following dam construction upstream of the lower Snake River dams (mostly from Hells Canyon Dam upstream). The relatively small region of historical fall chinook salmon spawning habitat in the lower Snake River is currently inundated by the lower Snake River reservoirs. The actual historical use of this habitat by spawning fish is unknown. Historic river reconstruction of conditions during 1934 was done by the U.S. Geological Survey, Biological Resources Division (BRD) for the USFWS (Appendix M, Fish and Wildlife Coordination Act Report [FWCAR]) (1999) and Battelle-Pacific Northwest Laboratory (Hanrahan et al., 1999). Based on estimates of suitable physical habitat conditions (e.g., depth, velocity, substrate) developed through a geographical information system (GIS), BRD estimated that 23 percent of the historical river channel had conditions considered usable for spawning. Most of the predicted spawning habitat was below Ice Harbor Dam, and within Ice Harbor and Lower Monumental reservoir areas. The data also indicated that two deep runs (>50 feet deep) located just upriver from the Palouse River in the Lower Monumental reservoir and in Anchor Canyon in the Ice Harbor reservoir could have provided coolwater holding habitat for upstream migrating adults, such as fall chinook salmon and steelhead, during warm periods. An alternate method, based on geomorphic characteristics, estimated that up to about 55 percent of this region may have been suitable for spawning, and that a relatively greater portion of the potential spawning habitat was further upstream in the Little Goose and Lower Granite reservoirs. These estimates could have overestimated the actual spawning habitat used in the lower Snake River because comparisons with the predicted spawning potential of the Hanford reach, based on the geomorphic method are about an order of magnitude greater than the actual area used (Appendix H, Fluvial Geomorphology). Some very limited fall chinook salmon spawning currently occurs in the tailrace areas below Lower Granite and Little Goose Dams and there could be some potential spawning habitat below the other two dams but in less than one percent of the reservoir area (Dauble et al., 1999). Continued operations under Alternative 1—Existing Conditions would allow for maintenance of the limited use of these areas for spawning.

Adult Summary

Overall, under Alternative 1—Existing Conditions, conditions would remain the same as they were in the recent past, with some slight changes. The extent of spawning habitat for adult salmon and steelhead in areas upstream of the four lower Snake River reservoirs would remain the same. Continued efforts would occur at improving adult passage facilities at some of the dams (see Section 3.1). This should allow better conditions for upstream migration. Gas abatement methods would be improved including installation of spillway flow deflectors at Lower Monumental, Little Goose, McNary, and Bonneville Dams to reduce the effects of spill on increasing TDGs. While not directly planned for the benefit of adult fish, some increased frequency or duration of cooler water releases from Dworshak in mid- to late summer could occur. This could benefit upstream migrating fall chinook salmon and steelhead by reducing delays in the Snake River reservoirs, thereby reducing the use of reserve energy stored in fish tissues. This could result in the increased survival of adults migrating to spawning areas.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Many Columbia River basin stocks of anadromous salmonids outside of the Snake River have recently been listed or proposed for listing under the ESA (see Section 4.5, Aquatic Resources). However, because current operations would remain the same under Alternative 1—Existing Conditions, there would be no change in the effects already occurring from the four lower Snake River dams on these non-Snake River basin stocks. The factors (e.g., temperature, transportation, and predation) discussed previously for Snake River stocks would apply as they relate to the relative location of each of these stocks. However, the direct effects of the hydrosystem within the Columbia River are not part of the currently evaluated actions.

Columbia River Stocks Above Bonneville Dam

Potentially affected stocks originate from two geographical areas: 1) Columbia River and tributaries (except the Snake River) above McNary dam, and 2) Columbia River and its tributaries between Bonneville and McNary dams. These stocks primarily include steelhead, sockeye salmon, and chinook salmon. They also include three listed Evolutionary Significant Units (ESUs) involving chinook salmon and steelhead. Stocks originating above McNary would be affected by passage both up and downstream through the lower four Columbia River dams in a similar manner to Snake River stocks that pass these dams. These include similar effects for juveniles from transportation, dam passage, predation, flow and water velocity, dissolved gas supersaturation, temperature, and rearing habitat. Upstream migrating adults would also encounter situations involving potential migration delay at dams, interproject loss of adults, increased exposure to elevated dissolved gas, and potential water temperature problems. Those stocks originating below McNary Dam would be similarly affected, except they would not be affected by juvenile transport and would have fewer dams to pass.

The only factors that could directly affect the non-Snake River stocks under Alternative 1—Existing Conditions are related to potential changes in the flow regime or water quality in the Snake River. Under Alternative 1—Existing Conditions, no changes in either flow or water quality from the Snake River are anticipated. Therefore, effects on non-Snake River stocks would also remain unchanged from current conditions.

Columbia River Stocks Below Bonneville Dam

There are seven Federally listed, proposed, or candidate ESUs primarily originating in the lower Columbia River involving either chinook salmon, chum salmon, coho salmon, steelhead, or coastal cutthroat. There are fewer issues related to project effects for these stocks than there are for non-Snake River stocks originating above Bonneville because hydrosystem operations of the lower Snake River do not directly affect them. The major factors that could indirectly affect these stocks are quantity of flow and water quality (e.g., temperature, gas saturation). As with the non-Snake River stocks above Bonneville Dam, conditions for stocks originating below Bonneville Dam would not change as a result of Alternative 1—Existing Conditions.

Other Anadromous Stocks

American Shad

Populations of American shad undergo fluctuations from year to year, but have remained generally abundant in the Columbia-Snake River System for over a decade. The fluctuations could be somewhat dependent on flow and water temperature, as juveniles rear in the reservoirs prior to outmigrating in the fall. Future considered actions under Alternative 1—Existing Conditions (see Section 2) are not likely to cause changes that would affect the overall populations of American shad.

Pacific Lamprey

Future conditions under Alternative 1—Existing Conditions for Pacific lamprey are unclear, but may not result in significant changes in the overall decreasing trend in abundance. Most spawning and rearing of lamprey currently occurs in tributaries to the mainstem Columbia or Snake Rivers, so project actions are not likely to affect rearing. However, there is concern that passage at dams could be having adverse effects on these stocks (Appendix M, FWCAR). Pacific lamprey juveniles appear to migrate in deeper water and are often found entering turbines near the middle to bottom of the turbine intake (Long, 1968; Close et al., 1995). The survival rate of lamprey through turbines is unknown. Screening systems that are currently in place at most Snake River and Columbia River dams may be unable to divert many of these fish away from turbines because of their deeper orientation. However, lamprey have been occasionally impinged on these screens (Hammond, 1979). The planned installation of deeper STSs or ESBSs in the future under Alternative 1—Existing Conditions could improve passage over current conditions by diverting fish away from turbines, but also could increase the probability of impingement mortality.

The effects of flow or reservoir environments on survival or predation of Pacific lampreys as they migrate downstream are not known. However, their small size and poor swimming ability as juveniles suggest that migration downstream could be primarily correlated with water velocity (Kan, 1975). With higher velocities, migration (associated with increased flows during the spring) could result in shorter migration times. Adult upriver passage effects on Pacific lamprey have been unmeasured until recently. Because lamprey prefer climbing by using their sucker mouths over active swimming through a ladder, research is ongoing on adult salmon ladder modificatioins for facilitating more efficient passage for this species.

5.5.1.2 Alternative 2—Maximum Transport of Juvenile Salmon

The effects under Alternative 2—Maximum Transport of Juvenile Salmon differ only slightly from Alternative 1—Existing Conditions. The major operational changes under Alternative 2—Maximum Transport of Juvenile Salmon that would affect survival of anadromous fish are a near elimination of voluntary spill at Lower Monumental, Little Goose, and Lower Granite Dams. Ice Harbor Dam does not have transport facilities, so spill would continue at this dam during the spring and summer juvenile migration period. This would increase the portion of juvenile fish collected and transported from the Snake River for release below Bonneville Dam. Because the portion of fish that are transported is already moderately high under existing operations, maximum transport would result in a modest increase in that number, and overall effects on Snake River listed stocks also would be expected to be moderate depending on survival of transported fish.

Effects on Juvenile Salmonids

The increase in portion of fish transported for Alternative 2—Maximum Transport of Juvenile Salmon relative to Alternative 1—Existing Conditions, may be as high as the difference between current fish passage efficiency (FPE) and the current portion of fish transported. Current estimates of the portion of fish transported from the Snake River are 54 to 68 percent for hatchery spring/summer chinook salmon, 62 to 75 percent for wild spring/summer chinook salmon, and 63 to 72 percent for hatchery and wild steelhead (NMFS, 1998). Under current operations, estimates of FPE at these dams are 85 percent, 86 percent, and 61 percent at Lower Granite, Little Goose, and Lower Monumental Dams, respectively (Appendix A, Anadromous Fish Modeling). These values indicate the number of fish approaching each dam that do not pass through the turbine (i.e., they either pass through the spillway or are diverted from the turbine by screens and then collected for transportation downstream or released below the dam).

Current operating plans require spill ("voluntary spill") at each of these facilities at certain flows to "spread the risk" by passing some fish downstream through the spillway. Under Alternative 2—Maximum Transport of Juvenile Salmon, voluntary spill would be minimized so that collection and transportation could be maximized. Decreased spill would likely reduce FPEs if fish guidance efficiency (FGE) is held constant because more juvenile fish remain near the surface and are more effectively passed downstream by spill than by diversion using screens. It is estimated that 0 to 20 percent change from existing conditions would occur in the portion of chinook salmon and steelhead transported (Marmorek et al., 1998a).

The primary difference between Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 1—Existing Conditions is that Alternative 2 would increase the benefits and deficits of collection and transport for an additional relatively small portion of spring/summer chinook salmon and steelhead in the Snake River. The benefits of transport include reducing in-river mortality (from dam passage, predation, and early arrival at the estuary). Deficits include such factors as potential increased straying, increased stress, and possibly delayed mortality. Likewise the benefits and deficits of in-river migration would be reduced (see Alternative 1—Existing Conditions). Additionally, the reduction of voluntary spill under Alternative 2—Maximum Transport of Juvenile Salmon could have some benefit because dissolved gas would be reduced in the Snake River and possibly in portions of the Columbia River. This might benefit juvenile salmonids primarily during the spring season. However, since voluntary spill is limited to TDG concentrations not exceeding 115 to 120 percent, and these concentrations have not been shown to cause major problems for salmon or steelhead, this reduction would likely have minor benefits to anadromous stocks. Periodic elevated dissolved gas saturation would continue to an extent dictated by involuntary spill resulting primarily from high natural flows.

Effects on Adult Anadromous Salmon and Steelhead

A reduction in voluntary spill could result in reduced frequency of dissolved gas supersaturation distribution less than 115 to 120 percent and more often less than 110 percent. Lower saturations would reduce the potential for adverse effects to adult fish. High gas concentrations may impair fish swimming ability so a reduction could aid upstream migration rate. Also, high spill sometimes appears to be correlated with "headburns", a condition where open wounds are found on adult fish heads (Elston, 1996). This condition could be reduced if high spill is reduced. The level of spill that causes headburns is unknown, but usually is only common during above-average seasonal spills. However, involuntary spill can still occur, which is the major cause of the high dissolved gas saturations and possibly other effects that are harmful to adult salmonids.

Therefore, the overall effect of dissolved gas and high spill to adult fish is expected to be similar to Alternative 1—Existing Conditions.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Effects on Columbia River anadromous salmonids would be the same as under Alternative 1—Existing Conditions.

Other Anadromous Stocks

Effects on American shad and Pacific lamprey would be the same as under Alternative 1—Existing Conditions.

5.5.1.3 Alternative 3—Major Systems Improvements

NMFS (2000 Biological Opinion), USFWS (Appendix M) and various State agencies and Tribes, including independent reviewers such as Independent Scientific Advisory Board (ISAB), do not currently promote many components of SBC technology or further development and testing at Snake River dams, especially development of additional collection capabilities for smolt transportation. Instead, these entities have concentrated their support toward development of RSW-type systems. The shift of support within surface bypass systems follows the 4 years of prototype testing that has been compared to the NMFS Biological Opinion spill program, and is based upon the following results:

- Low biological benefits in passage improvements adding to survival of any one or all stocks tested, as measured to date;
- The target passage efficiency related to flow volume required based upon Well's Dam is not achievable;
- SBCs on the lower Snake River can not operate or be designed as stand alone systems, but must be hybrids with the existing turbine screen systems;
- The marginal percent passage increased calculated from the best tested gate configuration and assumed component configuration (BGS included) of the

SBC shows that the SBC gains the marginal passage efficiency through robbing FGE from the existing ESBS screening system operation, not from the turbines as expected;

- PATH and CRI indicate that increased collection and transportation of smolts above the 60 to 85 percent that currently occurs does significantly improve the adult salmon return rate (SAR), overall juvenile salmon lifestage survival due to common estuary effects and delayed mortality effects for nontransported and transported smolts, the probability of survival and recovery for any stock, or decrease the probability of extinction; and most influential,

- Dewatering such a large structure to the degree of low facility mortality less than 1 to 2 percent is highly complex, never studied or attempted anywhere, and would require 10 to 20 years of testing and development that would result in eliminating large amounts of funding important to implementing more suitable and timely operational survival measures.

In addition, full SBC complements with SWI, BGS, and other associated componentry would require vast and long-term expenditures of funds that approach the estimated funding required for dam breaching, while offering little certainty of successful increases in passage efficiencies and survival. For the dollar investment, such componentry could only increase juvenile salmonid survival through the hydrosystem lifestage by about 1 percent contributing virtually nothing to lifecycle survival (Appendix A). Other components that may be included with a SBC system are a behavioral guidance system (BGS) to help guide fish to the SBC, and a removable spillway weir (RSW) to allow fish to be passed safely over the spillway without being collected for transport (Appendix E, Existing Systems and Major System Improvements Engineering).

The benefits of a fully operating SBC system might be relatively minor in terms of fish numbers bypassed or collected because the current intake screen systems are already efficient at collecting a high proportion of juvenile fish. The potential benefit of an SBC is that it allows fish to pass the dam without sounding to the turbine intake and immediately being carried up near the surface again by upwelling flows in the gatewell. Rather, juvenile fish are allowed to stay at the level in the water that they prefer when naturally migrating.

Testing of various prototype conditions of SBC systems at Lower Granite Dam has been ongoing from 1996 through 2000. The prototype SBC is only a partial powerhouse model and it was never intended to be a complete bypass structure. It was built to test fish reactions to various flows and entrance configurations to aid in developing a design for a permanent SBC.

Effects on Juvenile Salmonids

Based on results of ESBS tests at Lower Granite and elsewhere, some increase in survival would occur if ESBSs were installed at Lower Monumental and Ice Harbor Dams. This increase would result from the higher percentage of fish that would be diverted away from the turbines. For example, FGE could increase from the current levels of about 60 to 70 percent for yearling chinook salmon to as high as 80 percent with new ESBSs (Marmorek and Peters, 1998a).

The PATH estimated that the number of smolts transported from Lower Granite could be increased by 6 to 13 percent if the SBC system were as effective as the system at Wells Dam on the Columbia River, where 90 percent of the fish are passed through the spillway. While an SBC at Lower Granite is unlikely to reach the stand-alone performance that the Wells Dam system has achieved due to differences in facility configuration and forebay flow characteristics, the performance of a system combining SBC and ESBSs at Lower Granite has, in fact, reached 90 percent. Based on the results from 1998 through 2000 tests and the estimated range of possible configurations that could be used for SBC/BGS systems in conjunction with ESBS, estimated fish passage efficiency (FPE) (i.e., percent of juvenile fish that pass a dam without going through the turbines) could range from 89 to 96 percent for yearling fish, which is an increase of about 7 to 14 percent over current conditions (Appendix E, Existing Systems and Major system Improvements Engineering). The major portion of this percent increase comes from the SBC prototype redirecting fish from the ESBSs, not from the turbine units as desired. The net result of SBC prototype testing as based upon the prototype at Lower Granite Dam is only as good in increasing passage as ESBSs are bad. Currently, ESBS efficiencies are sufficiently high enough at the lower Snake River dams that additional SBC and BGS development would be questionable (ISAB, 2001).

Tests were initially conducted with a prototype, partial powerhouse SBC at Lower Granite in 1996 (Adams and Rondorf, 1999; Johnson et al., 1999; Adams and Rondorf, 1998a and 1998b; Adams et al., 1997). Based on promising initial results, a retest was conducted in 1997. Entrance gates on the SBC were also repaired between the 1996 and 1997 test seasons. Hydraulic and physical modeling, as well as test results from the first two test years, led to three major modifications in 1998. First, the Lower Granite turbine intakes below the SBC were modified to make them more like those of Wells Dam. Second, a behavioral guidance structure (BGS) was added to the SBC (see Chapter 3, Plan Formulation). The BGS is a 1,100-foot-long floating steel "curtain." The BGS was attached to the south end of the SBC and extended upstream and towards the south shore. The purpose of the BGS was to divert fish away from the south half of the powerhouse. The third modification in 1998 was the addition of an entrance near the confluence of the BGS and SBC. It was thought that fish would concentrate in this area. In 1999, the configuration of the two SBC entrances was modified to improve collection of fish that approach the structure. Based on results of these initial tests, in 2000, the entrance nearest the BGS was again modified and tested at different opening configurations and turbine flows that were believed to influence collection efficiency.

The BGS showed the ability to divert 78 percent of the fish away from Units 1-3 in 1998, although the ultimate passage fate of the smolts remained the same, the same proportion was diverted through ESBS, turbine passage proportion was not changed, nor was attraction to SBC as desired. SBC passage in 1998 was substantially improved from previous years, most likely as a result of structural modifications. Hydroacoustics determined that approximately 51 percent of all fish species passing through Units 4-6 or the SBC went through the SBC (Johnson et al., 1999). However, efficiency of collection, that is the proportion of fish actually collected in the SBC, was reduced relative to previous tests, which lead to modifications and tests in 1999 and 2000 (Corps, 2000).

Radiotelemetry provided species-specific passage information. Of the radio-tagged fish passing through either Units 4-6 or the SBC, 29 percent of yearling chinook salmon, 49 percent of hatchery steelhead, 28 percent of wild steelhead, and 54 percent of subyearling chinook salmon used the SBC in 1998 (Adams and Rondorf, 1998a,b). Following the modifications in 1999 and 2000, results differed in 2000 for the same units; units 4-6 had SBC efficiencies of 53 percent, 31 percent, and 43 percent for yearling chinook, hatchery steelhead, and wild steelhead, respectively (Plumb et al., 2000). The prototype SBC has a relatively high effectiveness at diverting fish for the amount of water required to operate the facility. Even so, the prototype SBC effectiveness has not been able to approach Well's Dam effectiveness. Typically, spill effectiveness is assumed to be slightly over 1 (percentage of fish passing over spillway is a little more than the percentage of water over the spillway). SBC effectiveness at Lower Granite was calculated at 7.1 in 1998, equivalent to passing 42 percent of the fish at about 6 percent of the flow (Johnson et al., 1999; although, the comparable Well's Dam effectiveness is calculated at greater than 18.0 equivalent to passing over 90 percent of the fish at less than 5 percent of the flow). The spill effectiveness was lower in 2000 with a value of 1.8 based on radiotagged fish and a value of 2.3 based on hydroacoustics (Plumb et al., 2000; Corps, 2000). While these values represent a fairly effective use of water for fish passage, the Lower Granite SBC prototype does not reach the performance of the surface bypass at Wells Dam, where approximately 90 percent of the fish pass in only 7 percent of the water (Johnson et al., 1992).

The combination of the prototype SBC and ESBSs that have been installed at Lower Granite Dam have marginally improved the efficiency of diverting fish away from passage through the turbines. Results were variable among the major test years (1998-2000), between species, and between radiotagging and hydroacoustic tests. The fish guidance efficiency of the ESBSs in areas with the SBC (at turbine intakes directly under the SBC) was estimated to be about 82 percent for yearling fish (Appendix E, Existing Systems and Major System Improvements Engineering).

Depending on final SBC/ESBS/BGS configuration, estimates of yearling juvenile chinook passage survival at Lower Granite Dam during non-spill periods would range from about 97.6 percent with ESBSs only to 99.1 percent for the most efficient SBC/BGS structures in combination with ESBSs (Appendix E, Existing Systems and Major System Improvements Engineering). Similar survival could occur at other lower Snake River facilities if similar structures were installed.

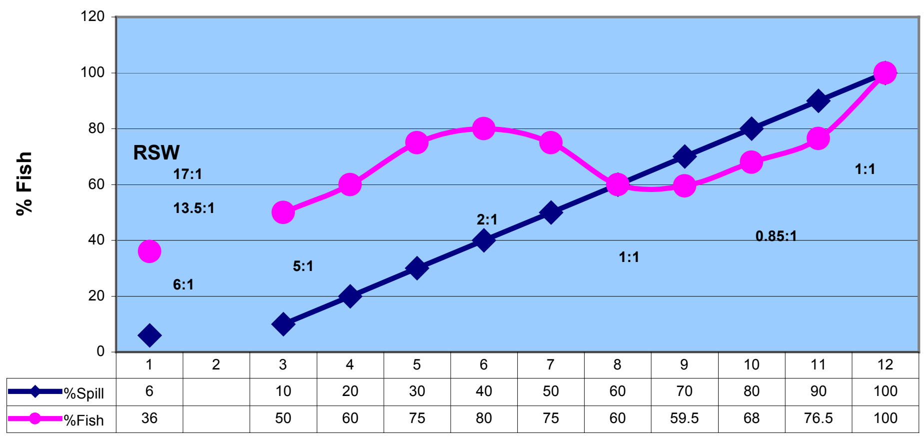
Passage survival could decrease with the dewatering required by adding the collection component to the SBC. Federal and State agencies do not support collection. They support surface bypass only on the premise that they believe dewatering cannot be developed in the near term, and that additionally collected smolts would not significantly increase survival.

A potential benefit of SBCs could be reduced time spent in the forebay by migrating juveniles, which often appear to mill around in this area or move back upstream before passing downstream. However, among alternative passage routes (e.g., turbine, spillway, SBC), the residence time of fish in the forebay does not appear to have been reduced for fish using the SBC over the other routes (Adams and Rondorf, 1998a,b; Plumb et al., 2000). Studies have shown that a residence time in the forebay is short for all routes, typically less than 4 to 6 hours for most fish. This may be because all of the SBC test years have had relatively high flows. A larger benefit in reduced residence time may occur in low flow years. The presence of the BGS also appears to reduce residence time. In 1998, the forebay residence times of all test fish were shortest when the BGS was in the deployed position (Adams and Rondorf, 1999).

Snake River salmonid management under NMFS Biological Opinion operations for ESA stock survival and recovery will always require some volume of spill to ensure hydraulic entrainment of every single smolt because it will be impossible to divert every single smolt away from all possible routes that do not ensure 100 percent survival. Given this reality, voluntary spill for fish passage will never be totally eliminated, but can be optimized to balance water quality needs with fish passage needs. Dissolved gas concentrations could be greatly reduced by the use of SBC systems or surface-oriented spillway weir systems (Spillway Weir with the Removable component or a permanent installation without the Removable component since the spillway capacity at any one lower Snake River dam is over twice the calculated threshold flood flow volume or the recorded historical maximum flood flow volume). It may alleviate the need for large amounts of spill to achieve a high FPE at a project, thereby greatly reducing the amount of voluntary spill and associated high dissolved gas concentrations. Rearing and migratory habitat conditions would be similar to Alternative 1—Existing Conditions.

Given the desire of design engineers and hydropower managers to pass the maximum amount of juvenile salmonids with the minimal amount of spill and maximum amount of survival for all stocks, Figure 5.5-2 illustrates the relationship of spill effectiveness estimates for Biological Opinion operation spill measured during 1996 and 1997 at Ice Harbor, Lower Monumental, and Lower Granite Dams to what the RSW would have to produce (total river flow stayed near 100 kcfs). One would achieve the currently used estimate in models of 1:1 at 100 percent spill and 60 percent spill, both exceeding the state water quality criteria at 110 percent TDG. Of course, only 100 percent spill gives 100 percent fish passing via the spillway. Between 60 and 100 percent spill, spill effectiveness is below 1:1, even though the percent of fish remains above 60 percent. The percent of fish passing via the spillway and spill effectiveness increase below 60 percent spill where the percent of fish passing via the spillway is maximized at 80 percent with 40 percent spill, a 2:1 spill effectiveness. Figure 5.5-2 illustrates that spill can be optimized, but the maximum percent of fish passing via the spillway does not occur simply because the spill effectiveness ratio increases, even though the spill effectiveness increases as the percent of spill decreases. For example, a 5:1 spill effectiveness at 10 percent spill results in 50 percent fish passed via the spillway, where a 2:1 spill effectiveness at 40 percent spill results in 80 percent of fish passed via the spillway, and the calculated spill effectiveness of 6:1 for pre-RSW testing using only 6 kcfs (or 6 percent spill) would result in only 36 percent of the fish passing the spillway (i.e., RSW). In order for the RSW to outperform the most optimum conventional spill that balances fish passage with water quality production of less than 110 percent TDG (40 percent spill with 80 percent fish for a spill effectiveness of 2:1), the RSW would have to achieve a spill effectiveness of 13.5:1. Assuming that the assumed spill effectiveness of 6:1 for the RSW is realistic (the RSW has not been tested to date), then in order for the RSW to achieve the Well's Dam spill effectiveness equivalent, one of the following concepts must be proven: 1) the design of the RSW would have to modified to achieve a spill effectiveness of greater than 16:1 if spill flows to remain at 6 percent of 100 kcfs total river flow, or 2) three RSWs would have to be installed at each dam, raising the percent of spill up to 18 percent instead of 6 percent.

Dissolved gas concentrations could be greatly reduced by the use of SBCs. It may alleviate the need for large amounts of spill to achieve a high FPE at a project, thereby greatly reducing the amount of voluntary spill and associated high dissolved gas concentrations. Rearing and migratory habitat conditions would be similar to Alternative 1—Existing Conditions.



Source: Table D-4, pages D-17-19 in NMFS 2000, Appendix D

Figure 5.5-2 Spill Effectiveness (Empirically Estimated Curve from Ice Harbor Reservoir, Lower Monumental, and Lower Granite PIT-tag Hydroacoustic, and Radio-tag Studies)

In summary, the overall effect of Alternative 3—Major System Improvements on survival of juvenile salmonids is likely to be increased over Alternative 1—Existing Conditions. While the number of additional fish potentially collected and transported compared to Alternative 1—Existing Conditions is not large, it could prove to be an added benefit over in-river passage during low flow years. The assumptions about benefits of transport versus in-river passage are discussed under Alternative 1—Existing Conditions and in Section 5.5.1.5, Model Analysis of All Alternatives. The as-yet-unknown stress-reducing benefits of SBC technology may also make surface collection a much more viable route of passage.

Effects on Adult Anadromous Salmon and Steelhead

Under Alternative 3—Major System Improvements, there could be a slight benefit to upstream migrating adult salmon and steelhead from the ESBS improvements and additions, and the installation of a SBC compared to Alternative 1—Existing Conditions. These facilities could reduce the frequency of fish that fall back through turbines. The relative loss of adults through turbine passage at Lower Granite is unknown, but considering that most fish do not fall back (about 93 to 97 percent), and that most fallbacks successfully ascend the fish ladder a second time (Bjornn et al., 1998), it is likely that the current number that are lost as a result of passage through turbines is low. Therefore, any reduction in losses by keeping fish from passing through turbines with major system improvements is likely to be minor relative to Alternative 1—Existing Conditions.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Effects to Columbia River anadromous salmonids would not be changed markedly from Alternative 1—Existing Conditions.

Other Anadromous Stocks

American Shad

If the ESBS improvements and additions and the new SBC were to be operated into the fall season, they could benefit downstream migrating juvenile American shad by reducing their passage through turbines and providing additional shelter areas with low flow velocities within the SBC. Additional sheltered shad in structures such as SBCs would act to impede or partially block juvenile salmon passage much like shad do to adults in ladders. Because this stock is not native, it may compete for resources with listed stocks, so any gain in this stock may be detrimental to listed stocks. It is anticipated that these facilities would be operated during most of this period. This alternative would be beneficial to Snake River American shad individuals compared to existing conditions. However, the populations of shad have remained strong in the Columbia River System under existing conditions. The total run of American shad into the Snake River is a small portion (likely less than 10 percent) of the total Columbia River runs. Therefore, any major system improvements in the lower Snake River, although they may benefit some individuals, would have insignificant effects on the overall population.

Pacific Lamprey

Some benefit could occur for downstream migrating Pacific lamprey, if they were successfully diverted with the SBC and/or the ESBSs instead of passing through turbines. However, this species appears to migrate in deeper water and would not likely encounter the SBC. Also, this species could become impinged on screens in the bypass systems. This could occur with ESBSs that would be installed at Lower Monumental and Ice Harbor and with screens needed to separate water from fish at the SBC. Overall, the net benefit, if any, of Alternative 3—Major System Improvements over Alternative 1—Existing Conditions can not be determined for Pacific lamprey.

5.5.1.4 Alternative 4—Dam Breaching

Alternative 4—Dam Breaching would eventually change what is currently a series of four reservoirs on the lower Snake River stretching over 140 miles to a river environment more closely approaching what is considered near-natural conditions. The process, however, would not be instantaneous and would require several years (estimated to be 5 to 10 years) before major changes in the environment are stabilized. The dam breaching and drawdown process would have some significant adverse effects to anadromous stocks destined for the Snake River in the short term. For example, short-term effects would continue for several years as the sediment that has been trapped behind the four dams is moved downstream through natural and regulated hydrologic processes and as other physical changes stabilize.

Part of this alternative would include actions intended to minimize detrimental short-term impacts through methods of decommissioning, timing of actions, and additional mitigation (see Section 3 and Appendix D, Natural River Drawdown Engineering). Once the environment has stabilized, the long-term effects from this alternative should be beneficial to most Snake River anadromous stocks, although the relative overall gains have many uncertainties (see Section 5.5.1.5, Model Analysis of All Alternatives). Because short- and long-term effects are quite different, the following discussion presents these effects separately.

Short-term Effects

A brief summary of dam breaching methods to be used is needed to help understand where and what types of effects could occur (see Appendix D, Natural River Drawdown Engineering). The general schedule for dam breaching is expected to cover 8 or 9 years, with the drawdown and removal of two dams occurring in each of 2 consecutive years beginning year 5 or 6. To minimize effects to migrating anadromous fish, construction activities that could potentially affect ESA listed fish would be scheduled to occur between August and December each year.

Most juvenile and adult salmon and steelhead outmigrate or inmigrate from spring through mid-summer (April into August). However, the period of major dam-breaching activities still overlaps with the major migration period of adult fall chinook salmon and steelhead and some juvenile chinook. While the period of lowest numbers of migrating anadromous fish is January to March, the risk of high flows during this period, which could have catastrophic effects on the removal process, precludes scheduling removal at this time and was the reason the fall removal was selected. The risk of harm to migrating fish is likely greater if removal did not begin until mid-December from the risk of massive uncontrolled bank erosion if a high flow event were to occur during removal (see Appendix D, Natural River Drawdown Engineering).

In the breached dam area, river flow would be directed through a fairly narrow opening where water velocity could be much higher than it is in most of the river. Also, post drawdown, stabilizing riprap would be placed along about 25 percent (70 miles of a 280-mile shoreline) of what would be the future shoreline (Appendix D, Natural River Drawdown Engineering), thus altering shoreline characteristics. Following breaching, much of the accumulated sediment behind each dam, with the most behind Lower Granite (about 65 percent), would move downstream as suspended sediment and bedload like a long dynamic wave, depending on sediment size fractions (see Section 5.3, Water Resources). Eventually, it is expected that most of the new unimpounded river reach would consist of cobble/gravel substrate interspersed with sections of bedrock/cobble and gravel/sand. High flows (often over 140 kcfs) would be required to remove imbedded sediment and return the riverbed to its original substrate composition. However, most of the accumulated sediment in the river channel, particularly fine sediment, would be eroded from the former reservoirs about 2 to 5 years after the last dam is removed, although coarser sediment would take longer (Figure 9-4, Appendix H, Fluvial Geomorphology). Within 5 years after the last dam is removed, suspended sediment concentrations would likely return to background levels (Appendix F, Hydrology/Hydraulics and Sedimentation). Channel equilibrium, however, would not be achieved for about 5 to 10 years after breaching (Appendix H, Fluvial Geomorphology) with some areas in the lower Snake River retaining sediment for up to 10 years (Hanrahan et al., 1999). It is expected that much of the sediment would deposit in McNary reservoir over a 5 year period following dam breaching. This would be a change in the 140 miles of the lower Snake River from sediment rich reservoirs to a sediment deprived river.

Suspended Sediment Effects

Suspended sediment resulting from dam breaching could have adverse effects on all aquatic organisms present in-river, particularly during the first 5 year period. Most recent estimates (based on models and re-estimates of total sediment) suggest peak suspended sediment concentrations would increase downstream through the reach with lowest peaks in Lower Granite of 3,600 and highest of 9,000 milligrams per liter (mg/l) in the vicinity of Ice Harbor Dam (Foster Wheeler Environmental, 1999a).

Other than the initial values noted, it is not possible to estimate the suspended sediment concentration and duration of concentration during removal and the years following. However, it is known that concentrations of suspended sediment would be highest during the drawdown of the reservoirs when high flows occur, at least for the first year following drawdown (Appendix H, Fluvial Geomorphology and Appendix C, Water Quality). This would mean that concentrations would be very high beginning in August of the first year (when drawdown begins) and continue at a high level into the fall, and then be reduced in the winter. When spring flows increase there would be a spike then decrease in the summer until the second two dams are removed (August the second year), and then increase again to very high concentrations. The same cycle would repeat until the next summer when concentrations would be high for short time periods following rain events.

Alabaster and Lloyd (1982) reviewed the effects of sediment on fish and concluded there was ample evidence that concentrations of 200 to several thousand mg/l might cause deaths to fish exposed for several weeks or months. For short-term exposure (usually less than 6 days), concentrations in excess of 3,000 mg/l might cause some death of salmon and trout (Newcombe and Jensen, 1996; Newcombe and MacDonald, 1991; Alabaster and Lloyd, 1982; Servizi and Martens, 1987). Lloyd (1987) found concentrations less than 80 to 100 mg/l for extended periods were moderately tolerated by salmon and trout. Some feeding rate reduction has been observed for coho salmon at concentrations of 25 mg/l (Noggle, 1978). Newcomb and Jensen (1996) noted mortality of sac-fry stage at suspended sediment concentrations as low as 20 mg/l when exposed for 4 days. Generally, aquatic insects and younger salmonids are more sensitive to suspended sediment than adult salmon or trout (Newcombe and MacDonald, 1991; Newcombe and Jensen, 1996).

Newcombe and Jensen (1996) reviewed hundreds of published studies concerning suspended sediment and developed predictions on types and severity of effects to salmonids based on concentration and duration of sediment exposure. The authors used this information to develop models to predict the effects of suspended sediment to various species and life stages as to the type and level of effect. A summary of some of the estimates of effects to salmon and steelhead are shown in Table 5.5-3. The results of the modeling are dependent on both concentration and duration. As can be seen in the table, even relatively low concentrations (e.g., 4 to 60 mg/l) can have adverse effects (e.g., moderate physiological stress) based on this model. The authors found that concentrations as low as 20 to 50 mg/l for periods of 2 to 7 weeks would reduce feeding success and result in poor condition and major physiological stress (not shown on Table 5.5-3). But direct mortality would typically require suspended sediment concentrations in the thousands of mg/l for extended periods. However, adverse effects to growth could occur with sustained levels in the tens or hundreds of milligrams per liter. It must be remembered that empirical data are not available to corroborate all of the data in the model, even though there are good overall correlations. For example, only two sources were available for adult salmon migration, with the actual values reported as having adverse effects at 350 to 650 mg/l, which was for volcanic ash studies. Therefore, predictions based on this model should be viewed cautiously.

Although predictions are not available for drawdown suspended sediment concentrations over extended periods, it is reasonable to expect that values in the range of 20 to 50 mg/l for extended periods would be common during at least the first 3 years following initial drawdown and removal. Higher levels, as predicted earlier, at several thousands of mg/l, would occasionally be expected, especially during initial drawdown

Table 5.5-3. Modeled Effects of Suspended Sediment (in mg/l) on Salmon and Steelhead Based on Newcombe and Jensen (1996)

Continuous Duration of Concentration	Moderate Physiological Stress (mg/l)	Inhibited Migration of Adults (mg/l)	Reduced Growth of Juveniles (mg/l)	0-20% Direct Mortality (mg/l)	20-40% Direct Mortality (mg/l)	40-60% Direct Mortality (mg/l)
1 day	60	150	4,500	13,000	55,000	200,000
1 week	12	45	700	2,700	10,000	40,000
2 weeks	7	30	350	1,500	6,000	23,000
1 month	4	20	170	800	3,000	12,000

Source: Newcombe and Jensen (1996)

of the reservoirs (two separate events), and each following spring with high flows. Based on the Newcombe and Jensen (1996) model, if the peak concentrations indicated (3,000 to 9,000 mg/l) were maintained for a week, some direct fish mortalities would occur. These high concentrations would be expected to occur primarily during the drawdown period (August to December) when an estimated 50 percent of the annual adult fall Chinook and 20 to 30 percent of steelhead would pass into the lower Snake River. High concentrations during the second year would also be possible during high runoff in the spring (April to June) when an estimated 80 to 90 percent of juvenile spring/summer chinook and sockeye salmon, 30 to 40 percent of juvenile fall chinook, 60 to 80 percent of juvenile steelhead, and > 90 percent of adult spring/summer chinook salmon pass into the lower Snake River. These concentrations would be most likely during the first 2 years or drawdown and the following year.

While suspended sediment would have general effects on overall survival, other factors in the short term would affect conditions for both juveniles and adults. The following sections summarize these effects, including additional effects of sediment as they relate to specific issues for juvenile and adult salmonids.

Effects on Juvenile Salmonids

In the short term, some beneficial effects could aid survival of juvenile salmonids; for example, faster migration rates and elimination of mortalities associated with dam passage. In addition, increased sediment and turbidity could provide more favorable cover from predation. Several negative factors would also affect juvenile fish, including direct effects of suspended sediment, no smolt transport by barge, reduced habitat quality, and decreased food supply.

Flow and Water Velocity

With dam breaching, increased water velocities in the lower Snake River would result in a faster migration rate of all juvenile salmonids through this reach up to six-fold in any one flow year (Wik et al., 1993). The increase would likely vary somewhat from the long-term conditions because other factors such as turbidity, food supply, and relative changes in hydrology within the reach as sediment stabilizes could influence migration rate. The possible overall effects of the physical changes on migration rates are discussed in the Long-term Effects section.

Dam Passage and Transportation

While juvenile spring/summer chinook salmon and steelhead would migrate out of the Columbia River System prior to the beginning of scheduled drawdown and removal periods (August to December), some subyearling fall chinook salmon and sockeye salmon would still be outmigrating during these operations. The changes in dam passage conditions during the removal period could adversely affect these stocks.

The dams would be in a state of transition from full pool to river conditions, and normal operations for passage of fish at these facilities would not be possible. Turbines would operate at less than maximum efficiency, spill conditions would be altered, and transportation of fish would not be possible from the facilities being removed. All of these conditions could significantly increase mortality of fall chinook salmon and, to a lesser extent sockeye salmon outmigrating during the 2-year removal period. Loss of transportation would also increase direct mortality of fish of all stocks not transported, although the apparent effects on indirect mortality (i.e., "delayed transport mortality") would be reduced. See Section 5.5.1.1, Alternative 1—Existing Conditions and Section 5.5.1.5, Model Analysis of All Alternatives, for discussion of transportation effects.

Dissolved Gas Supersaturation and Sediment Contamination

TDG could reach adverse saturation and distribution normally in the spring, under current conditions from spill through dams. Therefore, potential adverse effects of supersaturated gas would be reduced in the Snake River without the dams. This is discussed in more detail under Long-term Effects.

Initial evaluation of potential contaminants in reservoir sediments (e.g., metals, miscellaneous organics, pesticides) predicted that four Chemicals of Concern (total DDT, dioxin TEQ, manganese, and ammonia) relating to aquatic organisms may be elevated following sediment movement (Foster Wheeler Environmental, 1999a; Appendix C, Water Quality). Study results indicated that dioxin, which can be highly toxic, was found in the sediment behind Lower Granite Dam. While the primary exposure route to anadromous salmonids may be through bioaccumulation from eating resident fish (which would rarely occur) and direct sediment contact, the concentrations in the sediment were well below those considered to cause direct harm to salmonid life stages (Appendix C, Water Quality).

Total DDT, which was detected in sediment behind each dam, was estimated to reach chronic effect concentrations only during the first year after breaching of Lower Granite Dam and remain below chronic effect concentrations in all remaining areas and time periods. This compound has the potential to bioaccumulate in larger predatory fish that are resident to the locale, which would not likely include anadromous stocks in the lower Snake River.

Manganese is present in each of the four pools of the lower Snake River. The literature suggests that excessive dissolved manganese is only a concern for commercial and domestic water supplies. With the exception of the lower Snake River, most natural waters are usually well below 1,000 μg/l (Thurston et al., 1979). Actual toxicity of manganese to aquatic life is not well documented. However, some documentation exists suggesting that the 1997 eluatriate may be tolerated by most freshwater organisms (McKee and Wolf, 1963). Morgan (1967) described how different compounds of manganese use differing concentrations of oxygen based on the alkalinity (measured by NaOH). Because of the short term and quantity of manganese released, it is likely that there would be a very minor localized effect of lower dissolved oxygen in the immediate area. Morgan (1967) showed there was a rapid consumption of oxygen within 10 to 20 minutes followed by an extended period of very slow oxygen uptake. This demonstrates the potential for anaerobic sediment, suddenly released in the alkaline water column with manganeous salts, to rapidly scrub dissolved oxygen in the solids suspension. While the manganese has no direct effect on the environment, the loss of dissolved oxygen does provide a potential secondary effect.

There are 210 dioxin and furan congeners. Seventeen of these congeners are toxic. Dioxin TEQ refers to the mathematical operation of converting the toxicity of a congener to the toxicity of tetrachlorinated dibenzo dioxins (TCDD). There are 75 different TCDD congeners, or forms, of which 2,3,7,8-TCDD (commonly referred to as dioxin) is the most toxic and widely studied. Tetrachlorinated dibenzo furans (TCDFs) are chemically similar to TCDDs and occur in 135 forms.

TCDD and TCDF are persistent toxic substances that enter the environment as unintended byproducts of several industrial processes. They represent a hazard to aquatic life and human health because of their toxicity at low levels, persistence, and bioaccumulation factors (NRCC, 1981, and Eisler, 1986). The most significant sources are pulp mills, municipal waste incinerators, and fires involving polychlorinated biphenyl (PCB)-contaminated oil (EPA, 1987; Palmer et al., 1988). Other potential sources of deposition include open burning of household waste in barrels (Lemieux et al., 2000). The U.S. Environmental Protection Agency (1993) considers dioxin-like compounds to be carcinogens.

Potential impacts of disturbing sediment containing TCDDs and TCDFs are expected to be minimal. As indicated in the text above, concentrations of TCDDs and TCDFs primarily occur above Lower Granite Dam. Sampling conducted in 1999 (CH2M HILL, 2000) above and below Lower Granite Dam resulted in “no detect” or “below detection limits” for 2378-TCDD and 2378-TCDF.

Ammonia was common in sediment behind all dams, primarily because it is a compound naturally developed through decay of organic matter in low oxygen environments. Its toxicity to fish is dependent on water temperature and pH. Based on the expected temperature and pH values, ammonia may barely reach chronic concentrations in the region of the Ice Harbor and Lower Granite reservoirs in the warmest portion of the summers during initial drawdown (i.e., year one and possibly 2 for Lower Granite and year 2 and possibly 3 in Ice Harbor). During cooler periods in the winter and spring ammonia concentrations would remain at acceptable levels. The overall effects of release of chemicals from the sediment with dam breachings appear to add some risk to migratory and rearing salmon and steelhead, but this risk appears to be minor. Should this alternative be selected, additional sampling should occur and monitoring would be conducted during removal to help manage this risk (Appendix C, Water Quality).

Predation

Drawdown would affect factors that likely both increase and decrease predation rates in the short term. Initial drawdown would likely increase predator density as the populations currently present in the reservoirs would initially be concentrated in a much smaller surface area and water volume. This could increase the predation rate on migrating fish. However, increased turbidity during drawdown would reduce the efficiency of predators attempting to capture juvenile salmonids. Gregory and Levings (1998) examined predation rates in clear and turbid river systems in British Columbia. They found that predation with turbidity in the range of 27 to 108 nephelometric turbidity units (NTUs) during the spring was greatly reduced compared to turbidity of less than 1 NTU. Currently, turbidity in the Snake River reservoirs during the spring season ranges from about 10 to 30 NTUs. During periods of lower flow, it is in the range of 5 to 10 NTUs (see Appendix C, Water Quality; Corps, 1992). These concentrations would be much higher during the short term following dam breaching, especially during the first 2 to 3 years following dam breaching, which would reduce predation.

The short-term effects of drawdown directly on predator populations within the lower Snake River are not clear. With disturbed conditions, the environment would be worse in some ways for the predators (e.g., disturbed bottom, shoreline, and elevated turbidity) which could reduce their populations and ultimately their success in preying on migrating juvenile salmonids. This is especially important for fall chinook salmon, which appear to suffer high mortality from predation within this reach. However, there appears to be lower predation rates on spring/summer chinook salmon and steelhead within the reservoirs of the lower Snake River dams and therefore, the importance may be much less (Petersen et al., 1999). Predation is discussed in more detail under Long-term Effects.

Changes in water temperature following drawdown could also influence predation. Temperature changes are discussed in more detail under Long-term Effects.

Rearing and Migratory Habitat

Adverse affects from suspended sediment would occur primarily to anadromous fish that rear in the lower Snake River and those that take a long time outmigrating through this reach. Fall chinook not currently rearing in the lower portion of the Snake River may still take several weeks to outmigrate through the lower Snake River, especially during the first year when two reservoirs remain. During this period, subyearling fish are likely to encounter suspended sediment when concentrations may be toxic at peak levels (e.g., 3,000 to 9,000 mg/l). However, these concentrations would be less likely to occur in the summer migration period, except during August to September of the first and second year, during and immediately following drawdown. In the third year, effects would be reduced because migration would likely be faster (no reservoirs present) and the suspended sediment concentrations in the upper two reservoir areas would be lower because most would already have been eroded.

Even though fall chinook would likely suffer the greatest adverse effects from elevated suspended sediment in the short term, other anadromous stocks would also suffer conditions that may cause direct mortality during outmigrations, especially during the first and possibly the second year of activity. Based on recent estimates of travel time (FPC, 2000 and 2001), once the first two reservoirs are drawn down it may take about one to two weeks for yearling chinook, steelhead, coho, and sockeye to migrate downstream from the former Lower Granite reservoir to Ice Harbor Dam. During the April to June period of the first year of drawdown, when these fish primarily outmigrate, concentrations of suspended sediment may be very high at certain times, possibly approaching maximum concentrations (e.g., 3,000 to 9,000 mg/l). Based on the values in Table 5.5-3, fish that spend 1 to 2 weeks passing through this area could suffer between 0 and 40 percent direct mortality if the suspended sediment remain at peak concentrations for the whole period (e.g., 1 week at 2,700 mg/l result in 0 to 20 percent mortality and 2 weeks at 6,000 mg/l result in 20 to 40 percent mortality). During the second spring of drawdown, however, all four dams would be removed so passage time would likely be lower (e.g., less than a week) and the upper two reservoir areas would typically have much lower suspended sediment concentration because most of the fine sediment would already have moved downstream. During the second year, it is therefore likely that very few yearling fish would directly encounter toxic concentrations of suspended sediment (e.g., 2,700 mg/l continuous for a week). However, concentrations would still likely be in the range that could cause other adverse effects such as reduced growth and physiological stress during the 1-week passage period. The short duration of exposure, even to these potentially adverse concentrations, should greatly reduce the impacts starting in the second year and continuing to reduce in following years. However, it is not possible to make detailed predictions of concentrations. For example, rain and high runoff events could result in unpredicted high concentrations of suspended sediment for short periods which may cause direct mortality to portions of the populations of migrating yearling fish.

The short-term effects of turbidity and moving sediment would likely be most detrimental to rearing fall chinook salmon, which is the only stock that spends substantial time (typically 2.5 to 4 months) rearing in the mainstem lower Snake River. Currently, most of this period occurs upstream of lower Snake River reservoirs. Effects of suspended sediment would likely severely limit rearing in the lower Snake River for juvenile fall chinook salmon for at least the first year or two following removal of all dams. However, this long duration of rearing in the Snake River mainstem may not be the normal condition of the original native fall chinook salmon stocks in the Snake River System (Waples et al., 1991). These fish, and possibly some of those still present, may have moved downstream and out of the Snake River in the spring to rear in McNary Reservoir before outmigrating to the ocean at a later date. Nearshore bottom areas that supply a benthic food source to migrating juvenile fish would likely be poor during the first few years following removal. With continual movement of sediment during higher flow, the shallow water and backwater areas that are often used by rearing fish would often have new sediment added, burying benthic food supplies. Also, without reservoirs, pelagic food sources that fall chinook salmon use when available (Curet, 1993) would be absent. In addition, the increased turbidity would greatly reduce primary production by limiting light penetration needed for production of both phytoplankton and attached algae. This would adversely affect the food base of a limited number of invertebrates that would remain in the lower Snake River, particularly during the two drawdown years and year following, and to a lesser extent in following years.

Juvenile fall chinook salmon could also become stranded in pools as the reservoir elevations are reduced. Currently, the plan is to reduce the reservoir elevations 2 feet per day for an 8-week drawdown period. It was found during the test drawdown in 1992 that some 15,000 resident fish (only 11 salmonids) were stranded when the water elevation was reduced 30 feet in March, a time when few migrating salmonids would be expected in the reservoirs (Wik et al., 1993). By August, few spring/summer chinook salmon or steelhead are passing downstream at these reservoirs. However, fall chinook salmon and sockeye salmon continue to outmigrate into November and could be present during drawdown. By mid-summer, fall chinook salmon are rarely found near the shore (Curet, 1993) where potholes for entrapment would occur during drawdown. Therefore, losses from stranding during drawdown would likely be minor.

Effects on Adult Anadromous Salmon and Steelhead

Upstream Passage

Four factors could influence the success of upstream migration during the short term: 1) sediment concentrations, 2) passage around breach and shoreline protection structures, 3) access into tributaries, and 4) water temperatures. Sediment concentrations have the greatest potential for impact during the short term. Upstream migration could be impeded during high suspended sedimentation periods. Highest concentrations of suspended sediment would likely occur during initial drawdown (August to December) during the dam removal period and then again during high flow, typically April through June. This spring increase would reoccur annually for several years after removal, but with decreasing intensity. Brannon et al. (1981) found reduced preference of adult chinook salmon to homing water when concentrations of volcanic ash reached 350 mg/l. Following the eruption of Mount St. Helens, straying of nearly all Toutle River anadromous stocks occurred apparently from sediment in the range of 300 to 75,000 mg/l, although lower concentrations (600 to 18,000 and 28 to 8,700 mg/l) also appeared to result in fish straying (Martin et al., 1984). These effects may not be permanent, however. For example, Schuck and Kurose (1982) reported that even with elevated levels of sediment in the South Fork Toutle following the first and second winter after the eruption, many steelhead ascended the river to spawn.

While Newcombe and Jensen (1996, Table 5.5-3) suggest much lower suspended sediment concentrations may inhibit migration (e.g., less than 150 mg/l), no specific empirical data were cited in this document. Therefore, Newcombe and Jensen's model predictions may be somewhat conservative and the empirical data noted above may be a better indication of concentration levels where significant straying or avoidance may occur.

During late summer and fall of at least the first 2 years of activity (the 2 years of drawdown and dam removal), the high suspended sediment would greatly inhibit or stop most upstream migration into the Snake River (primarily fall chinook and steelhead). This likely would adversely affect the majority of fall chinook and steelhead runs these 2 years. During the two spring periods following each set of dam breachings during high flows, spring chinook, coho, and sockeye salmon would similarly be greatly impeded in upstream migrations. Migration of the summer chinook component would be less affected, but much of this run occurs during high flows in June, when suspended sediment concentrationswould remain high, thus impeding migration for these 2 years. During this 2-year period, many adult fish would likely stray to other areas such as the Hanford reach, Yakima River, or possibly other streams downriver or upriver. However, it is not possible to predict the portion of adults that would still attempt to migrate upstream under high sediment conditions. For example, even though many fish were known to avoid the high concentrations of sediment and migrate to other systems during the fall following the May 1980 eruption of Mt. St. Helens, small numbers of adult fish were found in the Toutle River under very high suspended sediment conditions (typically 1,000 to 10,000 mg/l) (Stober et al., 1981).

Direct mortality from the suspended sediment would likely be limited because most adult salmonids would be expected to avoid regions of high concentrations. However, some adult fish could suffer mortality if in the river for extended migration periods (likely more than 2 weeks) during periods of extended high concentrations (see Table 5.5-3).

One year after the last drawdown period, conditions would be improving but suspended sediment would still be sporadically elevated to concentrations that would impede or stop adult upstream migration particularly for spring migrating stocks (spring/summer chinook, coho, and sockeye). Effects would be reduced by the second year after final drawdown but there would continue to be sporadic periods of migration disruption, possibly for 2 to 5 years following final dam breaching (3 to 6 years from first dam breaching).

Specific actions would be implemented to ensure that fish move upstream during the removal period (see Appendix D, Natural River Drawdown Engineering). The current two-tiered, two-dam removal plan, recommends trap and haul truck transport of adult fish around the construction region. This would likely include collection of adults at Ice Harbor Dam and Little Goose Dam during the respective two-dam removal periods. However, blockage of upstream migration at the dams could occur in the fall/winter period during the years that dams are breached because passage facilities would be inoperable. Blockage could affect those fish that migrate to the Tucannon River, those that return to the Lyons Ferry Hatchery, as well as fish destined for locations upstream of Lower Granite.

Capture and release of adult fish has its own risks. For example, transporting adult fish by truck could result in increased risk of disease, stress, or injury, especially during periods of warm water in August when fish are taken from warmer river water, transported in trucks where water temperatures are cooler (through chilling), and then released again in warmer river water upstream of Lower Granite Dam. This could result in increased mortality. Also, any unmarked fish destined for tributaries to the reservoirs (e.g., Tucannon River) or adults that spawn in tailraces (e.g., fall chinook salmon) would be transported upstream of their natal tributary or mainstem spawning area. Additionally, during some years, the peak daily count of fish may exceed 4,000 fish, which could tax daily available truck transport capacity.

Physical impedance of adult movement past the current dam sites would not likely occur following dam removal (see Long-term Effects). This is because upstream fish movement normally stops at flows of about 170,000 cfs, which can occur on an estimated average of every 5 years. The channel structure within the breach zone at each dam would be designed to regulate water velocities that would not impede upstream fish movement at flows up to 170,000 cfs.

As reservoirs are drawn down, deltas at the tributary mouths could be temporarily impassible. An impassible delta was observed at Alpowa Creek during the 1992 drawdown test (Schuck, 1992) of Lower Granite. However, erosion rates could be rapid as flow increases, especially at larger streams like the Tucannon River. Rapid erosion of a channel would make the tributary more passable.

Restricted access to tributaries could have its greatest effect during early fall (August and September) when tributary flows are at their lowest. This would primarily affect steelhead and fall chinook salmon that enter these streams during the fall. Based on experience from drawdown tests on Lower Granite and the Elwha River, it appears that passage would not likely be a problem on the mainstem Snake River or Clearwater River because the erosion would proceed rapidly, and develop a passable channel (USFWS, 1998a).

Changes in water temperature and dissolved gas could also influence migration success. The likely temperature and dissolved gas effects on migration are discussed under Long-term Effects.

As discussed in the Effects on Juvenile Salmonids, some risk of slight adverse effects may occur to anadromous adult fish from release of ammonia and DDT from the sediment primarily during the first and second year of breaching. However, the overall risk appears small and manageable (see Sediment Contamination under Juvenile subsection; Appendix C, Water Quality).

Spawning and Overwinter Habitat

In the short term, spawning habitat for fall chinook salmon that spawn in tailraces of some lower Snake River dams would be disrupted. From 1993 to 1997, from 1 to 18 redds were observed in the tailrace areas below Lower Granite and Little Goose Dams (Dauble et al., 1999). Other lesser-used spawning areas are present below Lower Monumental and Ice Harbor Dams. These few areas of spawning would likely be lost either from sediment movement, dam breaching activities, or changes in velocities. The spawning fish that utilize these tailwater areas, however, are a very small portion of the total spawning population of fall chinook salmon and insignificant in the amount of suitable spawning habitat that would be restored in the breached state of these tailwater areas.

As sediment and channels begin to stabilize, spawning habitat within the lower Snake River would gradually increase following dam breaching. The fluvial processes of sediment redistribution, channel cutting, and flushing of fines would develop a riverine environment including suitable spawning gravel and cobble, mostly free of excessive fines, after about 5 years (Hanrahan et al., 1999). Some spawning habitat would likely develop sooner, depending on the frequency of flows that are high enough to produce sheer stress forces to deconsolidate and clean cobbles and gravels. These flows can be as low as 140 kcfs (Appendix H, Fluvial Geomorphology). This prediction is based on models developed for dam removal on the Elwha River (USFWS, 1998a) and on actual observations of spawner use in heavily sediment-impacted regions of the South Fork Toutle River a few years after the Mount St. Helens eruption (Lucas, 1985; Lucas and Lock, 1991).

Current model estimates predict possibly 24 or 55 percent of the lower Snake River may ultimately be suitable for fall chinook spawning when the river channel reaches equilibrium with sediment movement (Appendix H, Fluvial Geomorphology). But these model estimates may be optimistic in their assessment of area that would actually be used for spawning. The method that estimated 55 percent spawning area for the lower Snake River when applied to the Hanford Reach estimated 67 percent of the Hanford Reach was suitable for spawning, but measured use was only 5 percent.

For several years prior to reaching equilibrium, the high fine sediment concentrations would reduce spawning success and egg survival in any areas affected. Movement of fine sediments (<0.84 millimeter [mm]) over spawning areas following spawning would further reduce egg survival. High concentrations of fines in spawning areas are known to be highly detrimental to egg survival (Chapman and McLeod, 1987; Diplas and Parker, 1985; Young et al., 1991).

Fall chinook salmon have been found to use new spawning areas as they become available. During the early years after dam breaching is complete, fall chinook salmon from fish produced upstream would likely use some of the developing spawning habitat in the lower river, especially around reformed islands. Much of the fine sediment would not have stabilized in the early years after dam breaching is complete, especially if high flows occur. New areas used for spawning could produce poor survival for a number of years which could result in lower than predicted normal production of fall chinook salmon using these areas.

Adult steelhead could be displaced or lost during at least the 2 years of fall drawdown. Currently, several thousand steelhead overwinter in the lower Snake River reservoirs before completing their migration to upstream tributaries the following spring (a duration of possibly 4 to 6 months). Any fish that overwintered in the river would be at risk of suffering direct mortality and adverse affects (e.g., stress) because they would be subjected to extended periods of moderate to high sediment concentrations, especially during the first 2 to 4 years during and following drawdown. Also, as reservoirs are drawn down, this overwintering habitat may be lost and not available . These overwintering fish could be forced to move up or downstream to find other overwintering habitat and survival of these fish could be reduced. Two to three such deep water areas were present prior to impoundment of the Ice Harbor and Lower Monumental reaches (Appendix H, Fluvial Geomorphology; Appendix M, FWCAR). However, it is more likely that fish would not overwinter in this reach during the short-term post-breach period because of the adverse conditions during periods of high sediment concentrations.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

During dam breaching and several years following, some adverse effects could occur to anadromous stocks in the mainstem Columbia River. The effects would primarily result from elevated suspended sediment and reduced rearing and migratory habitat quality documented in McNary Reservoir (Appendix F, Hydrology/Hydraulics and Sedimentation; Appendix M, FWCAR). Some Columbia River Federally listed species would be affected, such as middle Columbia River steelhead and upper Columbia River spring chinook.

It is predicted that increased suspended sediment concentrations would be highest in the vicinity of Ice Harbor following dam breaching. Concentrations of up to 9,000 mg/l could occur (Foster Wheeler Environmental, 1999a). These concentrations would likely decrease in a shorter timeframe in the Columbia River where flow is typically twice that of the Snake River.

As water enters the McNary reservoir, sediment traveling as bedload and fine suspended sediments would settle out. Peak suspended sediment concentrations would be decreased by settling of sediment behind McNary Dam. Suspended sediment concentrations at McNary Dam are estimated to be about 80 mg/l (Foster Wheeler Environmental, 1999a). The resultant effects would be limited to the McNary reservoir, with some increased turbidity consisting of the finest particles extending downstream to the mouth of the Columbia River. As noted previously, the period of largest effects would be during the first fall seasons (August to December) and the following spring seasons (April to June) after each drawdown.

Juvenile Salmonid Rearing and Migratory Habitat

Short-term effects described for juveniles in the Snake River as a result of increased sediment would be similar for juveniles in the McNary reservoir, but to a much reduced level. Some reduction in habitat quality would occur in the McNary reservoir from burial of substrate by a predicted 50 to 75 million cubic yards which is expected to settle in lower velocity areas, mostly near the mouth of the Snake River (Appendix F, Hydrology/Hydraulics and Sedimentation). This area is typically shallow and provides rearing habitat for primarily subyearling chinook salmon which would include Hanford Reach fall chinook salmon, and, to a lesser extent, Snake River fall chinook salmon and Columbia River summer chinook salmon. Other upriver stocks use the region mainly as a migration corridor and spend little time in the region. The burial of these shallow areas along 5 miles of shoreline of the McNary reservoir with over 3 feet of sediment (Appendix C, Water Quality) would eliminate benthic production during the 2 years of dam breaching and likely for a few years following.

The effects of suspended sediment on juvenile salmonid rearing and migratory habitat would likely be minor, especially below the McNary reservoir. The U.S. Fish and Wildlife Coordination Act Report (Appendix M, FWCAR) predicts that a large proportion of the current backwater and/or shallow water open-sand habitat currently used by rearing fall chinook salmon in McNary reservoir would be converted to wetland habitat due to filling by silt. However, some reduction in predation by fish and birds could occur from elevated turbidity in downstream areas (Gregory and Levings, 1998). These benefits could extend downstream, diminishing at each pool as more fines settle out and turbidity decreases (assuming that turbidity in mainstem waters is lower than water from the Snake River). Any areas of increased turbidity could reduce primary production, which could reduce zooplankton production, a food source for many juvenile salmonids. Other than the area near the mouth of the Snake River, elevated suspended sediment are unlikely to frequently reach concentrations and durations considered directly harmful to fish.

Under Alternative 4—Dam Breaching, reduced TDG in Snake River water entering the Columbia River could be a positive effect for fish in downstream areas. However, mortality from elevated dissolved gas concentrations under normal operations has rarely been documented in recent years. Therefore, overall benefits that might increase survival could be minor except during periods of extremely high flow under a breached condition when lower TDG would reduce the risk of fish developing gas bubble trauma.

Adult Salmonid Upstream Passage

Migration of adults in the Columbia River past the mouth of the Snake River could be delayed for brief periods primarily in the first 2 to 3 years during and following dam breaching. A significant reduction in effects would be expected thereafter. Elevated suspended sediment has been found to cause avoidance of and delay in adults returning to natal streams (Brannon et al., 1981). This could primarily affect upper Columbia River adult summer and fall chinook salmon (those destined to migrate upstream of McNary Dam) from August to December, and to a lesser extent, spring chinook salmon during high runoff in the two spring seasons following dam breaching. Some water temperature changes could occur in the Columbia River, partly due to increased suspended sediment effects (see Long-term Effects).

Summary of Effects to Columbia River Listed Anadromous Fish

In summary, for the other listed or candidate anadromous fish in the Columbia River System (Table 4.5-2 in Section 4.5, Aquatic Resources), short-term potential adverse effects under Alternative 4—Dam Breaching would likely only affect the upper Columbia River Spring Chinook Salmon and Upper Columbia River Steelhead ESUs. Fish from these ESUs would pass by the mouth of the Snake River and could be affected by elevated concentrations of sediment over a range of exposure periods. These effects are expected to be minor because the overall effects of suspended sediments in this portion of the Columbia River, other than habitat burial, would also be minor. Other listed or candidate stocks in the Columbia River are further downstream. For these fish, any effects of sediment would be very minor and possibly beneficial by providing cover from predation during downstream migration of juveniles. Benefits of reduced TDG in water flowing out of the Snake River are likely to have very minor, if any, effects on fish downstream of McNary Dam.

Other Anadromous Stocks

American Shad

Negative effects would likely occur to American shad during the short-term period of dam breaching and channel recovery. This would be a slight benefit to native anadromous fish which may compete for resources with this abundant introduced stock. Shad rear in reservoirs and outmigrate in the fall. Dam breaching would eliminate the reservoirs during much of their rearing and part of their outmigration periods. Habitat quality for shad would be reduced, water velocities would be increased, and suspended sediment could be directly harmful to their survival. The river habitat developed immediately after dam removal, with its elevated suspended sediment and less stable substrate, could be less conducive to shad because they have not been found in high numbers in Columbia River tributaries under similar habitat conditions. However, dam breaching could enhance downstream passage survival (e.g., no turbine mortality) and eliminate structures (e.g., dams) that impede upstream migration.

Pacific Lamprey

Tolerance of lamprey to suspended sediment is not well known, but is likely greater than that of salmonids because their juvenile life stage includes residence in stream sediment. Increased sediment could affect adult migration success, but it is unknown if this would be positive or negative. Also, any juvenile ammocoetes that could have resided in the reservoirs would likely be displaced or lost during drawdown due to erosion of their refuge habitat. Juvenile lamprey are expected to reside primarily in tributaries or rivers and not in reservoirs (BPA et al., 1995). Therefore, losses would be expected to be minor. Outmigration of juvenile lamprey appeared to be lower in 1992 following the drawdown test, suggesting that some individuals could reside in the upper reaches of the reservoir where water is shallower but water velocity is higher. However, Pacific lamprey could benefit in the short term from dam breaching which could enhance downstream survival because salmonid bypass systems at the dams, which Pacific lamprey do not utilize to any great extent, would be non-functional (Hatch and Parker, 1998; Close et al., 1995).

Long-term Effects

Overall, long-term effects of Alternative 4—Dam Breaching are primarily beneficial to most anadromous species destined for the Snake River. The following section presents a qualitative assessment of the long-term effects that could occur under Alternative 4—Dam Breaching and discusses some of the uncertainties within specific issues.

Effects on Juvenile Salmonids

Flow and Water Velocity

The migration rate of juvenile salmonids through the lower Snake River could increase once drawdown is complete. Also, any passage delays presented by reservoirs and dams would be eliminated. Without dams, the water velocity through the whole reach would increase dramatically. For example, at flows of about 120 kcfs, travel time of water through this reach is about 175 hours. This could be shortened to 30 hours if dams were breached. Since the travel time of juvenile migration downstream appears to be related to flow (FPC, 1999), the travel time for yearling fish should be faster under the free-flowing conditions. However, these faster travel times may not apply to subyearling fall chinook salmon because their migration rates through reservoirs are not always correlated with flow (Muir et al., 1998; Giorgi et al., 1997b) in the upper reservoirs where they may still require some rearing before smoltification. Once subyearling fall chinook are sufficiently fit for smoltification, they migrate more actively through lower reservoir and river reaches, where a flow/survival relationship can become positive for certain flow seasons or years (Muir et al, 1998; Muir, 2001; FPC, 2001). The effects of these possible changes in migration rate, if any, on survival are addressed in Section 5.5.1.5, Model Analysis of All Alternatives.

Migration rates in a free-flowing lower Snake River would likely be similar to rates of fish passing through similar areas of the Snake River upstream of Lower Granite. Estimates of migration rates for steelhead in the free-flowing river upstream of Lower Granite are about 2 to 3 miles per hour, while migration rates through Lower Granite Reservoir are about 1 mile per hour (Appendix A, Anadromous Fish Modeling). There also are indications that the migration rate of subyearling chinook salmon could be faster in the portion of the river upstream of Lower Granite reservoir than within the reservoir itself (Appendix A, Anadromous Fish Modeling).

Results of studies by Muir et al. (1998) showed that the migration rate for subyearling chinook salmon was about 2.1 miles per day for fish released 104 miles upstream of Lower Granite, while it was 1.3 miles per day for fish released 65 miles above Lower Granite Dam. This could indicate that fish migrated faster in the free-flowing portion of the river and then slowed through the reservoir. However, this may not be the case because the migration rate through the reservoirs downstream, with no flowing river segments, was much higher—greater than 6 miles per day. Therefore, while some information suggests that the rate of migration for subyearling chinook salmon could be faster with a free-flowing river, and other factors such as temperature, turbidity (Muir et al., 1998; NMFS, 2000b fish passage white paper), stage of development, or size of fish due to more optimal growth conditions during rearing likely plays a greater role in increasing system-wide juvenile survival (Appendix M, FWCAR, Annex D; Beer, 1998).

Recent estimates of survival of fall chinook salmon through the free-flowing reach of river upstream of Lower Granite were quite high for hatchery fall chinook salmon, at 99.9 percent survival per mile. This estimate appears to be greater than survival estimates for passage through the reservoirs (USFWS, 1998a). The USFWS (1998a) concluded that migration rates would likely be much greater without the reservoirs for all anadromous salmonids and that survival would likely be greater under these conditions for subyearling chinook salmon.

Elimination of Dam Passage and Transportation

Under Alternative 4—Dam Breaching, mortality for in-river migrants within the lower Snake River would be reduced substantially (Marmorek and Peters, 1998a). Fish transportation would be eliminated from the lower Snake River with this alternative. Therefore, without transport, overall direct downstream passage mortality (in-river plus transport) would be increased relative to Alternatives 1, 2, and 3 for most stocks.

Passage at each dam adds a mortality rate of about 2 percent for bypass systems, 10 percent for turbines, or 2 percent for spillways. These causes of mortality would no longer exist in the lower Snake River.

The current estimate of direct mortality is 2 percent due to transport. Recently (1994 to 1999), about 64 to 89 percent of juvenile spring/summer chinook salmon and steelhead from the Snake River have been transported, and about 48 percent of Snake River fall chinook salmon have been transported annually (NMFS, 2000a). Without transport, the mortality that results from migrating downstream through the lower Snake River and then through the four lower Columbia River dams would be much higher than the 2 percent direct mortality estimated for transported fish. As discussed in Section 5.5.1.5, Model Analysis of All Alternatives, the question of total mortality of transported fish is dependent on the estimates of how much additional mortality (differential delayed transport mortality) occurs after transported fish have been released compared to fish that are not transported. As stated by NMFS (2000c), this is one of the prime questions that can not be accurately determined with available data.

Dissolved Gas Supersaturation

Dissolved gas concentrations, which often reach 115 to 120 percent and occasionally over 130 percent under current conditions, can be harmful to rearing and migratory juvenile anadromous salmonids. For example, total dissolved gas concentrations during much of the spring and early summer were above 120 percent for about one and a half months in 1996 and 1997 near the mouth of the Snake River, and greater than 125 percent for much of this time. During these periods, signs of gas bubble disease were reported in some migrating fish (FPC, 1999). Over the long term, without the lower Snake River dams, these high concentrations of TDG would not be present in this area. Although some elevated TDG (currently about 108 to 110 percent in Lower Granite reservoir) could occur during spill at upstream dams (e.g., Hells Canyon and Dworshak), the TDG would likely be reduced to near saturation (i.e., 100 percent) in the lower Snake River.

Current saturations are not considered to be causing mortalities. Unfortunately, these estimates cannot be verified at this time. Therefore, some benefits from reduced gas supersaturation would occur for Snake River fish. Little effect would occur to Columbia River fish because the Snake River flow remains along the Oregon side of the river and fish moving upstream pass mostly on the Washington side in areas near the mouth of the Snake River. These benefits would likely be greatest for juvenile migrants that pass through the lower Snake River because of their potential for cumulative exposure to elevated TDG concentrations.

Predation

Over the long term, predation on juvenile migrants, after dam breaching is completed, should be less than under current conditions. However, the exact overall magnitude of change is not well defined. Under current conditions, the primary predators on juveniles in the reservoir areas are northern pikeminnow and smallmouth bass. Predation is often considered highest near the forebay or tailwater of reservoirs. The increased travel time through reservoirs often increases the opportunity for predation in the lower water velocity. During the late summer season of higher water temperatures, predation also increases proportionally in reservoirs and rivers.

Petersen et al. (1999) developed a model that analyzes the potential predation rate in the lower Snake River under near-natural river conditions. Based on studies from the Hanford Reach and the Snake River upstream of Lower Granite, the authors estimated the future populations of pikeminnow and smallmouth bass in both the reservoir and in the lower Snake River under unimpounded river conditions.

Using the EPA estimate of future water temperatures under unimpounded river conditions (Yearsley, 1999), expected prey and predator abundance, and knowledge of feeding habitats and bioenergetics of the two prey species, Petersen et al (1999). estimated the current and future predation rates within the lower Snake River during spring and summer seasons. The spring season represents the period of primary migration of spring/summer chinook salmon and the summer season primarily represents fall chinook salmon and some sockeye salmon migrants. Petersen et al. (1999) then estimated that within the lower Snake River reach, the current northern pikeminnow population would double and smallmouth bass would decrease by 50 percent under unimpounded river conditions.

Under current conditions, consumption of juveniles by predators in the reach during the spring season (April to May) is only 1 percent of the migrating juvenile spring/summer chinook salmon population. In contrast, according to Petersen et al. (1999), estimated predator consumption of summer migrants within reservoirs is high, at 59 percent. The authors predicted that the change to a drawn down river environment would result in a reduction in the rate of predation by 74 percent during the spring season and 83 percent during the summer. The change in predation rate was based on predictions of change in diet, predator population sizes and structure, and temperature (Petersen et al., 1999). Based on these values, the overall reduction in absolute predation rate for spring migrants under flowing river conditions was estimated to be reduced from about 1 percent currently to less than 1 percent after drawdown. The reduction in summer predation rate would be larger, ranging from 59 percent to 10 percent after drawdown for fall chinook salmon and late-migrating sockeye salmon.

If the Petersen et al. (1999) model is correct, the greatest benefit from the change to near-natural river conditions would be for summer migrating fall chinook. Other studies suggest quite different changes in predator populations with dam breaching and changes in temperature (Appendix B, Resident Fish; Appendix C, Water Quality). Changes in existing populations of predators could also alter the predictions, primarily the great reduction of adult northern pikeminnow during the last 10 years, especially in Lower Granite Reservoir, due to the high removal efficiencies in the Sport Reward Program for pikeminnow. For example, Appendix B, Resident Fish presents estimates that the northern pikeminnow population would decrease by half, while smallmouth bass would double under near-natural river conditions reflective of smallmouth bass densities currently found in the unimpounded Snake River above Lower Granite Reservoir. This is the opposite of what is predicted by Petersen et al. (1999). With the estimates provided in Appendix B, Resident Fish, there would likely be much less change in summer predation rates between reservoirs and the drawn down river conditions.

Water temperature greatly influences predation rate. As temperatures increase, predation rates also increase. Predictions of water temperature changes under Alternative 4—Dam Breaching vary considerably depending on which temperature models are used and whether Dworshak water releases are used to cool the river (Appendix C, Water Quality). The EPA RBM-10 model, which predicts average daily temperature, estimates little change in frequency of days over 68°F (20°C) at Ice Harbor Dam with or without dams when no flow was released from Dworshak Dam to cool river conditions. The average degrees over 68°F were nearly the same without dams (range 2.9 to 3.6°F or about 1.6 to 2.0°C) or slightly lower with dams (2.2 to

3.6°F or about 1.2 to 2.0°C) under conditions without Dworshak flow enhancement. The EPA model indicate Dworshak flow releases intended to reduce temperature have a much greater relative effect with dams breached than with dams in place. For example, the number of days exceeding 68°F at Ice Harbor Dam would be noticeably reduced most years with estimated reductions of 35, 27, and 37 percent under high, average, and low flow conditions. However, the average increase over 68°F without dams in place would typically be slightly higher (average less than 1°C higher than with dams). As is indicated by a separate model, MASS2, peak daily temperature would typically be higher with dams breached than with dams in place in the Ice Harbor Dam region (Appendix C, Water Quality). This is because greater daily variation occurs in a more natural river condition. The effect would likely be that late in the day, temperature without dams would be higher than it is now. The overall effect of the higher peak temperature changes was not considered in the model by Petersen et al. (1999), but it may have an influence on overall predation.

Historical records indicate that some of the highest temperature periods in the Snake River occurred prior to construction of the lower Snake River dams (Chapman et al., 1991). However, the most noticeable effect of the Snake River dams on water temperature has not been the magnitude of change. Rather, it has been the timing of the temperature changes (Appendix C, Water Quality). Generally, peak temperatures (usually considered greater than 68°F [20°C]) occurred from mid-July through August prior to construction and operation of the dams. This peak shifted to August through September after dams became operational (Appendix C, Water Quality). Temperature modeling (Appendix C, Water Quality) indicated that during low flow years, water temperature under near-natural or drawn down river conditions would drop in the fall much faster (15 days sooner to 59°F or about 15°C) than under current conditions resulting in less predation. Under high flow conditions, the shift would be much less, about 5 days.

Also as included in recent modeling on juvenile fall chinook throughout their outmigration distribution (since 1995), flow releases from the Dworshak reservoir—primarily for flow augmentation—have contributed to lower temperatures in the Snake River reservoir areas, which likely contribute to decreased predation in the lower Snake River. However, the future release of this water may change because there are various demands for its use (see Adult Anadromous discussion under Alternative 1—Existing Conditions subsection). As shown in the RBM-10 model if additional releases from Dworshak continue under dam breaching, they would likely reduce temperature even more than they do currently. This may reduce predation over current conditions.

The effects of the predicted temperature changes on predation are not completely clear because the overall change in temperature is difficult to determine. While Petersen et al. (1999) predicts changes in predation rate based on the RBM-10 model (Yearsley, 1999), the actual changes could differ depending on flow year and depending on where flow enters the river (i.e., releases from Dworshak or Hells Canyon Dams). In general, however, decreased temperatures during the migration season would tend to decrease predation, but the precise change is uncertain.

Rearing and Migratory Habitat

The newly formed and stabilized 140-mile river environment under Alternative 4—Dam Breaching would be more typical than reservoirs of the habitat used by Columbia River fall chinook salmon for rearing prior to outmigration. The substrate and flow conditions would be more conductive for producing food resources (e.g., benthic insects) commonly consumed in river environments by salmonids. The development of a more complex environment including pools, riffles, runs, and rapids would also likely develop both more diverse and possibly more abundant food resources. The food supply for fish in a near-natural river may increase from greater primary production (Appendix C, Water Quality) and be more typically composed of mayflies, midges, and caddisflies.

Terrestrial insects would also make up a larger portion of the diet as the riparian area develops along the streambanks (Appendix M, FWCAR) and riprap is moved downslope along about 25 percent of the new shoreline. However, this would be a very long-term change because southeast Washington climate and soils are less conducive to extensive riparian coverage along the shoreline of a river the size of the historic Snake River. Caddisflies, a typical flowing water benthic insect taxa eaten by fall chinook salmon, supply a much greater energy source for subyearling fall chinook salmon than *Daphnia*, a zooplankton, which is more typically consumed in the Columbia River reservoir environments (Rondorf et al., 1990). The slight shift in earlier temperature increases under Alternative 4—Dam Breaching in the summer would not likely be of a magnitude to alter migration timing of fall chinook, which are partly dependent on increasing early temperatures for onset of outmigration (Appendix C, Water Quality). Should temperatures remain lower in the summer but within the optimal growth range around 16°C, such as under conditions with continued Dworshak flow releases, survival of fall chinook may increase as conditions would be more conducive to more rapid growth and increased survival (this assumes lower temperatures reduce predation). Dissolved oxygen concentrations, which occasionally are below 8.0 mg/l in the summer in the deeper water areas of reservoirs, are likely to be higher without the dams. This also has the potential to increase growth and condition of fall chinook and other juvenile fish migrating through the lower Snake River. The addition of riprap along about 25 percent of the reconstructed shoreline near breached areas, roads, and railroads could reduce the quality of cover and rearing habitat more intensively used when fall chinook salmon first emerge from the gravel while replacing a substantial proportion of smallmouth bass predator habitat lost during the breaching phase. GIS analysis (Appendix M, FWCAR) indicates only about 42 percent of shoreline that existed in the lower Snake River reach (140 miles) in 1934 met habitat criteria for subyearling rearing that has been developed from studies conducted since 1986 (Bennett et al., 1987-97). However, this forty-two percent of shoreline equates to only 5 percent of the total wetted perimeter area. Overall, it is not possible to predict the effect of the changes in habitat conditions in the lower Snake River from Alternative 4—Dam Breaching on rearing fall chinook, and migration of these and other anadromous stocks.

Effects on Adult Anadromous Salmon and Steelhead

Upstream Passage

The overall upriver migration rate of adult salmonids through the breached lower Snake River is unlikely to change significantly from current rates through the reservoirs. Bjornn et al. (1998) noted that while some delay occurs at dams, fish migrate faster through reservoirs than it is estimated they would have through the pre-dam river. In a natural river system, adult fish on their upstream migration to spawning areas normally stop and go, pausing below rapids and falls, holding in deep water areas such as Anchor Canyon, and cruising through slower pools. Because of this behavior, it is reasonable to expect that fish would take longer to pass through a 30- to 35-mile reach of near-natural river than it would take to pass through a reservoir. Because of this behavior, the authors indicated that the lower Snake River facilities likely have not delayed total net passage time through this reach relative to natural conditions.

The breached areas would not cause delays of upstream fish migration because they would be designed to pass fish at flows up to 170,000 cfs, which is equivalent to a 5 year high flow event. For breached areas where velocities are predicted to be above 5 feet per second (ft/sec), at flows less than 170,000 cfs, concrete resting structures would be installed to assist fish in migrating upstream in steps, like they would in a normal river rapids area. Flows less than 5 ft/sec are not considered to impede movement and require no additional resting structures (Appendix D, Natural River Drawdown Engineering). While velocities in the breach area at flows greater than 170,000 cfs could be in ranges that may impede movement even with structures, upstream migration does not occur during these high flows (Appendix D, Natural River Drawdown Engineering). The high flow periods occur in the spring when spring chinook salmon, sockeye salmon, and some steelhead migrate upstream through the lower Snake River.

Several benefits to passage would occur under Alternative 4—Dam Breaching. Fish would not fall back through turbines or over spillways; fallback could cause injuries or contribute to losses between dams. Additionally, although TDG has not been documented in recent years to cause measured mortalities, saturations have been in excess of standards (110 percent) as allowed through water quality waivers obtained by NMFS from state water quality agencies. Without spill through dams, these saturations would be reduced, which would decrease the chance for adverse effects from dissolved gases, especially during very high flows. PATH (NMFS, 1998) assumed that the current loss of adult spring/summer chinook salmon migrating upstream through the lower Snake River would decrease from the current estimated value of 15 percent to 3 percent if the dams were breached. However, increases in upstream passage survival may not occur or may be much less than predicted once dams are removed. NMFS (1999b) indicated that limited historical data did not show differences between current (all four dams in place) and historical passage survival prior to the construction of the lower Snake River dams. Gains or losses for other adult anadromous stocks have not been estimated by PATH or others.

Temperature

The effects of temperature changes on adult migration following dam breaching are not clear. This is partly because predictions vary among temperature models used and the future uses of Dworshak water for flow augmentation and cooling are unknown (see Predation subsection for more temperature discussion; Appendix C, Water Quality, Yearsley, 1999; Perkins and Richmond, 1999; Normandeau, 1999a). Should Dworshak water not be used to help reduce temperature, average daily river water temperature conditions near Ice Harbor would change little from current conditions (June to August average water temperature only 0.4°F or about 0.2°C lower with dam breaching, Appendix C, Water Quality). The exception may be a more rapid cooling in the fall during low flow years (about 15 days early for temperature to reach 0.4°F or about 15°C), with little change under other flow conditions. This may benefit fall chinook and some steelhead migrants in August and September in these low flow years. However, temperature would be more variable with dams breached, with daily peak temperatures likely warmer and minimums cooler (estimated average daily range about 1.8 to 3.6°F or about 1 to 2°C under breached conditions) than they would be for the same weather conditions with reservoirs in place. Peak daily temperatures near the mouth of the Snake River under these conditions would actually be warmer than under current conditions. The effect of this type of condition on migration of adults is not clear but high temperatures (especially those greater than 70°F or about 21°C) have been found to stop upstream migration. Also, fish subjected to recurrent daily cycles of high temperatures, even with lower temperatures during the same day, may suffer adverse effects (DEQ, 1995). However, the diel variations under breached conditions would provide some relief from high temperatures. Should Dworshak flows be used to cool the river, the number of days in excess of 68°F (20°C) average would be reduced considerably, likely reducing effects of higher temperature on migration of summer chinook, fall chinook, and steelhead. However, even under these conditions, temperature would remain more variable and peak daily temperature under warm climatic conditions would still be higher than under current conditions at Ice Harbor.

Also, under breached conditions, temperature refuges from groundwater seeps (maybe 43 to 46°F or about 6 to 8°C cooler than the river) may be more accessible than under reservoir conditions which could improve upstream passage. However, there is no way to estimate if groundwater seeps would develop in both quantity and quality sufficiently suitable to be of benefit to migrating adults.

Overall, there is likely little improvement in temperature conditions for migrating adults salmon and steelhead with dam breaching without the benefit of Dworshak cooling water releases. The exception would possibly be in low water years when fall temperatures would cool more rapidly, benefiting fall chinook and steelhead. Even with additional water from Dworshak, which would noticeably reduce frequency of high average daily temperatures and possibly improve migrations, some detrimental maximum daily temperatures would persist in excess of current conditions, possibly offsetting some of the benefits of lower average temperature on migration.

Dissolved Gas Supersaturation

Periods of adverse effects of elevated dissolved gas on adults within the lower Snake River reach would be reduced under Alternative 4—Dam Breaching relative to all others. Although some spill from upstream dams could increase gas saturation, it should still result in TDG concentrations of less than 110 percent near the Snake River mouth, even during high flow periods. The lack of spill, and possibly reduced systemwide TDG supersaturation, could increase survival of adults during passage through this reach during high flow years and likely reduce headburn injuries which have been associated with high spillway discharges from dams (Elston, 1996). It should be noted that headburns have not been directly tied to elevated TDG or gas bubble disease signs (Elston, 1996) and may be from contact and abrasion from dam structures. Even with breaching of the four dams on the lower Snake River, fish would still encounter dam structures, elevated TDG concentration, and high spill in the lower Columbia River during high flow years.

Spawning Habitat

As noted earlier, with dam breaching, potential spawning habitat would greatly increase with 24 (habitat model; USFWS, 1999) or 55 (geomorphic model; Battelle and USGS, 1999) percent of the 140-mile reach of the lower Snake River being estimated as suitable for spawning salmon (USFW, 1999; Appendix H, Fluvial Geomorphology) once reservoirs are removed and channel substrate conditions stabilize. However, also as noted earlier, these estimates may be optimistic. For example, the geomorphic model when applied to the Hanford Reach estimated that 67 percent of the Hanford Reach would be suitable spawning habitat, but only 5 percent of the Hanford Reach has actually been used for spawning (Appendix H, Fluvial Geomorphology). The functionality of this habitat would be limited until sediment equilibration/ pseudo-stabilization could occur, which would likely be 10 to 20 years without active periodic manipulation of flow releases greater than 140 to 200 kcfs to scour fines out of gravel/cobbles (Hanrahan et al., 1999). However, spawning in the reach is likely to occur much sooner with nearly all of the fines (which are a major factor inhibiting successful spawning) removed in about 5 to 10 years, with about 80 percent removed in the first 2 years of this period. Fall chinook salmon would be the primary anadromous salmonid using the newly available spawning habitat in the lower Snake River because they are the only anadromous salmon or steelhead species that use large mainstem areas for spawning and rearing. However, the gain in spawning habitat actually functional and available, relative to historic levels, would remain slight. Greater than 90 percent of the historical fall chinook salmon spawning habitat was upstream of Hells Canyon Dam, which remains inaccessible to fall chinook salmon since 1958.

The timeframe for actual use of the new spawning areas cannot be predicted. However, studies from the Hanford Reach, Deschutes River, and portions of the lower Columbia River (near Pierce/Ives Island) indicate that fall chinook salmon would establish in regions where suitable spawning habitat and adjacent suitable rearing habitat are available (USFWS, 1998a). The fish that would use new spawning habitat in the lower Snake River may be those originating from the upper Snake River or Lyons Ferry Hatchery, both of which are considered part of the current Snake River fall chinook salmon ESU. However, stray fall chinook salmon from other regions, and particularly other hatcheries, have been common and often abundant in the past, passing one or more of the lower Snake River dams (Waples et al., 1991; Mendel et al., 1993; Mendel and Milks, 1997; Myers et al., 1998). There is the possibility that these fish may also spawn in the newly developed spawning habitat, which, would be concentrated in the lower two reservoirs areas (Ice Harbor and Lower Monumental) based on the habitat model (Appendix H, Fluvial Gemorphology). The result could be development of fall chinook salmon runs in the Snake River, that are not from the Snake River fall chinook salmon ESU, or possibly the loss of the genetic integrity of the whole Snake River fall chinook salmon ESU.

Water temperature changes in the system under Alternative 4—Dam Breaching would affect both migration into the lower Snake River and the timing of spawning by fall chinook salmon. As previously discussed, it is unclear if summer water temperatures, which at times are currently too warm to permit favorable passage conditions, would change (Appendix C, Water Quality). However, it is likely that late summer and fall water temperatures under Alternative 4—Dam Breaching would decrease more rapidly than under Alternatives 1, 2, or 3. This should benefit upstream migrating fall chinook salmon and steelhead. Releases of cool water from Dworshak during the summer could be used to aid cooling in the lower Snake River, but this is a secondary benefit for enhancement of adult passage. The Technical Management Team process (see Section 1, Introduction) allows for the use of this water for the benefits of adult fall chinook salmon, and some members of the Technical Management Team have regularly requested release of this water in August and early September to improve adult passage. As noted earlier (see Alternative 1—Existing Conditions, Adult–Temperature), the actual allocation of this water has varied demands and may not be used only for this purpose. Particularly in low flow years, cooler fall temperatures that would occur without reservoirs could allow fall chinook salmon spawning to begin sooner than under current conditions.

Effects on Other Columbia River Anadromous Salmonids Including Federally Listed and Candidate Species

Juvenile Salmonid Rearing and Migratory Habitat

Without reservoirs upstream, substrate and fines from the Snake River would move into the Columbia River below the mouth of the Snake River. The primary effect would be to increase turbidity during periods of high flow, such as in the spring. The increased turbidity should remain below concentrations considered harmful for relatively short periods (e.g., 25 mg/l for less than a week) (Newcombe and Jensen, 1996), which would be more typical of what is present upstream of Lower Granite.

Increased turbidity could help reduce fish and bird predation on outmigrating juvenile fish. This would most likely affect spring chinook salmon and steelhead, which are most abundant during high spring flows. These benefits would diminish below McNary Dam, because the fine sediment would settle out.

Increases of sediment in the McNary reservoir could have some adverse effects on local benthic and possibly primary production. These effects include local burial of benthic organisms from sediment movement into the reservoir and reduced light penetration from turbidity. These effects could reduce local food supplies for juveniles, but should result in only minor effects for migrating fish, which only spend a brief period in the McNary reservoir during downstream migration. Reduced TDG concentrations in water leaving the Snake River, which often has been greater than 120 percent in the spring, could decrease effects on migrating juveniles in the McNary reservoir and further downstream. Effects from lower river dams on TDG would remain.

Adult Salmonid Upstream Passage

Under Alternative 4—Dam Breaching, any long-term effects to adult salmon and steelhead in the Columbia River would be minor once equilibration takes place (which could take from 5 to 20 years). Suspended sediment concentrations should not interfere with upstream migration after possibly 1 to 2 years after final dam breaching. Snake River water temperatures could differ from current temperatures, with reservoirs in place, possibly decreasing, at least in the late summer and fall. Any temperature changes in Snake River water would be relatively slight and their effects would be diluted by greater flow in the Columbia River. Therefore, any temperature changes should have no effects or may be slightly positive on adult migration within the Columbia River. Reductions in TDG concentrations could also benefit migrating adult salmon and steelhead, particularly spring and summer chinook salmon and sockeye salmon that use the McNary reservoir and areas downstream.

Summary of Effects to Columbia River Federally Listed Anadromous Salmonids

Of the listed or candidate species within the Columbia River System, exclusive of those from the Snake River, some minor benefits would occur to those fish originating in the upper Columbia, (e.g., upper Columbia River spring chinook salmon, upper Columbia River steelhead). The types of benefits are discussed in the previous section and include possible reductions in predation on juveniles due to increased turbidity, lesser effects of TDG, and possible lower water temperature during adult migration. Effects on listed and candidate fish ESUs in the middle and lower Columbia River would be minor to non-existent because any incremental changes in turbidity, temperature, and TDG resulting from the dam breaching operations would rapidly diminish below McNary Dam.

Other Anadromous Stocks

American Shad

Overall, populations of American shad in the Columbia River should not be noticeably changed over the long term as a result of Alternative 4—Dam Breaching. However, the Snake River population segment is likely to be reduced. Because shad production in the Snake River is a small portion of total production in the Columbia River System (less than 10 percent based on passage estimates of abundance), any changes in the Snake River populations would have no significant effects on system production. Although this species, in its native east coast environment, uses rivers for spawning and early rearing, in the Columbia River System it appears to most successfully use reservoirs for these functions. This suggests that American shad production in the Snake River would decrease under Alternative 4—Dam Breaching. Changes in the Columbia River (e.g., turbidity, temperature, dissolved gas) from changes in the Snake River are not likely to influence overall American shad survival or production in the system.

Pacific Lamprey

The removal of dams and formation of a near-natural river environment could improve Pacific lamprey production in the Snake River. Dam breaching should enhance downstream passage survival for juveniles as they would no longer be impinged on screens or suffer mortality as a result of passage through turbines in this river reach. However, these potential effects could continue to exist at the four lower Columbia River dams.

The long-term effects of increased water velocities on migrations in the lower Snake River as a result of dam breaching are unknown, but could be beneficial if fish depend on velocity for movement downstream. While major spawning appears to occur in sediment deposition areas of tributaries or near confluences of tributaries, the development of riverine conditions could allow the increased suitability and use of the lower Snake River for adult spawning and juvenile rearing in shallow fine sediment areas of the river. Adult passage could also improve as a result of dam breaching due to the bypassing of adult ladders for salmon that impede adult lamprey.

Lyons Ferry Hatchery

Dam breaching actions could interrupt, disable, or reduce the use of the Lyons Ferry Hatchery. This hatchery is located on the Lower Monumental reservoir. The hatchery is used for spawning and rearing of Snake River fall chinook salmon, spring chinook salmon, steelhead, and rainbow trout. The fall chinook salmon operations provide pre-smolt chinook salmon stock to tribal acclimation facilities located in the unimpounded reach of the Snake River above the Lower Granite reservoir. The water supply depends on eight wells located 2 miles upstream. The water supply pipeline is on piers under the reservoir. There is the possibility that once the reservoir is removed, the loss of the buoyancy supplied by the water may result in pipeline damage or collapse. Also, the current wells would supply reduced volumes or no water to the hatchery because of the reduced water elevation in the wells following drawdown. This may require the development of new water wells to maintain current hatchery needs. The suitability of water quality (e.g., temperature) for hatchery needs of any new well is unknown. The adult fish ladder access would also need to be modified or extended because its current entrance would be about 60 vertical feet above the new river shoreline.

5.5.1.5 Model Analysis of All Alternatives

This section presents the results from the quantitative assessment of the effectiveness of each alternative relative to the survival and recovery of listed Snake River anadromous fish stocks. It does not address effects to any other Snake River or Columbia River anadromous fish. This assessment is based on the NMFS evaluation of the alternatives as presented in Appendix A, Anadromous Fish Modeling. The NMFS assessment relied extensively on the synthesis and analysis conducted in the process known as PATH. While this analysis relies extensively on the PATH results, NMFS developed additional analysis and provided its independent review and interpretation of the results from the PATH analysis as they pertain to the Snake River anadromous salmonid species and alternatives being evaluated.

Additionally, due to some limitations in the PATH analysis (see Subsection 5.5.1.6), NMFS developed a Cumulative Risk Analysis, referred to as the Cumulative Risk Initiative (CRI analysis). This analysis is complementary to the analysis conducted by PATH. The CRI is intended to more directly address the chance of extinction of stocks among the alternatives. Risk of extinction is not directly assessed in the PATH analysis. PATH only addressed the effect of hydrosystem. The CRI addressed how alterations in risk factors in addition to hydrosystem—such as harvest and habitat—may affect survival, recovery, and extinction either in conjunction with or independent of operations of the hydrosystem.

A major portion of the NMFS analysis involves a salmon lifecycle model developed by PATH. The PATH model evaluates a variety of measures and assumed historic and future survival factors for each alternative (see Marmorek et al., 1998a for specific details of PATH analysis of alternatives). NMFS compared the most recent passage survival research (PIT-tag detection probabilities) against historical conditions and survival estimates to evaluate the validity of assumptions and level of uncertainty of the results of the model for two Snake River species—spring/summer chinook salmon and fall chinook salmon—that were modeled by PATH. NMFS then used this information to identify likely effects for each alternative and project them into the future. NMFS' analysis placed more emphasis on empirical measures from recent (post-1991) research because the structural configuration and operation of the dams have substantially changed since the 1970s retrospective reference time series used by PATH.

Sufficient data were not available for NMFS to model effects on Snake River sockeye salmon and steelhead to the same detail as spring/summer and fall chinook. Therefore, NMFS used the model results from spring/summer and fall chinook analyses and other literature to project likely effects for Snake River sockeye salmon and steelhead. The effects of the critical assumptions or values used in the NMFS analysis were also evaluated (e.g., delayed transport mortality) to help interpret the meaning of the results of the models for each of the four groups of fish.

The CRI analysis will be discussed following the PATH analysis subsection. Details of the methods and performance measures used for the CRI analysis are presented in Section 5.5.1.6, Cumulative Risk Analysis.

Methods and Performance Measures from PATH Analysis

Since use of the PATH analysis by NMFS is key to the overall assessment of the four alternatives, it is important to briefly define important components of the PATH analysis that affect the results. The process includes detailed lifecycle models to predict future chinook salmon populations under a variety of management alternatives. The details of how the PATH analysis conducted the model analysis include a high number of individual computer runs. These runs each had 8 to 10 different key assumptions (e.g., rates of survival at various locations). In general, because of natural variability, the analysis for each alternative would require literally thousands of replicate model runs to develop an outcome. Because of the many varied assumptions used in the analysis and a wide range of results, the PATH process assembled a group of four experts (called the Science Review Panel [SRP]) to "weigh" seven key assumption values that are included in the lifecycle models (Marmorek and Peters, 1998a). PATH comparisons of the SRP weighting and equal weighting showed little difference in outcomes, suggesting no reduction in uncertainty for the seven key assumptions other than the 50:50 chance. NMFS, however, decided not to use these weighted results in their analysis for three reasons (Appendix A, Anadromous Fish Modeling): *"(1) clarity, (2) using the weighted assumptions does not qualitatively alter any of the conclusions (Marmorek et al., 1998a), and (3) new data render some of the weightings obsolete."*

The performance measures used by NMFS for evaluating the alternatives used in Appendix A, Anadromous Fish Modeling, are based partly on the NMFS 1995 Biological Opinion, as interpreted by PATH. The measures used by PATH defined the criteria for the survival and recovery of Snake River listed stocks. The details of what is considered to be meeting "survival" and "recovery" criteria are defined in detail in the Appendix A, Anadromous Fish Modeling.

For spring/summer chinook salmon, the modeled estimates of the number of fish returning to the spawning stream of origin were used to determine the "survival" and "recovery" criteria. The criteria used for "survival" was that six of the seven index stocks would have estimates of escapement of at least 150 to 300 fish (depending on index stock) in the model runs. The NMFS "survival" criteria would be met if six of the seven index stocks met their survival escapement levels for at least 70 percent of the model assumption sets. The survival periods examined were for 24 and 100 years.

The "recovery" criteria were for these same index stocks to have escapement equal to 60 percent of the average spawner counts that were made prior to the 1971 brood year. For "recovery", this escapement was to be achieved for six of the seven index stocks in the last 8 years of a 48-year simulation period. "Recovery" criteria selected by NMFS were for at least 50 percent of the model assumption sets to achieve this escapement. The percent frequency of each of the alternatives meeting these two criteria was determined by PATH.

Methods used to estimate "survival" and "recovery" were similar for fall chinook salmon, except only one stock is present—those fish that spawn primarily in the mainstem Snake River upstream of Lower Granite Dam. The "survival" number of fall chinook salmon spawners used was 300 fish, while "recovery" escapement level used was 2,500 fish. Survival criteria were analyzed for modeled periods of 24 and 100 years, and recovery criteria were modeled for 24 and 48 years after a specific alternative is implemented.

NMFS selected only the 24-year survival and 48-year recovery criteria to compare the alternatives. Selections are described in Appendix A, Anadromous Fish Modeling.

NMFS evaluated how closely the alternatives met the criteria in the Biological Opinion by determining the fraction of simulations that satisfied the survival and recovery criterion across all assumption sets for a specific alternative.

PATH results also indicate which management options (alternatives) are most robust (i.e., those alternatives that achieve the greatest portion of computer runs meeting the criteria under all assumptions analyzed). For example, if an alternative had 100 percent of the runs meeting the criteria, it would be considered better than one that met the criteria in only 60 percent of the runs, if it was believed that all assumptions included had equal weight.

NMFS examined the effects to the listed species as shown in Appendix A, Anadromous Fish Modeling. This examination was based on PATH results. Only four of these alternatives are included in the following text. For various reasons (see Section 3), the three other alternatives were not considered suitable for detailed evaluation in this FR/EIS. The four alternatives included in the text are those presented throughout this FR/EIS.

The analysis presented by NMFS also considered a variety of factors that affect the lower Snake River stocks including: population dynamics, direct and indirect effects on juveniles and adults, climate, harvest, hatcheries, and habitat. As noted above, the

Cumulative Risk Analysis subsection (5.5.1.6) presents results from a quantitative analysis of potential cumulative effects from factors not related to the hydrosystem. Other than this subsection, the analysis summarized in this FR/EIS is limited to the discussion of those factors in the hydrosystem that affect the overall survival and recovery of listed species.

Key Issues

The survival of salmon in the Snake River, as indicated by the smolt-to-adult ratio (SAR), has decreased dramatically from the period prior to 1970. However, there are many factors that appear to correlate with this decline. These have included such factors as increased number of dams, increased number of hatchery releases, and changes in ocean conditions. Similar trends among many factors make it difficult to determine the exact cause or "blame" for the decline. Additionally, it is unlikely that any one factor, either natural or human-induced, can be assigned the total blame for the decline. The current populations of salmon and steelhead in the Snake River are likely the result of many combined factors (NRC, 1996). It should be noted that spring/summer chinook returns of 2001 appear to have SAR much higher than other recent years and are more likely in the range of those prior to 1970. These data, although scant, suggest that changes in natural estuarine or ocean conditions may be having significant effects on overall survival, at least for some years, and that hydrosystem conditions may be adequate at least some years to sustain some stocks.

There are several key technical issues that affect both the analysis and interpretation of the results that are discussed in the following sections. Because the data available cannot definitively determine how certain factors affect survival, observed changes in past survival have become open to interpretation. However, as more data are gathered, the interpretation of the observed changes may be narrowed. Two key factors that had major effects on both how the PATH analysis was conducted and the meaning of the results include:

- Differential Delayed Transport Mortality
- "Extra Mortality" and its sources

Each factor is summarized below.

Differential Delayed Transport Mortality

Differential delayed transport mortality is the inferred additional mortality transported juvenile fish suffer relative to those fish that have survived passage of the dams and reservoirs. This component has a large effect on estimates of juvenile fish survival in the Snake River System because about 60 to 90 percent of spring/summer chinook salmon, and steelhead, have been transported to below Bonneville Dam in recent years (NMFS 2000a Biological Opinion).

Differential delayed transport mortality is not actually measured, but is an estimated value based on other measurements and assumptions. If the delayed mortality is the direct result of activities associated with the hydrosystem, then modifying or removing these activities would eliminate this source of mortality. However, if the assumptions used to estimate differential delayed transport mortality are wrong or the source of the additional mortality is caused by something other than activities associated with the hydrosystem, then modifications would not eliminate this mortality factor. For example, if fish suffer additional mortality from disease (not caused by the hydrosystem), breaching of dams or cessation of transport would not affect overall survival.

Estimates of differential delayed transport mortality have been made based upon transport study estimates of TIRs, in-river survivals and SARs for over two decades. There are differing scientific opinions about which estimates of this mortality should be given most credence in determining future conditions for each alternative, especially for Alternative 4—Dam Breaching.

The parameter used to delineate the effects of delayed transport mortality is the "D-value." This value is the ratio of survival of transported fish to below Bonneville Dam to that of surviving untransported fish. If D=1, there would be no differential delayed transport mortality, while values less than 1 would mean that released transported fish survive at a lower rate than untransported surviving fish. For example, when D=0.33, the estimated survival of transported fish is only one-third that of surviving untransported fish.

Extra Mortality

Another important concept is "extra mortality." While many stocks in the Northwest, including the middle Columbia River, have declined since the late 1970s, those from the Snake River have suffered greater mortality rates, as measured by the SAR, even considering measurable hydrosystem passage improvements and other management actions resulting in positive effects, such as reduced harvest rates. The extra mortality is essentially the remaining additional mortality that needs to be added to the models to obtain the observed SAR values after all other measured and estimated values are included. There are generally three possible sources hypothesized for this extra mortality: hydrosystem, ocean/climate regime shift, and stock viability degradation. These are discussed below.

<u>Hydrosystem</u>

Extra mortality from the hydrosystem would be considered mortalities that are in addition to those already included in the models (e.g., direct hydrosystem mortality, dam and reservoir passage mortality, and differential delayed transportation mortality), but are secondary effects unique to the Snake River stocks as a result of changes caused by the hydrosystem. Examples of this type of mortality could be changes in flow that affect the estuary, thus reducing its suitability for Snake River stocks, changes in arrival timing of the stocks to the estuary, and additional stress increasing susceptibility to predation due to worsened conditions following migration through the Columbia-Snake River System. Although data are not available to quantify that hydrosystems have had additional effects on survival, the fact that large physical and biological changes have occurred to the Columbia River System as a result of the hydrosystem is well documented (Williams et al., 1999). Many plausible mechanisms are available to suggest that some form of extra mortality may be occurring as a result of the hydrosystem. These mechanisms are experimentally difficult or impossible to measure. Consequently, less direct statistical analyses are the primary means of evaluating whether the hydrosystem causes appreciable mortality or reduced fitness to fish below Bonneville Dam.

Ocean/Climatic Regime Shift

Extra mortality could also result from changes in the ocean current induced productivity which hasuniquely affected Snake River stocks differently than other Columbia River stocks. There is a large volume of scientific information that has indicated which changes in ocean conditions have affected many coastal stocks. Examples include El Niño, which occurs over several years, and the Pacific Decadal Oscillation (PDO) that occurs over decades. Most of the information that has actually documented these effects is for Alaskan and Canadian salmon stocks; there is minimal information on Snake River stocks. Some of the changes in ocean conditions known as the PDO Index, have occurred over the 1977 to 1986 period, which corresponds to the onset of low SARs of many salmon stocks (not just Snake River stocks). The theory behind the PDO suggests that when the ocean cycle becomes more favorable, smolt-to-adult values would also increase.

The recent record return of chinook salmon to the Columbia River Basin and the Oregon coast during 2001 has been credited by many analysts to ocean conditions. Ocean productivity encountered by returning salmon has been above average over the last couple of years, providing a wider variety of prey species to the ocean rearing lifestage of salmon like herring, anchovies, sardines, and zooplankton. Such prey fish had virtually disappeared from West Coastal waters throughout the 1990s. From 1977 to 1998, the low pressure system that resides off Kodiak Island in Alaska every winter, known as the Aleutian Low, was larger and more intense than it had been since the mid-1940s. This 1000-mile wide low-pressure system was characterized by strong, circling winds that pushed nutrient-rich waters north to Alaska and delayed upwelling off Oregon and Washington that feeds the nutrient cycle in spring and summer. The effect created good ocean conditions for salmon in Alaskan coastal waters, while less-than-ideal conditions for salmon off Oregon and Washington. The Aleutian Low became even larger and more intense in the fall and winter of 1997 to 1998, during a strong El Niño episode. Then in the winter of 1999, the pressure system shifted west dramatically to the Kamchatka Peninsula in Russia and the California current became stronger off the West Coast, causing increased upwelling. The resultant ocean hydrologic and biologic conditions changed rapidly, almost overnight. More northern distributed zooplankton species with greater abundance appeared off the Pacific Northwest coast from Alaskan waters.

During much of the intense Aleutian Low period, the waters off the Oregon coast were dominated by ‘southern’ copepod species that are more common off the central California coast. These species are typical of weak currents, weak upwelling warm water, and low productivity. Quickly in 1999 with the regime shift in the stronger California current, the southern copepods disappeared and were replaced by boreal, or northern copepod species redistributed southward from Alaskan waters. The actual biomass of the copepods doubled since 1999, causing anchovies to return to more northern waters and begin to spawn, and also causing herring and sardines to flourish in the same northern coastal waters.

During the 1980s and most of the 1990s, the relatively poor climatic conditions affecting the currents and ocean productivity led to low salmonid survival rates for the near ocean and open ocean lifestages, especially during the El Niño year of 1998. Analyses of juvenile salmon that had transitioned into the near ocean plume during 1998 found that the stomachs of these rearing juvenile salmon were relatively empty.

The stomachs had some small prey, such as a few juvenile rockfish, but mostly contained small copepods and jellyfish. Such food is not the usually preferred salmonid diet during this lifestage, when rapid growth is important to survival. During their ocean lifestages when growth needs to be greatest, salmon prefer to eat juvenile rockfish, smelt, anchovies, sardines, crab larvae, and krill. Starting in 1999, those prey reappeared in the stomachs of salmonids examined by scientists from NMFS and the Canadian Department of Oceans and Fisheries. Having an abundance of prey fish actually improves two aspects of salmonid lifestage survival. First, the prey fish are an important food source directly for the juvenile salmon. Salmon need to grow fast early to avoid becoming prey of other predatory fish and birds. Second, when prey fish are abundant, their availability as an alternate prey source for predatory birds and groundfish, like adult rockfish and hake, becomes important in a competitive sense.

Stock Viability Degradation

This is primarily referred to in the PATH analysis as the bacterial kidney disease (BKD) factor. Mortalities attributed to this factor would suggest that Snake River stocks have acquired increased BKD infections in more recent times. However, in the model, this factor really includes a wide variety of non hydrosystem or ocean-induced effects such as genetic effects due to hatcheries, species competition, and predation on juveniles by Caspian terns. If stock viability degradation is valid, then it is likely that none of the alternatives would eliminate this factor.

Individual Snake River ESU Model Analysis

The following sections present the results of NMFS' analysis of hydrosystem alternatives for each Snake River ESU. The CRI analysis follows in a separate subsection (5.5.1.6) that addresses the extinction potential and potential effects of other actions to these ESUs. The level of analysis varies markedly by individual ESU so that the type of analysis is not consistent among the ESUs. A fairly thorough analysis of the spring/summer chinook ESU was possible compared to the ESUs for the other Snake River stocks because more data were available, allowing the PATH group to direct greater effort at this ESU. This stock is assessed against specific recovery criteria in a quantitative manner. Although fall chinook salmon was analyzed in a similar quantitative manner as spring/summer chinook salmon, the analysis is more preliminary. This is because there are much less data available on this stock because of relatively few site-specific studies on downstream passage survival and transportation survival. Steelhead results are presented next, and there is even less information to develop quantitative results. The lack of escapement data for this stock has limited the ability of modelers to develop a full lifecycle model like they did for spring/summer chinook salmon. The analysis of sockeye salmon is really not quantitative in the same manner as the other three ESUs. This is because so few fish have been produced in the system for recent years, making it difficult to develop background information to conduct a similar analysis.

Snake River Spring/Summer Chinook Salmon

Several factors both within and outside of the hydrosystem affect spring/summer chinook salmon survival. Habitat, hatcheries, harvest, and hydropower are commonly described as factors that affect the survival of these fish. NMFS provides a summary of many of the effects (Appendix A, Anadromous Fish Modeling), both current and historical, of habitat, hatcheries, and harvest on Snake River spring/summer chinook salmon and additional information on important life history stages (e.g., egg-to-smolt). This information will not be repeated here.

Direct Survival to Below Bonneville Dam

PATH used two different passage models, CRiSP and FLUSH, to develop estimates of downstream passage survival (Beamesderfer et al., 1998; Marmorek et al., 1998a).

Survival estimates have been based on PIT-tag mark-recovery studies expanded to Bonneville Dam. Each of the two passage models uses run reconstruction information (Beamesderfer et al., 1998; Marmorek et al., 1998a) and makes assumptions about passage survival at each dam and reservoir. The details of each of these models are presented in PATH reports (Marmorek and Peters, 1998b; Marmorek et al., 1998a).

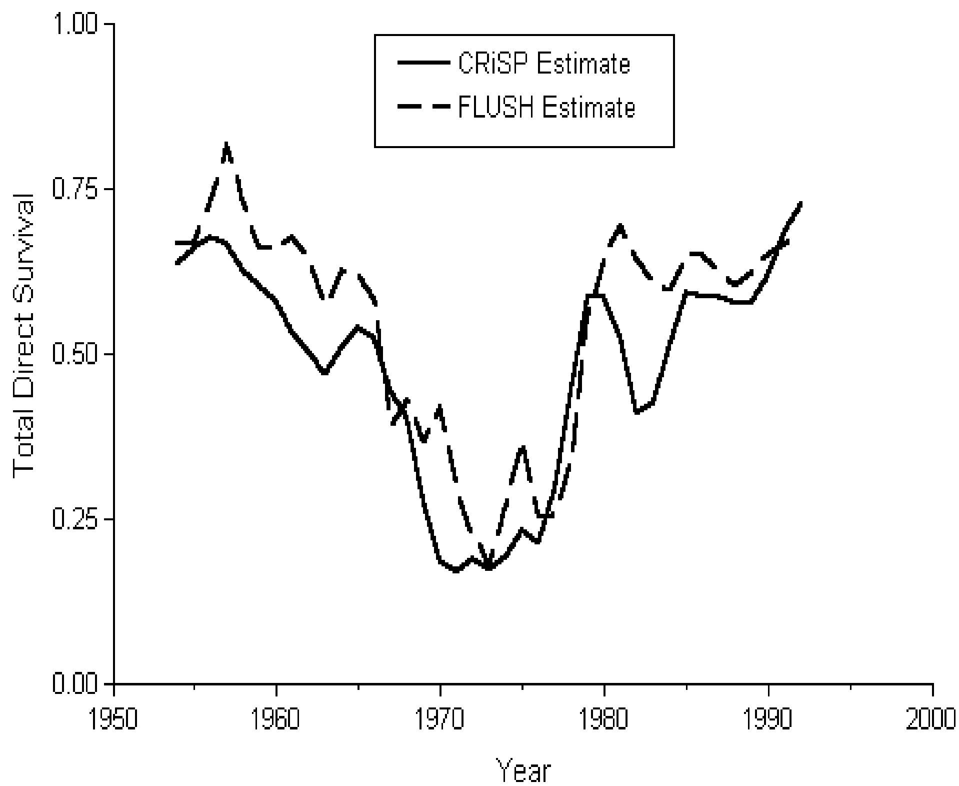
Although the passage models differ in their approach to determining reservoir mortality, they generally agree on the dam survival contribution to total direct survival for juvenile fish migrating from the Lower Granite reservoir to below Bonneville Dam. The historical passage survival estimates by the CRiSP and FLUSH models are shown in Figure 5.5-3. The fact that the SAR values have not paralleled those of the direct passage survivals suggests some other additional factors (e.g., ocean conditions, delayed transport mortality) are contributing to the continued low SARs. The two models differ on what delayed transport survival is (i.e., the effective D-value), which results in differences in their estimates of overall survival through the hydrosystem.

Ocean and Climatic Effects

Ocean and climatic conditions play a major role in salmonid survival. Noticeable changes in Alaska and British Columbia stocks have shown shifts in abundance beginning in the late 1970s in response to ocean changes that are apparently on an approximate periodic 30-year cycle (Mantau et al., 1997). However, the specific relationship to Snake River spring/summer chinook salmon stocks is unclear with statistical correlations between survival of Columbia River Basin stocks and ocean conditions being weak (Marmorek et al., 1998a). Some returns of West Pacific coho salmon and steelhead stocks (not of Snake River origin) had sharp declines in 1992 and 1993 that were similar to declines in Snake River spring/summer chinook salmon. This similarity lead to consideration by PATH that ocean conditions could disproportionally affect Snake River spring/summer chinook salmon if they were being affected in a similar manner as these coho salmon and steelhead stocks.

There are two views on the effects of ocean conditions and climate on the Snake River salmon runs. Some members of the PATH group believe available information suggest that the hydropower system and fish transportation are overriding factors affecting survival and the return of adult salmon from the ocean. Some other scientists, both within and outside of the PATH group, have contended that the effect of ocean conditions and climate are so overriding in the return of adult salmon that no matter how hydropower effects were diminished, or how successful the juvenile fish transportation program is, the runs would still be in dire condition.

Note: Direct survival does not account for any delayed mortality of either transported or in-river migrants.



Source: Appendix A, Anadromous Fish Modeling

Figure 5.5-3. Total Direct Survival (Transported plus In-River Migrants) of Juvenile Spring/Summer Chinook Salmon to Below Bonneville Dam, Graphed as 5 year Moving Averages

Taylor and Southards (1997) indicated that the rebound resulting from a shift to a cool/wet cycle in 1996 might already be occurring. In 1997, the Oregon Department of Fish and Wildlife reported the second highest chinook salmon redd counts on record since 1959 for the John Day River.

British Columbia fisheries scientists believe that ocean/climate conditions overwhelmingly drive the returns of Pacific salmon to British Columbia streams (Stocker and Peacock, 1998). Such predictions led to the complete closure of coho salmon fisheries along the British Columbia coast in 1998, and reduced harvest allowances in 1999.

Data collected since 1995 on NMFS weekly release groups of PIT-tagged smolts support the pre-dam lower Snake River observations of Van Hyning (1968) that some chinook salmon are oriented southward by the currents because their tags were recovered in California marine waters. Spring chinook salmon SARs for the 1995 outmigration are about 7 times higher for transported smolts that passed through the estuary after the second week of May than before. This date correlates with the spring transition shift of winds and currents in the estuary and near ocean.

Hydrosystem Passage Effects

Differential Delayed Transport Mortality

The D-values used by PATH for its analysis were derived from estimates of TIRs from transportation studies, in-river survival, and SARs for the 1970s and 1980s. Depending on the estimating methods used, the range of mean D values for the period from 1994 to 1997 were 0.63 to 0.73.

The D-values used in the PATH model were often lower than these means. The CRiSP mean D-value used was 0.66, while the mean FLUSH values ranged from 0.31 to 0.53. However, it should be noted that the more recent data have wide confidence intervals. NMFS scientists believe that the 1994 to 1997 PIT data should be given substantially more weight for prospective modeling into the future than early data because the estimation method using PIT tags is greatly improved and reflects current operation conditions consistent with the 1995 and 1998 Biological Opinions (see Appendix A, Anadromous Fish Modeling).

NMFS restricted its calculation of D-values to fish transported from Lower Granite and Little Goose Dams in recent years. They took this approach to be more consistent with most of the past estimates of D-values, and because the emphasis in the future transport will be mostly from the upper dams (Lower Granite and Little Goose). Methods that NMFS used to estimate D-values and survival are presented in various annexes of Appendix A, Anadromous Fish Modeling and NMFS, 2000c, White Paper on Transportation, April 2000).

Dam Bypass Systems

PIT-tag studies were also used to estimate the effect of dam passage systems on survival of smolts left to pass entirely in-river (NMFS, 1999b). Although sample sizes were small, it appears that the fewer number of times that fish travel through bypass systems at dams, the greater their survival, based on SARs. For wild fish, the SARs were 0.23 percent (15 of 6,544 fish), 0.18 percent (22 of 12,512 fish), 0.13 percent (9 of 6,801 fish), and 0.19 percent (3 of 1,602 fish) respectively, for fish that were detected zero, one, two, or three times after leaving Lower Granite Dam. Sample sizes were small for all of these groups, especially those detected passing three times (three fish), which made the significance of the results questionable (especially for the last, i.e., 0.19 percent group).

Extra Mortality

In essence, extra mortality is the remaining mortality value needed to balance the lifecycle model to the adult escapements of the run reconstructions after all other mortality factors have been estimated. It specifically does not include such factors as direct downstream passage mortality (from passage models), but could include uncertainties or errors in estimates of differential delayed transport mortality. While the cause of this mortality is not known, three factors are considered as possible sources: 1) climatic effects specific to Snake River salmon, 2) other factors known as "stock viability," and 3) delayed hydrosystem effects not accounted for in other estimates.

Ocean/Climate Regime Shift

This hypothesis promotes the idea that during certain cyclic periods of time, ocean changes specifically affect Snake River stocks on a cyclic nature of about 10 to 30 years known as "regime shift." Under this hypothesis, conditions have worsened in the ocean for Snake River stocks, beginning in the early 1970s and becoming more apparent starting about 1977. It is expected that these conditions are cyclic and will return to better conditions in about 2005. The SRP did not give much credence to this as a source of significant "extra mortality" for Snake River stocks (Peters et al., 1998).

Reduced Stock Viability

Another source of reduced stock viability other than the BDK hypothesis could be potential stress from interactions with hatchery fish, which has been demonstrated with large steelhead smolts under laboratory conditions. Additionally, predation directly by the large number of hatchery fish, such as large steelhead, may be a source of this extra mortality. Also, genetic degradation could be occurring as a result of hatchery practices. This could result from inbreeding of hatchery fish, or from having too few fish in the gene pool. This represents the hypothesis that a large proportion of extra mortality is in addition to direct dam effects; removal of that effect results in a marked increase in survival with no corresponding changes made in hydrosystem action.

Downstream effects on stock viability include possible changes in flow to the estuary that could affect nearshore production, and increased predation below Bonneville Dam from such sources as birds (e.g., Caspian terns) and marine mammals, which have both been on the increase since the late 1970s (NMFS, 200l predation white paper). For example, Caspian terns have been estimated to consume 5 to 30 million smolts annually (Roby et al., 1998). PIT tags show that the majority of tagged smolts taken near Rice Island are steelhead (up to 20 to 30 percent mortality vs. 0.5 percent mortality for spring chinook salmon for NMFS-tagged fish since 1988 compared to approximately 3 percent mortality for Idaho PIT-tagged fish. There is no estimate for fall chinook salmon).

Hydrosystem

Under this hypothesis, extra mortality of spring/summer chinook salmon is the delayed mortality resulting from fish passing through the four lower Snake River facilities. The general idea is that "extra stress" or a "weakened condition" reduces survival of fish after they arrive below Bonneville Dam. The rationale for this hypothesis is that the presence of the dams has changed the ecology of the river system, which would be expected to have additional effects on the native migrating fish. These changes would likely not be easily measured directly. If this hypothesis were true, then removal of the Snake River dams would remove this extra mortality component, returning the SAR to the 3 to 5 percent that it was prior to the construction of the four Snake River facilities.

Alternatives Analysis

For both CRiSP and FLUSH models, Alternatives 1, 2, and 3 have higher total direct survival than Alternative 4—Dam Breaching, primarily because of the high portion of fish transported which have a directly estimated survival value of 98 percent. However, with the inclusion of the estimated D-values, which differ between the CRiSP and FLUSH models, the results for Alternative 4—Dam Breaching have a higher system survival than the other alternatives (for both models). The use of different D-values between the CRiSP and FLUSH models account for almost all of the differences in survival between the two models (Appendix D of Marmorek and Peters, 1998a).

Drawdown

Breaching of the four lower Snake River dams (Alternative 4—Dam Breaching) includes conditions for four periods (Table 5.5-4): 1) pre-removal (prior to commencement of removal), 2) removal (dams actively breached), 3) transition (directly after dam breaching and prior to mostly equilibrated conditions, and 4) equilibrium (after transition). Sensitivity analysis was conducted for the transition period (Marmorek et al., 1998a). Values of 10 percent and 50 percent for in-river survival during this transition period were assumed for the sensitivity analysis. Even with this wide range of values, the resulting estimates of survival and recovery were little affected, indicating that the survivals occurring during the transition period would still have only a minor influence on achieving NMFS performance criteria. However, achieving NMFS criteria is highly influenced by duration of transition. The PATH analysis of Alternative 4—Dam Breaching assumes no additional mortality above current conditions to juvenile or adult salmonids during the removal or transition period.

The transition period would have several changes that could affect juvenile survival. The main factors of concern during this period are the effects on predation rate and effects of elevated suspended sediment, including possible contaminants. Several factors are thought to affect predation during transition. Many of these factors would also affect survival after the transition period.

Detrimental effects of suspended sediment or contaminants were not considered directly in the models. It is expected that habitat changes under Alternative 4—Dam Breaching would also be less conducive to predators. The reduced travel time of juveniles would result in reduced exposure to predators.

Lifecycle Modeling

PATH used a lifecycle model to estimate the number of adult spawners for each of the seven index stream stocks of spring/summer chinook salmon (see Appendix A, Anadromous Fish Modeling). The two ways of evaluating extra mortality in the lifecycle model were referred to as Alpha and Delta. The Alpha approach assumes that each of the seven index spring/summer chinook salmon stocks respond separately to changes in ocean conditions and climate and from reference lower Columbia River stocks with fewer dams to pass. Variations in climate/environmental factors are incorporated into this approach. The Delta approach assumes that there are common year effects of the ocean conditions and climate that affect lower Columbia River and Snake River stocks of similar life history in the same fashion. The Delta approach adjusts for these similar reactions in future projections based on data from the 1952 to 1989 period. Sensitivity analysis, however, found that the approach chosen (Alpha or Delta) had little effect on estimates of adult spawners for any of the alternatives.

Table 5.5-4. Summary of Estimates of Duration, Juvenile Survival, and Adult Survival for the Four Time Periods for the Lower Snake River Reach Only

Time Period	Duration (Years)	Juvenile Survival[1/]	Adult Survival[2/]
Preremoval	3 years or 8 years	Determined by passage models	Current estimates
Removal	2 years	No change from preremoval period	No change from preremoval
Transition	2 years or 10 years	Linear increase from preremoval survival to equilibrated survival	Linear increase from preremoval to equilibrated value
Equilibrium	Determined by length of simulation period	0.85[3/] or 0.96[3/]	0.97[3/]

1/ Juvenile survival is calculated over the four Snake River project reaches.
2/ Conversion rates.
3/ Assumed portion of fish surviving passage through the lower Snake River drawdown reach (from Lower Granite through Ice Harbor).

PATH Results for Spring/Summer Chinook Salmon

The results presented in this section are a summary of how NMFS interpreted the results of several PATH reports. It is important to note that only Alternatives 1 through 4 are discussed. Other alternatives and potential effects from other factors such as hatchery release, harvest, or habitat conditions were not directly evaluated.

One way to evaluate alternatives is to determine alternative robustness. The alternatives that meet the survival and recovery benchmarks under the largest number of assumptions would be considered the most robust. The results of a particular combination of alternative assumptions are expressed as the fraction of model runs exceeding the survival or recovery threshold number of spawners through time under that set of assumptions. PATH evaluated uncertainty in the models by running 4,000 100-year replicate Monte Carlo simulations for each assumption set. The result is the fraction of model runs exceeding the specific NMFS survival and recovery escapement criteria.

Based on the robustness of the results, Alternative 4—Dam Breaching exceeds the other alternatives in meeting recovery population escapement levels for spring/summer chinook salmon (Table 5.5-5). For this assessment to be correct, the large degree of uncertainties associated with estimating predicted post drawdown values of survivals, removal, transition, and equilibrated periods would need to almost immediately return to 1960 conditions within 2 to 5 years with respect to habitat, predation, and other factors influencing river habitat suitability. It is unlikely that 1960 conditions would occur in this timeframe. Also, this outcome does not consider recent PIT-tag data that show that in-river survivals through the Snake River dams can exceed the 85 percent reach survival criteria which was used for the drawdown simulations. Dam breaching meets these escapement levels in 82 percent of the runs while, for the other alternatives, there is a range of 47 to 50 percent of runs that meet recovery criteria. Dam breaching is, therefore, the more robust or least risk-averse of the alternatives, once all assumptions are acceptable.

Table 5.5-5. Average Fraction of Runs (Across All, Equally Weighted Assumption Sets) Exceeding NMFS Survival and Recovery Escapement Criteria for Spring/Summer Chinook Salmon for Alternatives 1, 2, 3, and 4

Alternative	24-Year Survival	48-Year Recovery
1	0.65 (240)	0.50 (240)
2	0.64 (240)	0.47 (240)
3	0.65 (240)	0.48 (240)
4 (3-year delay)	0.73 (439)	0.82 (439)
4 (8-year delay)	0.69 (439)	0.82 (439)

Note: Analyses for Alternative 4—Dam Breaching assume 3-year and 8-year delays prior to dam breaching, respectively (Marmorek et al., 1998). The number in parentheses indicates the sample size used to calculate each average.

Differences in the 24-year survival criteria among the alternatives are much less pronounced. The survival goal is met in 69 to 71 percent of the model runs for Alternative 4—Dam Breaching and only slightly less, at 64 to 65 percent for Alternatives 1, 2, and 3. However, single values do not indicate the range of the results for all of the different simulations run. The range of results for meeting the survival and recovery escapements are shown in Figures 5.5-4 and 5.5-5. These figures show the range (top and bottom of each line) and middle 50 percent of all of the outcomes (box). The dashed horizontal lines on these figures represent NMFS criteria for survival and recovery, respectively. These figures indicate that for a specific set of assumptions, all alternatives could or could not achieve these criteria. However, they also indicate that the spread of results is smallest for Alternative 4—Dam Breaching and most of Alternative 4—Dam Breaching values exceed the NMFS escapement criteria. NMFS therefore concluded that (Appendix A, Anadromous Fish Modeling):

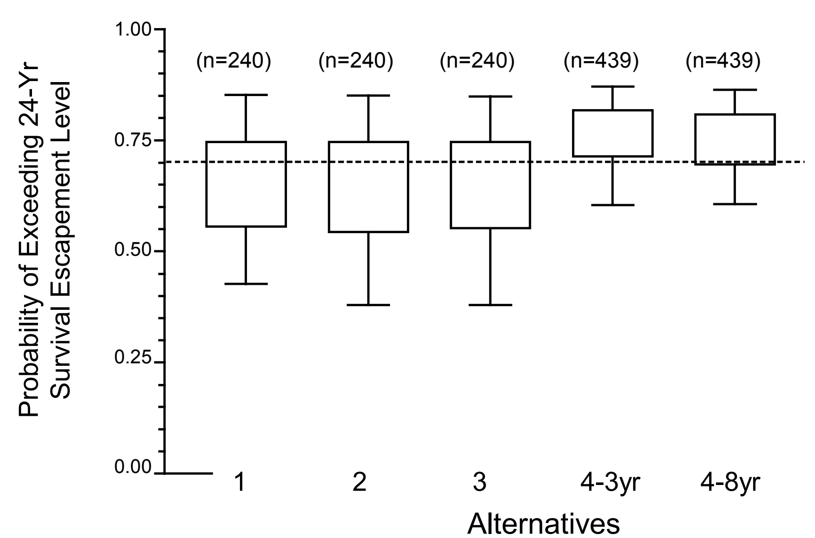
Thus, breaching [Alternative 4] *is more risk-averse in two ways:*

- *Breaching consistently yields predicted populations that exceed recovery criteria over a wider range of assumption sets.*

- *The uncertainty (or variability) in outcomes is consistently reduced with breaching (smaller "middle 50 percent" boxes).*

Critical Assumptions

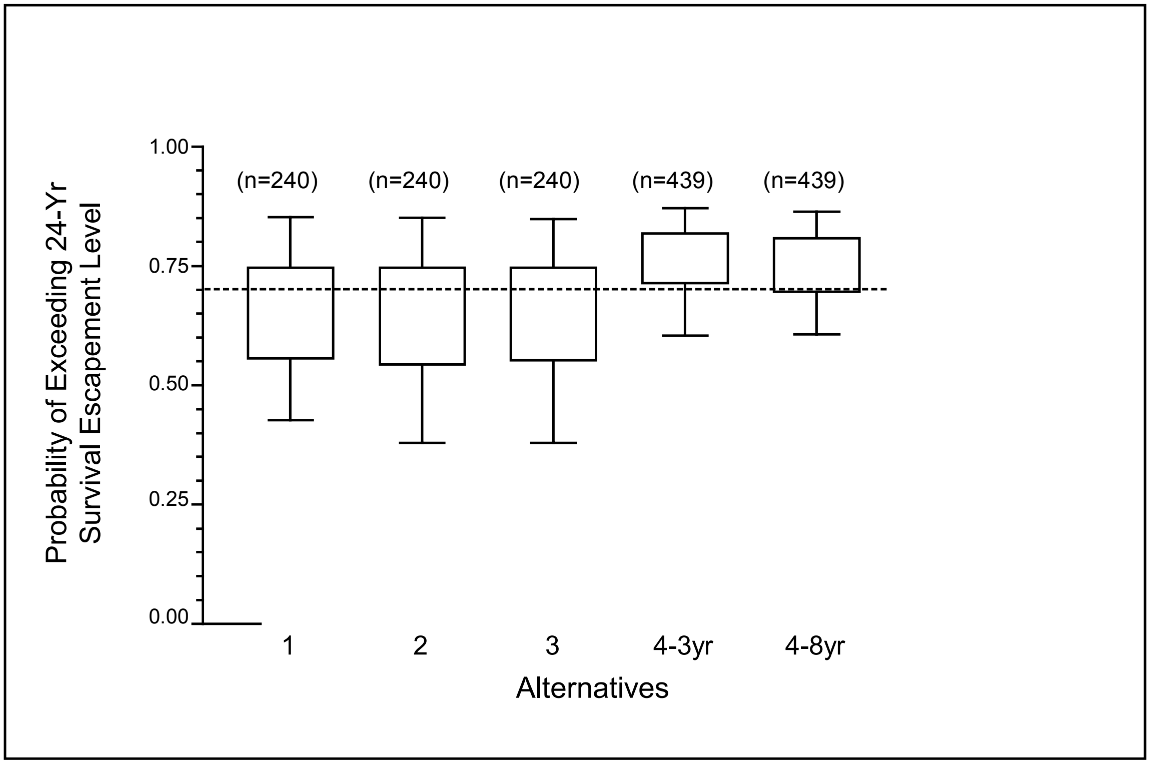
Analysis of which assumptions most affect model results can be informative in helping to determine how much weight should be placed on the overall outcome of this analysis. PATH found that the choice of CRiSP versus FLUSH and sources assumed for extra mortality had the greatest influence on results (Marmorek et al. 1998). Basically, the average of all CRiSP model results exceeded the 50 percent criteria for the 48-year recovery period, whether Alternative 1—Existing Conditions or Alternative 4—Dam Breaching was analyzed, although Alternative 4—Dam Breaching was still higher. In comparison, average values from the FLUSH model only exceed the 50 percent recovery criteria for Alternative 4—Dam Breaching.



Note: Alternative 4 (dam breaching) was evaluated assuming both 3-year and 8-year delays. "n" indicates the number of assumption sets for each scenario. Dashed line indicates the 24-year survival criterion. Plots show range (end of lines) and middle 50% of all model runs (boxes).

Source: Appendix A, Anadromous Fish Modeling

Figure 5.5-4. Frequency of Exceeding the 24-year Survival Escapement Level for Spring/Summer Chinook Salmon under Alternatives 1, 2, 3, and 4, According to the PATH Prospective Lifecycle Model



Note: Alternative 4 (drawdown) was evaluated assuming both 3-year and 8-year delays. "n" indicates the number of assumption sets for each scenario. Dashed line indicates the 48-year recovery criterion. Plots show range (end of line) and middle 50 percent of all model runs (boxes).

Source: Appendix A, Anadromous Fish Modeling

Figure 5.5-5. Equally Weighted Frequency of Exceeding the 48-year Recovery Escapement Level for Spring/Summer Chinook Salmon under Alternatives 1, 2, 3, and 4, According to the PATH Prospective Lifecycle Model

The sources of extra mortality, as assumed by the two models, affect whether this criteria can be met with each of the passage models (Figure 5.5-6).

Another major factor affecting the prediction of future conditions is the assumption about differential delayed mortality or D-values. Because the 1994 to 1996 D-values have been much higher (i.e., lower differential delayed mortality relative to fish remaining in-river) than those that have been used for the PATH model analysis, NMFS ran additional analyses. NMFS compared Alternative 1—Existing Conditions to Alternative 4—Dam Breaching, with varied D-values relative to the 48-year recovery criteria. Using a D-value of 0.8, which is close to the mean value determined for 1994 and 1995, the difference between Alternative 1—Existing Conditions and Alternative 4—Dam Breaching is 11 percent, which is much less than the 30 percent difference estimated by the PATH analysis. Also, if no differential delayed mortality were to occur (D=1.0), the difference between Alternative 4—Dam Breaching and Alternative

1—Existing Conditions would only be 2 percent. Additionally, the source of extra mortality plays an important role if dam breaching is being considered. If D=0.8, dam breaching would increase the chance of achieving recovery criteria by 19 percent, but only if the source of extra mortality is from the hydrosystem.

Snake River Fall Chinook Salmon

As noted for spring/summer chinook salmon, many factors affect chances for survival and recovery. These factors are discussed in the NMFS report (Appendix A, Anadromous Fish Modeling) and are not be repeated in this section.

The following discussion concentrates on the similar factors noted for spring/summer chinook salmon, where data are available, including a discussion of survival factors, preliminary PATH results, and pertinent habitat information relating to potential restoration of fall chinook salmon under Alternative 4—Dam Breaching.

Survival Factors

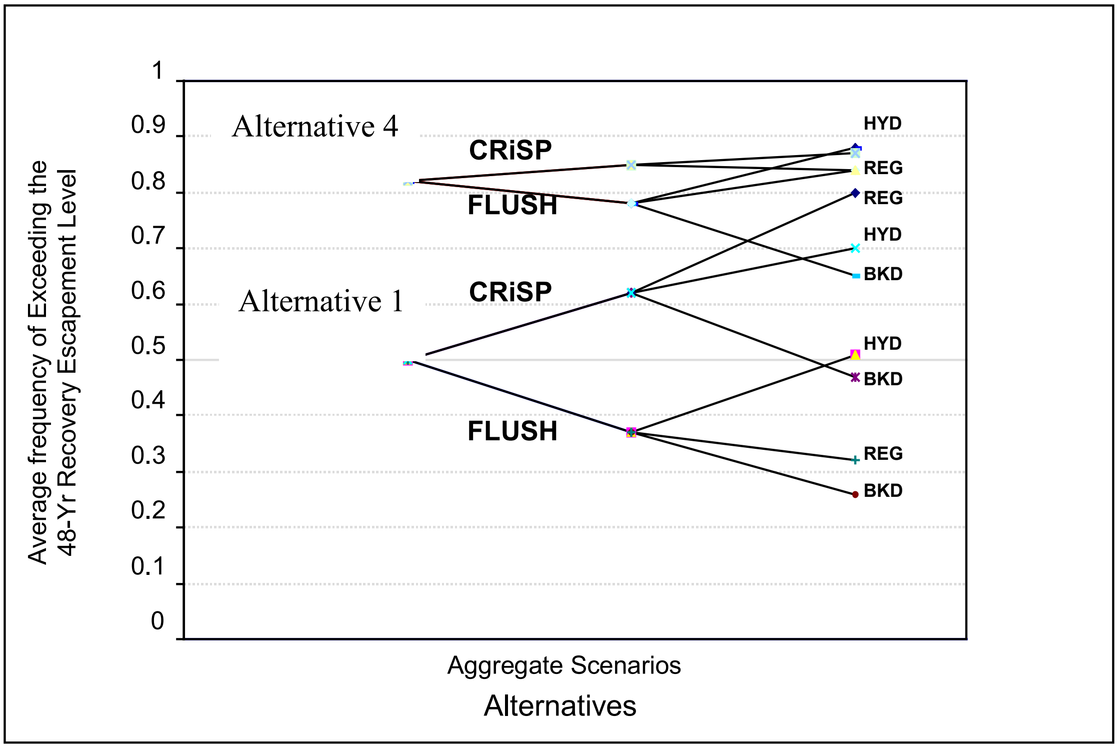
Similar to spring/summer chinook salmon, the main parameter addressed by PATH analysis is the smolt-to-adult life stage. However, the level of detail for fall chinook salmon modeling was much less because there is much less information available on Snake River fall chinook salmon passage survival. The analysis used by NMFS for fall chinook salmon is primarily based on the Decision Analysis Report for Snake River Fall Chinook Salmon (Draft 5) (Peters et al., 1999). Two passage models were used in this analysis for downstream passage, Fall CRiSP and Fall FLUSH. Unlike spring/summer chinook salmon, a very limited amount of information was available to estimate D-values. For this reason, the PATH fall chinook salmon analysis assumed four different sets of D-values to evaluate likely effects of each alternative on meeting NMFS survival and recovery criteria.

Reservoir Survival and Influences of Predation

Several studies have addressed effects of predators on fall chinook salmon during reservoir passage on the Snake and Columbia Rivers (Poe et al., 1991; Vigg et al., 1991; Bennett and Naughton, 1999; Muir et al., 1998). For fall chinook salmon, loss from predation during reservoir passage can be substantial. Recent studies by Muir et al. (1998) of PIT-tagged wild and hatchery fall chinook salmon upstream of Lower Granite reservoir found survival to be low from upriver release points to Lower Granite Dam, but substantially increased later in the season when smolts were larger.

Direct Survival at Dams

Bypass survival can decrease with lower flows and higher temperatures, and also survival can substantially decrease with large increases in spill volume (percent) (TDG studies of Dawley et al., 1997; 1998; 1999). Data from 1997 for Lower Granite Dam only, were used in the models to estimate bypass system survival for fish not transported (i.e., captured by the collection facilities but released just downstream of the respective dam and not transported), which was 88 percent. This value includes additional mortality in the tailwater from predation, not just passage mortality.



Note: Solid horizontal line indicates the 48-year recovery criterion. The effectsof assumptions shown by alternative (land 4) are for different passage models (CRiSP and FLUSH) and that of the sources of "extra mortality" which include hydrosystem (HYD), ocean regime shift (REG) and stock viability degradation (BKD).

Source: Appendix A, Anadromous Fish Modeling

Figure 5.5-6. Relationship between Different Combinations of Assumptions and the Average Frequency of Exceeding the 48-year Recovery Escapement Level, as Predicted by the PATH Lifecycle Model

Components of Post-Bonneville Dam Mortality

As with spring/summer chinook salmon, survival of fall chinook after passing Bonneville Dam (either through transportation or migrating in-river) has a significant effect on overall fish survival and model results.

D-Value of Transported Fish

Unlike spring/summer chinook salmon, very limited data are available to estimate D-values for fall chinook salmon. Because most fall chinook salmon that arrive below Bonneville Dam are currently transported, the D-value estimate has a very large effect on evaluation of the alternatives being considered. Because of the lack of available data to estimate D in the normal manner, PATH considered the different sets of indirect methods of estimating D listed in Table 5.5-6 (see Appendix A, Anadromous Fish Modeling).

Table 5.5-6. D-Value Hypotheses Used to Estimate Effects on Each Alternative

Scenario	Retrospective D	Prospective D	Evidence
D1	Drawn from posterior distribution of D-values (lowest values around 0.05)	0.24	Spawner-recruit data (retrospective), 1995 PIT-tag estimates (prospective)
D2	1.00	1.00	McNary T:C estimates, NMFS analysis of SARs (retrospective and prospective)
D3	Drawn from posterior distribution of D-values (lowest values around 0.05)	Drawn from posterior distribution of D-values (lowest values around 0.05)	Spawner-recruit data (retrospective and prospective)
D4	0.2	0.2	1995 PIT-tag estimates (retrospective and prospective)

There are a variety of reasons for believing that each of the methods may or may not be the best way to estimate D (see Appendix A, Anadromous Fish Modeling). However, without further information, there is no scientific basis to discount or accept any one of these over the others. For this reason, the four methods were carried through to calculate the D-values (Table 5.5-6).

The D-values shown in Table 5.5-6 were used in the development of four hypotheses about how transport affects survival both retrospectively (1965-1992) and prospectively (after 1992). Note that the four D hypotheses do not directly correlate to the D alternative methods noted above. The details of each alternative D-value hypothesis are provided in Appendix A, Anadromous Fish Modeling and are only summarized in this section.

In the models used, (known as fall chinook salmon Bayesian Simulation Model or "fall BSM"), two periods were considered when extra mortality may have begun to occur. The first is after 1970 and corresponds to the completion of Lower Monumental and Little Goose Dams. The second is after 1976, which corresponds to the ocean regime shift. In modeling, the extra mortality was assumed to be zero before 1970 or 1976, depending on which assumptions were made about its causes. The models assumed three different hypotheses concerning possible causes of extra mortality—ocean regime shift; hydro related; and "here to stay" hypothesis, which is other miscellaneous causes that have changed the system effects on fish survival (e.g., BKD, hatchery influences).

Harvest Effects

Unlike spring/summer chinook salmon, the harvest rate both in the ocean and the river can be quite high on fall chinook salmon and may have a significant effect on recovery of the stock. In the modeling of this ESU, PATH considered six harvest scenarios. The scenarios included variations in ocean and in-river harvest rates. They ranged from increases of up to 15 percent in ocean and river harvest to decreases up to 75 percent in ocean and 50 percent in-river harvest rate (see Appendix A, Anadromous Fish Modeling for details).

Alternatives Analysis

PATH Results for Fall Chinook Salmon

The model analysis of fall chinook salmon has not undergone the same level of effort and regional review as the spring/summer chinook salmon analysis. The alternatives were evaluated considering these limitations.

Despite the above caveats about the incomplete nature of the PATH analyses, examination of the results is still informative. PATH analyses evaluated Alternatives 2, 3, and 4. Alternative 1—Existing Conditions was not evaluated directly because it is essentially the same as Alternative 2—Maximum Transport of Juvenile Salmon. PATH model response variables for these different alternatives include trends in projected numbers of spawners over time, and average survival and recovery frequencies over short- and long-time periods. Independent of which D-value hypothesis was used, the assumed chance of meeting NMFS "survival" criteria was generally high for all alternatives (Table 5.5-7). Many of the alternatives and alternate D-value hypotheses also met recovery standards. Only Alternatives 2 and 3 with assumed low and unchanging D-values in the future (D3 and D4), did not meet recovery escapement. Dam breaching had noticeably much greater average escapement than other alternatives, except where D was assumed to be high. As is apparent from these effects, assumptions about transport survival have a large influence on both estimates of escapement and meeting recovery criteria.

For the PATH analysis, low assumed transport survival generally resulted in low escapements for Alternatives 2 and 3, but high escapements for Alternative 4—Dam Breaching (Table 5-5.7). When transport survival was assumed to be high (Hypothesis D2), escapement estimates were very similar among alternatives.

Much of the difference among escapement estimates with and without drawdown is the result of estimates of substantially more spawning habitat resulting from drawdown being included in the modeling effort (Peters et al., 1999). PATH conducted a sensitivity analysis to determine the effect of inclusion of additional spawning habitat in the model. This analysis determined that median spawner estimates increased 40 to 50 percent compared to estimates assuming no increase in spawning habitat. Based on increased river miles, NMFS noted (Appendix A, Anadromous Fish Modeling) that an assumed potential for an additional 5,000 spawners would be developed following dam breaching. The actual increase in spawning habitat that would be used is unknown.

PATH also conducted a series of analyses to examine survival and recovery fractions under a range of future ocean/Columbia River harvest scenarios. PATH developed a set of alternative harvest scenarios in which ocean and in-river harvest rates are reduced incrementally. Generally, results from model runs with decreased ocean harvest, with or without in-river harvest, met or exceeded survival and recovery criteria.

Table 5.5-7. Summary of Major Quantitative Results by Alternative for Fall Snake River Chinook Salmon

Performance Measure	Alternative	D Hypotheses (retrospective/prospective D-value) D1 (0.05 / 0.24)	D2 (1.0 / 1.0)	D3 (0.05 / 0.05)	D4 (0.20 / 0.20)
Number of runs per action/D hypothesis[1/]	2	2	6	2	6
	3	2	6	2	6
	4	16	48	16	48
Average spawning escapement over 100-year simulation period	2	5,028	5,259	2,131	2,328
	3	5,515	6,273	2,151	2,535
	4	21,312	8,325	20,842	15,425
Frequency of exceeding survival escapement threshold, 24 years	2	0.99	0.94	0.80	0.90
	3	0.99	0.95	0.73	0.89
	4	0.99	0.94	0.89	0.92
Frequency of exceeding survival escapement threshold, 100 years	2	1.0	0.96	0.80	0.92
	3	1.0	0.98	0.72	0.93
	4	1.0	0.97	0.97	0.98
Frequency of exceeding recovery escapement threshold, 24 years	2	0.86	0.70	0.26	0.34
	3	0.90	0.78	0.27	0.38
	4	1.0	0.84	1.0	1.0
Frequency of exceeding recovery escapement threshold, 48 years	2	0.87	0.68	0.28	0.34
	3	0.93	0.77	0.30	0.40
	4	1.0	0.83	1.0	1.0
Fraction of runs exceeding survival and recovery standards	2	2/2	6/6	0/2	1/6
	3	2/2	6/6	0/2	1/6
	4	16/16	41/48	16/16	48/48

1/ More runs are required for drawdown actions because of the uncertain factors that are specific to drawdown (e.g., length of transition period, survival rate in near-natural river).

Snake River Steelhead

This section discusses survival factors that influence steelhead. It primarily focuses on hydrosystem effects and a discussion of each alternative. Details of the life history stages and effects of harvest and upstream passage are presented in more detail in Appendix A, Anadromous Fish Modeling. Unlike the spring/summer and fall chinook ESUs, no survival or recovery criteria have been developed for this ESU. Because of the many similarities between steelhead and spring/summer chinook salmon, PATH analyzed the performance of each alternative by NMFS relative to predicted changes from conditions for spring/summer chinook salmon.

Survival Factors

As with spring/summer chinook salmon, the smolt-to-adult life stage of steelhead appears to reflect the decline of this stock. However, unlike spring/summer chinook salmon, PATH analysis has not addressed this stock through the use of passage or lifecycle models. Because of data limitations, it is not possible to perform the same type of model analysis as was done for spring/summer chinook salmon. The lack of known information on historical escapement by stock and comparable escapement estimates for lower river steelhead stocks are two of the reasons that similar analyses are not possible. Because of these limitations, the analysis of potential effects of each alternative is more qualitative, relying more on comparisons of effects of each alternative relative to the expected changes in spring/summer chinook salmon stocks.

Spring/summer chinook salmon has many similarities that make it a reasonable surrogate to predict relative changes to steelhead for each alternative. However, several differences occur and were considered in the analysis. Survival of juveniles during downstream passage is monitored similar to spring/summer chinook salmon. The major unknown survival factor is in the estuary and oceans. Also, uncertainty remains a factor for all of these areas included in the smolt-to-adult life stage.

Direct Survival to Below Bonneville Dam

Unlike PATH analysis of spring/summer chinook and fall chinook, detailed passage models have not been developed for steelhead. However, actual empirical measurement methods of survival during passage have been similar. Estimates of total in-river passage survival through the system were developed by Smith and Williams (1999) by expanding reach survival to the whole system (Figure 5.5-7). These recent estimates (1994 to 1997) reflect PIT-tag data for passage through the entire hydrosystem. These data indicate that steelhead that remained in-river have, in recent years, had similar passage survival to those fish in the 1960s when fewer dams were present.

Considering that since the 1970s, a large portion of steelhead have been transported (with direct transport survival of about 98 percent), total direct passage survival in recent years (1990s) would have been higher than even in the 1960s. However, SAR values have not followed this same trend.

SAR values followed the declining direct in-river survival trend through the late 1970s. However, SAR, increased in the late 1970s and 1980s followed by a decline again during the 1990s.

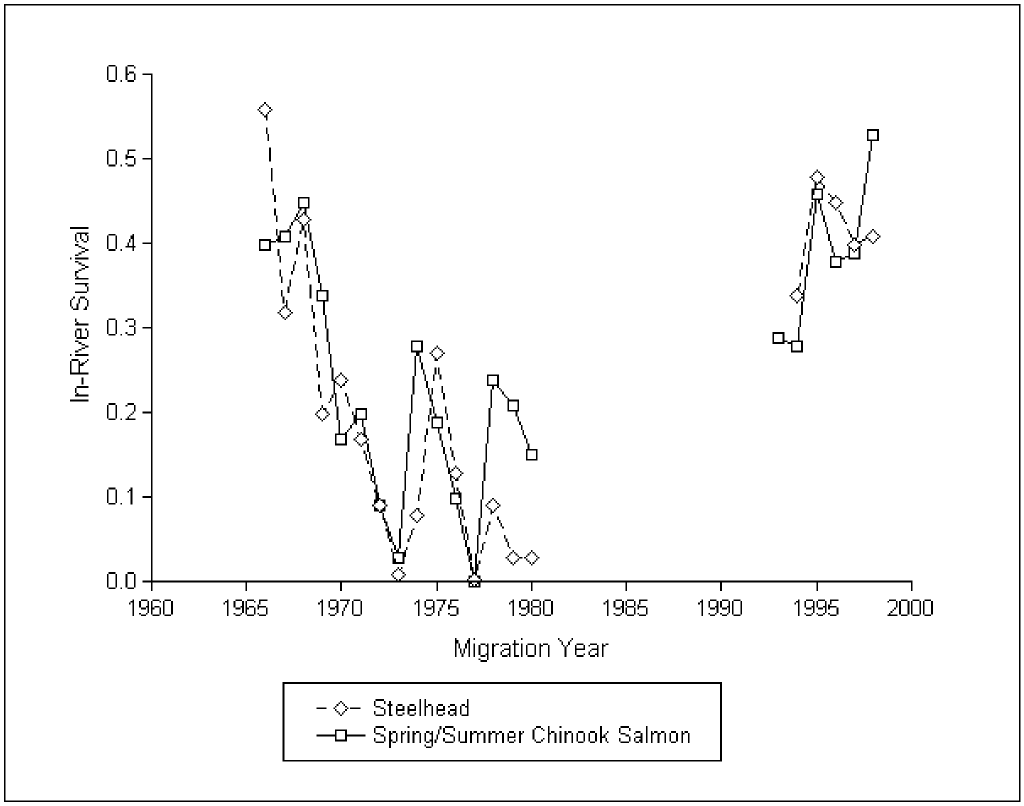
When the region began high voluntary spill under waiver for spring chinook salmon passage, it also affected steelhead. It is well documented that steelhead are more vulnerable to TDG >110 percent, and in the 1990s, after an entire lifecycle, over 4 to 5 years of spill resulted in Columbia and Snake River steelhead listings.

Survival Below Bonneville Dam

Because the most recent (early 1990s) decline in steelhead SARs do not follow direct system passage survival trends, other possible sources of this decline were considered by PATH. Like spring/summer chinook salmon, several possible sources of this additional mortality are considered, including: ocean/climate effects, indirect hydrosystem effects, and reduced stock viability.

Ocean and Climate Effects

Several studies have found correlations between the survival of Northwest steelhead stocks and ocean conditions (Coronado-Hernandez, 1995; Cooper and Johnson, 1992; Welch et al., In Press). Most authors have indicated that ocean conditions and reduced survival, beginning about 1989 and continuing into the 1990s, were correlated. The



Note: Some modifications of measured values are made for comparison purposes.

Source: Appendix A, Anadromous Fish Modeling

Figure 5.5-7. NMFS (In-river) Reach Survival Estimates, Expanded to Represent Survival Through All Lower Snake River and Lower Columbia River Projects in Existence During a Particular Period Using the Method in Smith and Williams (1999) survival patterns observed for some summer steelhead stocks in the Northwest (Coronado-Hernandez, 1995) mimic those of wild Snake River steelhead SARs. Factors such as increases in ocean temperatures after 1977 and anomalous ocean conditions throughout much of the Northeast Pacific after 1990 could be the cause (Watanabe and Nitta, 1999).

Indirect Hydrosystem Passage Effects

Two possible sources of delayed hydrosystem mortality for steelhead were considered by PATH (as they were for spring/summer chinook salmon). These sources were differential delayed transport mortality and delayed bypass system mortality. Data are limited for estimates of delayed transport mortality, with estimates of the D-value for steelhead limited to one year (1995). The D-value for that year was 0.32. This value is much lower than recent spring/summer chinook salmon estimates of about 0.87. Recent work suggests that some additional possible delayed mortality could be attributed to passage through the hydrosystem (Muir et al., 1998). However, the level of effect appears to be dependent on the specific passage route (e.g., spillway, bypass system, or turbine) a steelhead takes while migrating through the system. One explanation for these differences could be the accumulated physiological response to system-wide spill, increasing spill mortality at each dam from gas bubble disease caused by an elevated magnitude and prolonged exposure to TDG concentration greater than 120 percent, even through the estuary. This is a common effect that increases susceptibility to predation for both in-river and transported fish.

Extra Mortality and Reduced Stock Viability

Several sources of extra mortality could be possible for steelhead. Those considered as likely sources include reduced stock viability and delayed hydrosystem effects. The mechanisms for this mortality are the same as those discussed for spring/summer chinook salmon (see earlier section) and are not repeated here in detail. The declining SAR trend, beginning in about 1990, does not follow the increase in numbers of hatchery steelhead released (early 1980s) into the basin. As a result, it is less likely that stress is a major factor of extra mortality for steelhead. If spring/summer chinook salmon escapement criteria are again achieved, it is assumed that steelhead escapement criteria (and SARs) would respond accordingly.

Alternatives Analysis

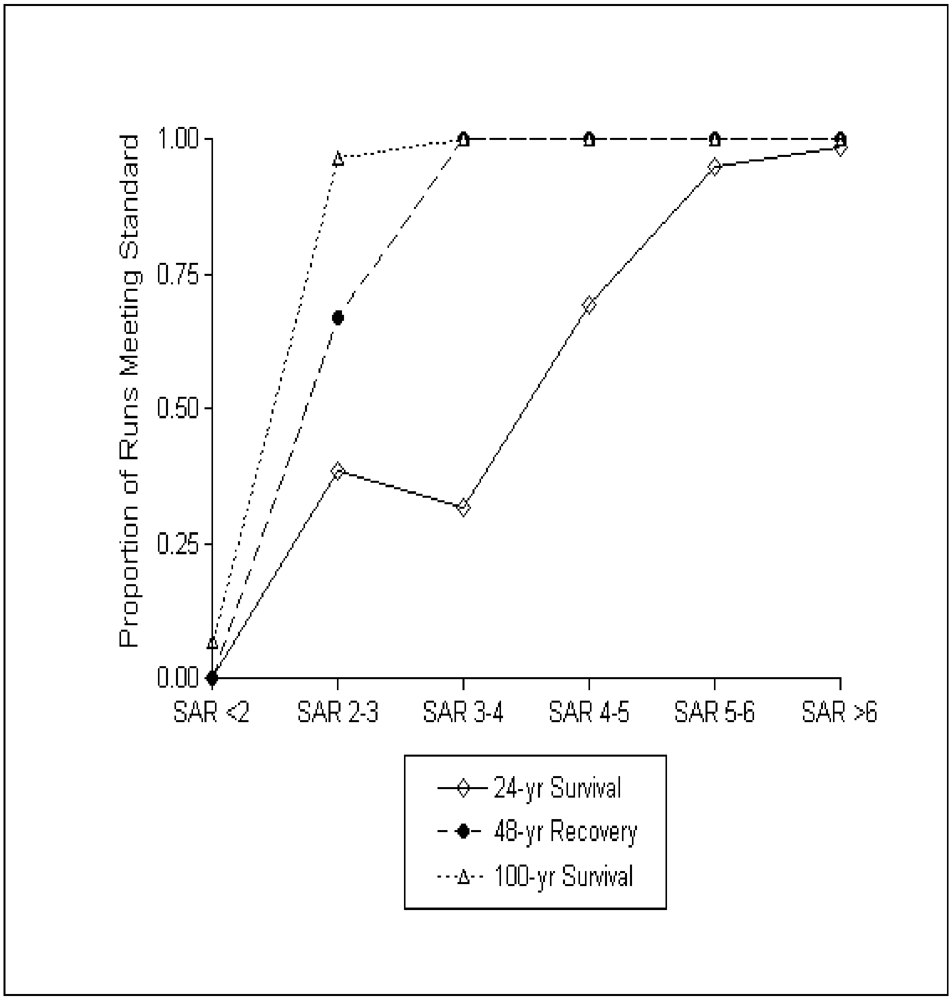
As noted earlier, the analyses used by PATH for steelhead were not performed in the same manner as those for spring/summer chinook salmon. Instead, conclusions about the effects of each alternative were made by inferences from the spring/summer chinook salmon analysis. NMFS used SAR values for spring/summer chinook salmon and steelhead as indicators of the probability of achieving the 1995 Biological Opinion criteria for survival and recovery, as they relate to steelhead. The details of these components are provided in the Appendix A, Anadromous Fish Modeling and are summarized in the following paragraphs.

Analysis of the historical SARs for spring/summer chinook salmon was used to develop survival and recovery levels of escapement for steelhead. It was assumed that historical steelhead SARs would correspond to the same spring/summer chinook salmon escapement criteria. Based on the PATH analysis, several conclusions can be drawn about both the use of spring/summer chinook salmon as a proxy for steelhead and how the analysis influences the estimates of effect of alternatives on steelhead stocks. First, it is apparent that estimated historical SAR values are in the range of those considered suitable for 100-year survival and 48-year recovery criteria, but possibly lower than those for 24-year survival criteria for spring/summer chinook salmon (Figure 5.5-8). This would suggest that historical steelhead SARs should be close to those needed to meet some of the NMFS survival and recovery criteria. The incremental change in SARs needed for steelhead to meet historical levels (assuming a similar relationship to NMFS spring/summer chinook salmon criteria) would be an increase in the current value by about 4 times instead of the 11 times increase needed for spring/summer chinook salmon (Table 5.5-8).

It is expected that the response of steelhead to environmental factors outside of the hydrosystem would be generally similar to spring/summer chinook salmon, but NMFS believes that some differences could occur, as indicated by the difference in SAR trends in the mid to late 1980s. Additionally, PATH did not consider the effect of reduced harvest rate on steelhead, which could contribute substantially to steelhead recovery (see CRI, Subsection 5.5.1.6). Due to the expected similarity of response to hydrosystem conditions, changes in the hydrosystem that achieve the criteria for spring/summer chinook salmon should also do the same for steelhead. Because the incremental change in SARs between current and historical levels is lower for steelhead than it is for spring/summer chinook salmon, meeting the escapement criteria for steelhead would likely take less change in overall hydrosystem survival, if responses to change in the hydrosystem were similar. Reduction in harvest rate would also aid substantially in recovery and would require even less change in hydrosystem survival. This would mean that Alternatives 1, 2, and 3 would more often meet the survival and recovery criteria for steelhead than would be expected for spring/summer chinook salmon. Alternative 4—Dam Breaching would likely have the greatest chance of achieving a comparable steelhead escapement criteria to that of NMFS spring/summer chinook salmon.

Snake River Sockeye Salmon

Specific modeling is not possible for Snake River sockeye salmon because little or no data have been collected for the key components that would be used in the models. Additionally, unlike steelhead, no suitable proxy model from one of the other stocks (i.e., spring/summer chinook salmon, fall chinook salmon) is considered suitable for Snake River sockeye salmon because of known differences or lack of knowledge about similarities to other stocks. While NMFS has suggested the probability of recovery in the proposed recovery plan, there is no way to assess whether these probabilities can be achieved for any of the alternatives.



Note: For example, for model runs resulting in a simulated median escapement SAR between 3.0 and 3.99, slightly more than 30 percent of these runs meet the 24-year survival criterion, slightly less than 70 percent meet the 48-year recovery criterion, and all of them meet the 100-year survival criterion. Certainty of meeting the 100-year survival criterion requires a median escapement SAR of at least 3 percent, certainty of meeting the 48-year recovery criterion requires a median escapement SAR of at least 4 percent, and certainty of meeting the 24-year survival criterion requires a median escapement SAR greater than 6 percent.

Source: Appendix A, Anadromous Fish Modeling

Figure 5.5-8. Probability that Model Runs Resulting in 100-year Median Escapement SAR (Generated by PATH Lifecycle Model as SAR to the Upper Dam) Meet Survival and Recovery Criteria for Snake River Spring/Summer Chinook Salmon

Table 5.5-8. SAR Estimates to Upper Dam[1/] (Escapement SAR) During Historical and Recent Periods for Snake River Spring/Summer Chinook Salmon and Snake River Steelhead

	Snake River Spring/Summer Chinook Salmon	Snake River Steelhead
Historical SAR Range (Geometric Mean)	0.037 – 0.073 (0.049)	0.045 – 0.064 (0.056)
Recent SAR Range (Geometric Mean)	0.002 - 0.011 (0.004)	0.012 – 0.015 (0.013)
Necessary Incremental Change to Achieve Historical Levels (Historical Mean ÷ Recent Mean)	11.2x	4.2x

[1/] Upper dam refers to the most upstream dam during the period when the four lower Snake River dams were constructed.
Source: (Petrosky, 1998a; Petrosky and Schaller, 1998)

Survival Factors

While no modeling information is available, it is apparent that many portions of the lifecycle of Snake River sockeye salmon, including passage through the hydrosystem, are affected in a manner similar to other stocks that do have available information. The smolt-to-adult survival rate has decreased by 90 percent from the period 1955 to1964 to a range of about 0.8 percent to 0.07 percent from 1991 to 1996. This indicates that survival of this stock is similar to other stocks over similar time periods. The following sections discuss what is known about survival of Snake River sockeye salmon both within and outside of the hydrosystem, concentrating on those factors that could be critical for future recovery as it relates to each alternative.

Survival to Below Bonneville Dam

No studies are available on survival of Snake River sockeye salmon smolts as they pass through the hydrosystem, either by transportation or in-river migration. However, there are indications that some hydrosystem effects could be more severe for sockeye salmon than for some of the other stocks. For example, sockeye salmon, on a system-wide basis, are more vulnerable to TDG and gas bubble trauma (GBT) resulting from spill. Also, the descaling rate remains high for sockeye salmon relative to other species, especially for wild sockeye salmon. However, no documentation of increased mortality of sockeye salmon from scale loss is available. Additionally, FGE from turbine screens is lower for sockeye salmon than it is for yearling chinook salmon and steelhead, as determined at McNary and John Day Dams, except when they pass through the most up-to-date ESBSs. Sockeye salmon migrate deeper in the water column, which could account for this difference. This lower FGE could contribute to higher mortality, particularly if fish pass through turbines. Changes in flow rate or velocity have been reduced by reservoirs in the Snake River System. There is an indication that the migration rate of upper Columbia River sockeye salmon does correlate with flow rate and water temperature when these fish pass through the lower Columbia dams.

Survival Below Bonneville Dam, the Estuary, and Ocean

Concerns about the effects of changing ocean conditions, marine mammal predation, and bird predation in the lower river are all possible factors affecting the survival of downstream migrating sockeye salmon (similar concerns exist for other Snake River stocks). However, no specific data are available concerning their effects specific to Snake River sockeye salmon.

There is no information on ocean distribution of Snake River sockeye salmon, so it is not possible to make inferences about changing ocean conditions on these stocks. Specific impacts from bird predation in the lower river have not been determined because so few tagged sockeye salmon are available, but bird predation is very likely an important factor. While adult sockeye salmon have been observed with increasing occurrences of marine mammal wounds when they pass upstream at the dams, overall effects to populations can not be determined (Fryer, 1998).

Hatchery Release Effects

The effects of releasing hatchery fish could be similar to the effects on other Snake River stocks downstream of Bonneville Dam. Again, no specific data are available for this stock. These effects could include stress from encounter with larger fish (e.g., steelhead), increased opportunity for disease transmission, and predation. However, the effect of extended hatchery releases that could result in genetic impacts from cross-breeding with wild stocks is less likely to be a factor for sockeye salmon. The only hatchery operations for sockeye salmon on the Snake River System are those that began in 1991 as part of a captive brood stock program that was initiated to avoid extinction of the stock. Therefore, genetic effects are unlikely at present. However, should the captive broodstock program continue for an extended period, negative genetic effects could result.

Alternatives Analysis

Because of the lack of species-specific information or a suitable proxy stock, good estimations of hydrosystem effects on Snake River sockeye salmon are not possible. Sockeye salmon have a deeper migration route which will reduce their ability to be diverted by screens and transported, and may result in this species being more susceptible to turbine mortality, even with ESBSs. However, spill and screens should help reduce their mortality. Therefore, it is reasonable to assume that actions designed to benefit the recovery of other Snake River stocks should benefit sockeye salmon.

Summary of PATH Model Analysis

PATH model analysis was only available directly or indirectly for three of the four listed anadromous salmonids ESUs in the Snake River. Based primarily on the model results of PATH, consistently higher relative probabilities of exceeding survival and recovery criteria occurred for Alternative 4—Dam Breaching than for Alternatives 1, 2, or 3. Differences in relative probability were most pronounced for the 48-year recovery criteria. However, predictions of the relative differences between Alternative 4—Dam Breaching and any of the other alternatives would be highly dependent on assumed values used for future conditions of one parameter, delayed transport mortality. If this value is low, differences among these two groups are estimated to be relatively large. However, if they are high, differences could be slight.

5.5.1.6 Cumulative Risk Analysis

NMFS has developed the Cumulative Risk Initiative (CRI) to complement the PATH analysis. Unlike PATH, CRI does not rely on large, detailed models. CRI is a chain of connected logical steps, each step simpler and easier to understand than the detailed PATH models. The CRI approach is not intended to replace PATH's detailed examination of modifications of transport or juvenile fish-passage systems. Rather, the CRI offers a more simplified approach to help provide information to make decisions on management options. The CRI approach was intended to address the following four factors that were not adequately assessed by the PATH analysis:

- PATH does not estimate the risk of extinction of index stocks or the effects that a delay in actions would have on risk of extinction.
- The performance criteria used by PATH (based on the 1995 Biological Opinion) are difficult to interpret.
- PATH analysis was intended to assess different fish passage actions (e.g., Alternatives 1 through 4) involving primarily the hydrosystem. While the PATH analysis addresses harvest, habitat, and hatcheries through sensitivity analyses, it is difficult to compare the effects of each among alternatives.
- Because a large number of hypotheses and assumptions are used in PATH, it is difficult to make simple comparisons among major groups of effects.

The details of the CRI analysis are presented in Appendix A, Anadromous Fish Modeling, and are only summarized here. NMFS divided the analysis into several specific steps, including: 1) estimation of extinction risk for specific populations, 2) development of a demographic matrix that includes such factors as juvenile freshwater rearing survival and estuary-early ocean survival, 3) performance of a sensitivity analysis (e.g., effects of changing mortality rates on certain life stages in the demographic matrix such as estuary-early ocean stage), 4) changing values in the demographic matrix to see how they would affect the overall population growth rate relative to what is needed to reduce the risk of extinction, and 5) evaluation and discussion of whether the changes in the matrix values that produced desired results (i.e., reduce the risk of extinction to the desired level) would be biologically feasible. For clarification, the term "demographics" as it was used by NMFS, refers to the abundance and survival rates at certain life stages that affect population growth characteristics of the fish species of interest.

Methods and Performance Measures of CRI Analysis

The CRI analysis has a different approach than PATH for calculation methods and performance measures. The complete details of methods and the differences between the CRI and PATH analysis are presented in Appendix A, Anadromous Fish Modeling. Some of the main differences are as follows:

- CRI does not use density-dependant mortality, making the results more conservative than PATH (i.e., having a lower survival rate than PATH at low numbers of spawners).

- CRI performance measures are estimates of the probability of extinction and changes in average annual population growth rate, while PATH performance measures used comparisons to NMFS "survival and recovery standards."
- "Delayed" and "extra mortality" are not specifically included in CRI.
- CRI uses a demographic matrix model (includes survival rates at various life stages) to estimate current and future population growth rate and risk of extinction for index stocks and ESUs.
- Using the matrix model, CRI evaluates what effects selected survival improvements, at certain life stages (e.g., juvenile freshwater rearing, downstream passage, estuary-early ocean), would have on population growth rate.
- CRI evaluates what changes in management actions (e.g., habitat improvement, harvest rate reduction, fish transport, dam breaching) would have on demographic life stage survivals and on changes in population growth rate.
- CRI analysis evaluates what data exist to support possible conclusions that survival improvements could, in reality, be obtained by dam breaching for hydro or management options in other Hs-like harvest reduction.

The salmonid population data used in the CRI analysis included estimates of the numbers of adult spring/summer chinook salmon, fall chinook salmon, and steelhead returning to the Snake River. For spring/summer chinook salmon, the data included estimates of spawners and respective recruits of seven index stocks over a brood year period of 1957 to 1999. The data were based on estimates developed from redd counts. CRI ran a constructed 1980 to 1999 database to represent lower Snake River hydrosystem configuration as it currently exists. This indicates a better correlation to PIT-tag estimated survivals (1994 to present). For fall chinook salmon, the analysis was based on data for the one wild spawning stock in the Snake River Basin from 1980 to 1996. Steelhead data were used for the whole ESU together and the two groups, Run A and Run B, but could not be used for separate streams because of lack of data. The steelhead analyses evaluated data from 1983 through 1997. All data were the same as the data that PATH developed for its analysis and therefore both CRI and PATH have a common database. Additionally, NMFS used data from Streamnet to estimate population growth rates (and risks of decline and extinction) for spring/summer chinook for which only redd counts were available (Appendix A, Anadromous Fish Modeling).

Extinction Risk Model

The primary purpose of the development of an extinction risk model was to determine the probability and time period of listed ESUs becoming extinct, if no changes in current conditions were to occur. In general, this analysis estimates the chances of Snake River ESUs becoming extinct under Alternative 1—Existing Conditions. As with any estimate of potential extinction, the results from the model developed and used by NMFS have a great amount of uncertainty due to the quality of data and other reasons (Ludwig, 1999).

The extinction risk model was developed as a stochastic exponential decline model and incorporated the methods described by Dennis et al. (1991) to estimate risks. The basic parameter used was spawner count or an index of these counts to estimate trends in population growth.

Also, hatchery escapement to spawning area may have affected both the production of the wild stock and the estimate of wild spawners originating from their parents. A method was developed to consider what effects hatchery fish may be having on estimates of population growth rate of the individual populations (ESUs) and stocks within each ESU.

Independence of density effects is inconsistent with some other analyses on the spring/summer chinook salmon (Schaller et al., 1999). However, over the period of record used by NMFS, the data indicate this assumption appears generally valid because populations are already at very low levels, where density factors have little biological effect.

Part of the NMFS extinction analysis includes the determinations of the population growth rate, λ (termed lambda). Generally, a λ value of greater than 1.0 indicates an increase in the population from one generation to the next, while λ values less than 1.0 indicate a decreasing population over time. Even though an average λ may be greater than 1.0, the population can still have a significant chance of becoming extinct due to factors such as low initial population size and variability of population growth rate from year to year, with some periods having negative population growth (λ less than 1.0).

Where total live spawner counts (i.e., total population) were available, the probability of estimates of absolute extinction (no spawners for an entire generation) over a 24- and 100-year period were made. Different level of risk was measured for those stocks where only index information (e.g., redd counts per mile) was available. For these stocks, the probability of a 90 percent decline in the index count was determined for the same periods. Absolute extinction for Snake River ESUs was determined for seven index stocks of spring/summer chinook, all fall chinook as one stock, and the two groups (A-run and B-run) of steelhead. The 90 percent decline probability was also determined for several index stocks of spring/summer chinook where absolute population estimates were not made. The estimates were made with two types of assumptions about hatchery stock considerations for all of these species. One consideration assumed that hatchery fish spawning in the wild produced no returning fish. The other consideration assumed hatchery stocks spawning in the wild produced the equivalent number of fish per individual as native wild spawning fish.

Demographic Matrix Model

NMFS (Appendix A, Anadromous Fish Modeling) developed a matrix model to use in exploring quantitative lifecycle characteristics, particularly where mortality occurs for listed stocks. In addition to the extinction model, this was deemed by NMFS to be necessary to help explore where opportunities for recovery may occur. For this matrix, NMFS adopted year-class as one way to iterate salmonid populations from one year to the next. Examples of these matrices are presented in Appendix A, Anadromous Fish Modeling. Generally the matrices provide a basis for calculating the survival and abundance at different life stages for a given stock of interest. The basic matrices are flexible and can accommodate a variety of conditions like individual dispersal between populations, impacts of the four Hs, environmental variability and uncertainty in parameter estimation, as well as other items, as indicated in Appendix A, Anadromous Fish Modeling.

Most importantly, because this matrix framework is supported by rich underlying statistical and mathematical theory (Caswell, 1989), it has become a standard tool for managing threatened and endangered species (Crouse et al., 1987; Crowder et al., 1994; Doak et al., 1994; Horvitz and Schemske, 1995). Details on the use of the matrix can be found in Appendix A, Anadromous Fish Modeling, along with values calculated for spring/summer chinook salmon stock. As with the extinction model, one of the components calculated in the model was λ.

Extinction Risk and Effect of Population Growth Rate

Population recovery and extinction risk are inversely related. The extinction risk is primarily affected by two factors—existing population size (number of adults) and population growth rate. In general, higher population growth rates are needed for smaller populations to have similar effects at reducing the risk of extinction than for larger populations. The following sections summarize the result of the extinction risk model for each ESA listed salmonid species in the Snake River. Sockeye salmon were not evaluated, as discussed in the previous section.

Spring/Summer Chinook Salmon

The extinction risks and population growth rate for spring/summer chinook were determined for both the whole ESU and individual stocks within the ESU. The estimated extinction risk for the seven index stocks having population estimates, assuming hatchery fish do not spawn successfully, for the short term (24 years) is mostly low (only one stock with 5 percent chance of extinction). But risk increases substantially for the long term under current conditions (Alternative 1—Existing Conditions) with 4 of 7 stocks having greater than a 5 percent chance of extinction within 100 years (Table 5.5-9). Even in the long term, only one stock has greater than a 21 percent chance of extinction. Also, at the ESU level, both short- and long-term risk of extinction remains low under current conditions (less than 1 percent probability). The relative increase in growth rate (λ) to ensure there is less than a 5 percent chance of absolute extinction in the long term, is less than or equal to 10 percent for all stocks, with most less than 3 percent (Table 5.5-9).

In the short term, the chance that stocks will decrease by 90 percent is moderately high, with 4 of 7 stocks having greater than a 10 percent chance of decreasing by 90 percent in 24 years. By 100 years, the chance of stocks decreasing by 90 percent increases substantially and the whole ESU has a 91 percent chance of decreasing by 90 percent in this period, under current conditions. The required increase in growth for the ESU is about 3.5 percent to prevent this rate of decline, 4 of the 7 stocks need a 5.5 percent increase or more in growth rate to prevent this decline.

Table 5.5-9. Estimated Population Size (Wild Only), Growth Rate (λ), Risk of Extinction and 90% Decline in Abundance, and Needed Improvements in λ to Reduce Risk of Decline or Extinction in 100 Years to below 5% for Snake River Basin Stocks[1/]

		Population Parameter Estimates				Risk of Extinction			Risk of 90% Decline		
				95% Confidence Interval							
ESU	Stock	Population Size Estimate [2/]	Average Population Growth Rate (λ)	Low	Up	24 yrs	100 yrs	Required Increase in λ (%)	24 yrs	100 yrs	Required Increase in λ (%)
Spring/Summer Chinook Salmon	**ESU Level**	**23,336**	**0.96**	**0.91**	**1.02**	**0.00**	**0.00**	**0.0**	**0.00**	**0.91**	**3.5**
	Bear Creek	736	1.02	0.83	1.25	0.00	0.03	0.0	0.07	0.15	3.0
	Imnaha River	657	0.93	0.83	1.03	0.00	0.78	5.5	0.33	1.00	9.5
	Johnson Creek	457	1.01	0.90	1.14	0.00	0.00	0.0	0.01	0.07	0.5
	Marsh Creek	291	0.99	0.82	1.19	0.00	0.19	3.0	0.13	0.39	5.5
	Minam River	338	0.99	0.80	1.23	0.00	0.17	3.0	0.13	0.33	5.5
	Poverty Creek	1,051	1.01	0.86	1.17	0.00	0.01	0.0	0.04	0.16	2.0
	Sulphur Creek	207	1.04	0.74	1.47	0.05	0.21	7.0	0.15	0.17	8.5
Fall Chinook Salmon	**ESU Level**	**1,505**	**0.94**	**0.81**	**1.09**	**0.00**	**0.40**	**3.5**	**0.24**	**0.96**	**8.5**
Steelhead	**ESU Level**	**39,809**	**0.91**	**0.86**	**0.97**	**0.00**	**0.13**	**1.0**	**0.48**	**1.00**	**9.5**
	Snake River A-run	33,603	0.93	0.87	0.99	0.00	0.01	0.0	0.20	1.00	7.5
	Snake River B-run	11,833	0.89	0.81	0.98	0.00	0.93	5.0	0.73	1.00	12.5

1/ Estimates assume hatchery fish do not reproduce.
2/ Population estimate is of total living current and future spawners. ESU levels are for Lower Granite Dam for all except Snake River fall Chinook, which was reconstructed from redd counts.
Source of data, Appendix A, Anadromous Fish Modeling

If the assumption of hatchery fish contributing to spawning success were true, then the risk of extinction for all stocks would change little in the short term, but would increase substantially in the long term (Table 5.5-10). All stocks and ESUs would still have a 5 percent or less chance of extinction in the short term under this model assumption. But in the long-term, the chance of extinction is 100 percent of the ESU. For the long-term conditions at the ESU level, the growth rate would have to increase by 17.5 percent to reduce the risk of extinction to less than 5 percent. Also, to reduce risk of a 90-percent decrease in population abundance, growth rate would have to increase by 28 percent for the ESU. At the individual stock levels, the overall risk of extinction, and decrease of population by 90 percent, is less than at the overall ESU levels. It should be remembered that this is not a measured negative effect of hatchery fish but a model effect because the assumed number of successful spawners is larger, making the smolt-to-adult ratio lower.

NMFS also examined the trends of an additional 34 index stocks of Snake River spring/summer chinook that only had index counts, not total population estimates (See Appendix A, Anadromous Fish Modeling, Annex I for data presentation). For these stocks, only the relative change could be determined. Therefore, the extinction probability could not be estimated. Of these 34 stocks, all but 2 had an estimated growth rate less than 1.0, indicating declining populations trends for each. Of these stocks, a majority (23) had a greater than 10 percent chance for a population decrease of greater than 90 percent in 24 years. Only 6 stocks had less than a 10 percent chance of at least this magnitude of decline in 100 years.

Generally, under short-term conditions the chances of extinction are low, but become high in the long term for some of the 7 main index stocks. However, it is moderately likely that individual stocks will decrease substantially in a 24-year period. Over the long term, the trend is assuredly negative if current conditions remain as estimated. Other index stocks suggest similar declining trends. However, relative changes in population growth rates needed to increase these declines are relatively low for most stocks. But these trends are generally worse if hatchery fish are spawning successfully.

Fall Chinook Salmon

The whole Snake River Fall Chinook Salmon ESU is considered primarily one stock that spawns in the mainstem Snake River upstream of Lower Granite Dam. The risk of extinction is low (less than 1 percent) in the short term, but increases to 40 percent in the long term under the assumption of no hatchery fish contribution to production (Table 5.5-9). Population growth rate (λ), which is estimated to average 0.94, would need to increase by 3.5 percent to reduce the risk of extinction to less than 5 percent in 100 years. Even though the chance of extinction is low in the short term, the estimated chance of a 90 percent decrease in the population in 24 years is moderately high, at 24 percent. The estimated long term (100 years) chance of a 90 percent decrease in population is 96 percent. The population growth rate (λ) would need to increase by 8.5 percent to reduce this risk of a 90 percent population decline in 100 years.

Table 5.5-10. Estimated Population Size (Wild and Hatchery), Growth Rate (λ), Risk of Extinction and 90% Decline in Abundance, and Needed Improvements in λ to Reduce Risk of Decline or Extinction in 100 Years to below 5% for Snake River Basin Stocks[1/]

			Population Parameter Estimates			Risk of Extinction			Risk of 90% Decline		
				95% Confidence Interval							
ESU	**Stock**	**Population Size Estimate [2/]**	**Average Population Growth Rate (λ)**	**Low**	**Up**	**24 yrs**	**100 yrs**	**Required Increase in λ (%)**	**24 yrs**	**100 yrs**	**Required Increase in λ (%)**
Spring/Summer Chinook Salmon	**ESU Level**	**72,497**	**0.80**	**0.70**	**0.91**	**0.00**	**1.00**	**17.5**	**1.00**	**1.00**	**28.0**
	Bear Creek	736	1.02	0.83	1.25	0.00	0.03	0.0	0.07	0.15	3.0
	Imnaha River	1,175	0.87	0.79	0.96	0.00	1.00	10.5	0.88	1.00	15.5
	Johnson Creek	457	1.01	0.00	0.00	0.00	0.00	0.0	0.01	0.07	0.5
	Marsh Creek	291	0.99	0.82	1.19	0.00	0.19	3.0	0.13	0.39	5.5
	Minam River	582	0.92	0.74	1.15	0.02	0.77	11.0	0.43	0.93	14.5
	Poverty Creek	1,055	0.99	0.84	1.17	0.00	0.05	0.5	0.09	0.35	4.5
	Sulphur Creek	207	1.04	0.74	1.47	0.05	0.21	7.0	0.15	0.17	8.5
Fall Chinook Salmon	**ESU Level**	**2,199**	**0.86**	**0.00**	**0.00**	**0.00**	**1.00**	**10.0**	**0.99**	**1.00**	**16.0**
Steelhead	**ESU Level**	**379,578**	**0.70**	**0.69**	**0.71**	**0.00**	**1.00**	**26.5**	**1.00**	**1.00**	**40.5**
	Snake River A-run	299,161	0.72	0.71	0.73	0.00	1.00	23.5	1.00	1.00	37.0
	Snake River B-run	100,455	0.73	0.71	0.75	0.00	1.00	26.0	1.00	1.00	38.0

[1/] Estimates are provided for individual stocks and ESUs. Estimates assume hatchery fish reproduce at same rate as wild fish.
[2/] Population estimate is of total living current and future spawners. ESU levels are for Lower Granite Dam for all except Snake River fall chinook which was reconstructed from redd counts.
Source of data, Appendix A, Anadromous Fish Modeling

Model results that assume successful hatchery fish spawning increase the estimated risk of extinction and substantial reduction in the population (Table 5.5-10). The short-term chance of extinction, however, remains low (less than 1 percent) primarily because of the moderately large initial population average, even though average population growth rate is estimated to be low (0.86 percent). Long-term extinction would be assured (100 percent) under this set of assumptions under current conditions. Growth would need to increase by 10 percent in order to reduce this long-term risk of extinction. The rate of substantial population decline, even in the short term, is also assured with a 99 percent chance of reduction of population abundance by 90 percent in 24 years if hatchery fish spawn at the same success level as wild fish. Population growth rate increases would need to be substantial, at 16 percent, to reduce the risk of a large reduction in population abundance within 100 years.

Steelhead

While specific tributary data are not available to estimate risk for individual steelhead stocks, there is information to assess these risks to two major groups, Run A and Run B, for Snake River steelhead in addition to the whole ESU (Table 5.5-9). The runs size estimate for this ESU is based on counts at Lower Granite Dam. Under the assumption of no hatchery fish contribution, risk of extinction is low for the ESU and Run A and B. Over the long term, the chance extinction for the ESU increases to 13 percent. Of the two stocks, Run B appears to be at greater risk of extinction with a 93 percent chance of extinction within 100 years. Run A would appear to be able to avoid extinction in the long term, with only a 1 percent chance of extinction. Again, the initially large population of this ESU and 2 major stocks are the main reason extinction is reduced in the short term and long term as indicated by the high chance of 90 percent reduction in population even in the short term for the ESU and each stock. A 90 percent reduction within 100 years is assured (100 percent) for the ESU and Runs A and B. However, fairly minor increases in population growth rate would be needed to prevent extinction of this ESU, which would require only a 1 percent increase in population growth rate to reduce extinction to slight levels. For Run A, which accounts for the majority of this ESU, no increase would be required, while Run B would need a 5 percent increase. To reduce the large decline in population abundance over 100 years would require much larger changes in growth rate, being 9.5 percent for the total ESU and even higher for Run B (12.5 percent).

Because of the very high abundance of hatchery fish (about 10 times that of wild steelhead), the modeled assumption which includes successful spawning of hatchery fish greatly increases the chance of extinction and population declines for steelhead. Should this assumption be true than steelhead would be in the greatest danger of extinction and large population decline of the three species evaluated (Table 5.5-10). Growth rate would be low, only 0.7 for the ESU and similar for the two runs. However, even with this low growth rate the chance of extinction in the short term remains very low, again primarily because of the relatively large populations that already exist. But in the long term all stocks would become extinct under these assumptions with current conditions. Population growth rates would have to increase substantially to prevent extinction being 26.5 percent for the ESU and similar for the two runs. Because of the low growth rate there is a 100 percent chance of both the short and long term populations of the ESU and specific runs to decrease by at least 90 percent. To prevent this decrease would require very large changes in growth rates, being 40.5 percent for the ESU and only slightly lower for the individual runs.

Overall in the short term under either set of assumptions steelhead are unlikely to go extinct. However, because tributary stocks cannot be evaluated, it is not possible to determine their fate with these methods, but it is likely some could go extinct if hatchery fish are contributing significantly to returning adult production. If hatchery fish do not contribute to runs, then minor increases in growth rate could prevent extinction in the long term, but more moderate growth rate increases would be needed to prevent large reductions in this ESU. The evaluation of this ESU, more than any other in the Snake River, is influenced by the assumptions about hatchery fish contribution to production. This make prediction of future stock status difficult without better information on hatchery fish contribution.

Demographic Matrix Model Results

It is important to understand how changes in survival of specific life stages will affect overall population growth rate because factors that affect λ also affect the recovery of stocks. In this way, an evaluation of the important factors that may affect stocks, both within and outside of the hydrosystem, can be assessed. NMFS and Kareiva et al. (2000) used the demographic matrix models to determine the sensitivity of population growth rates to past, current, and hypothetical changes in specific life stage survivals as a way of presenting how various types of actions (e.g., dam breaching, harvest reduction, fish transport, habitat improvement) may influence recovery. The NMFS analysis and that developed by Kareiva et al., 2000 are summarized in the following sections.

Spring/Summer Chinook Salmon

Kareiva et al. (2000) used an age-structured matrix model (Caswell, 1989; Ratner et al., 1997) for Snake River spring/summer chinook salmon to describe the population decline and explore the demographic effects of reducing mortality at different life history stages (Appendix A, Anadromous Fish Modeling). The matrices isolate survival during upriver and downriver migration from survival in other life history stages, allowing direct examination of the effect of mortality during in-river migration on population growth (i.e., measured as λ).

This analysis was done by examining the response of seven spring/summer chinook salmon index stocks, that have been used in other evaluations, using the survival and growth parameters for the recent brood years of 1990 to 1994 as the baseline conditions. This analysis indicated that under current conditions all seven stocks are in decline as indicated by decreasing population growth rate (i.e., λ less than 1) (Figure 5.5-9). This analysis also found that even assuming 100 percent downstream passage survival (which would not be possible even under natural river conditions), and eliminating all harvest (except minor tribal harvest) allowing all upstream migrating adults to reach the spawning ground, that all of these stocks would continue to decline (Figure 5.5-9). While the assumptions of achieving 100 percent on survival are not realistic under any scenario, they point to the fact that managing solely to improve in-river migration survival, either through system improvements or dam breaching, will not eliminate the decline of these stocks.

The effects of past management actions on spring/summer chinook was also examined to help put the current options into perspective. Three management actions were examined (i) reductions of harvest rates, from approximately 50 percent in the 1960s to less than 10 percent in the 1990s (Beamesderfer et al. (1998), (ii) engineering improvements increasing juvenile downstream migration survival rates from approximately 10 percent just after the last turbines were installed, to 40 to 60 percent in most recent years (Williams et al., 2001), and (iii) transportation of approximately 70 percent of juvenile fish from the uppermost dams to below Bonneville Dam, the lowest dam on the Columbia River (Marmorek et al., 1998a). If such improvements had not been made, rates of decline would likely have been 50 to 60 percent annually (Figure 5.5-10), and spring/summer chinook salmon may well have already disappeared from the Snake River. Hence, past management actions have reduced in-river mortality, but have not eliminated population declines.

To explore what magnitude of survival changes are needed in other portions of the Snake River salmon's life history to increase population growth to acceptable levels, Kareiva et al. (2000) examined the effects of increased first year survival in fresh water (i.e., egg to smolt stage) and early ocean/estuarine survival. Later ocean stages were not examined because enhancement in the ocean is limited and ocean harvest on this stock slight. This analysis was done using the Poverty Flats stock as it has median survival of the seven index stocks. The survival values needed to produce the minimum growth rate (λ =1.0) to prevent a declining trend were calculated. Because these models often overestimate true growth rate, survival values needed to result in an increasing growth rate of 10 percent (λ = 1.1) were also evaluated. The model results indicated a first year survival increase of 6 percent or early ocean/estuarine survival of 5 percent would produce a growth rate just preventing decline of the Poverty Flats stock (λ =1.0) (Figure 5.5-11). If reductions in mortality are simultaneously accomplished in both the first year of life and the early ocean/estuarine stages, then the combinations of mortality reductions required to produce a growth rate to equal 1.0 are as modest as a 3 percent reduction in first-year mortality and a 1 percent reduction in early ocean/estuarine ocean mortality. To achieve a more protective 10 percent annual growth rate, first-year mortality must be reduced by 11 percent, or early ocean/estuarine mortality must be reduced by 9 percent.

Concerning this alternative analysis, many questions remain that can not be answered with available data. Alternative 4—Dam Breaching has the potential to affect some portions of the lifecycle neutrally, positively or negatively depending on what assumptions are ultimately true about factors that affect their survival. Breaching will not affect spawning because the spring/summer chinook spawn well upstream of the lower Snake River dams. Breaching may affect estuarine conditions, possibly increasing survival in the estuary. But breaching would also eliminate barging of fish. Barging is known to have very high direct survival, but the question of how much delayed mortality (e.g., D value) results from this has not been accurately determined. Current best estimate of D is around 0.63 to 0.73 (i.e., transport fish survive at 63 to 73 percent the rate of non-transported fish) for this ESU. Breaching would eliminate this delayed mortality. Fish traveling downstream without four of the eight dams may have increased physiological vigor, possibly increasing estuarine survival. Additionally, "extra mortality" of fish, which may result from fish passing through the impounded modified river system or being transported, may be reduced with fewer dams. If this extra mortality, for example, were to be reduced by at least 9 percent as result of dam

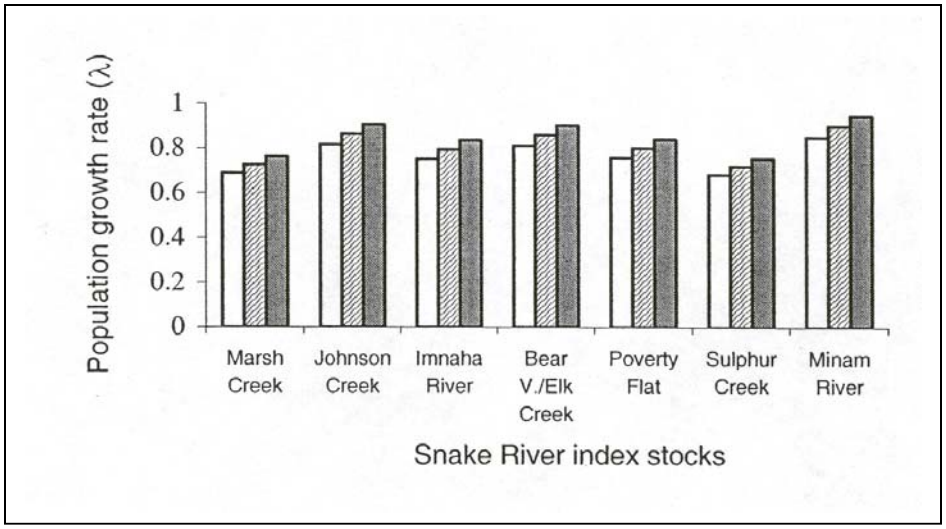


Figure 5.5-9. Numerical Experiments Exploring 100 Percent Survival During In-river Migration

Note: Baseline matrices (clear columns) were adjusted to simulate 100 percent survival during downstream migration (hatched columns) and 100 percent survival during both downstream and upstream migration (shaded columns) (Kareiva et al., 2000).

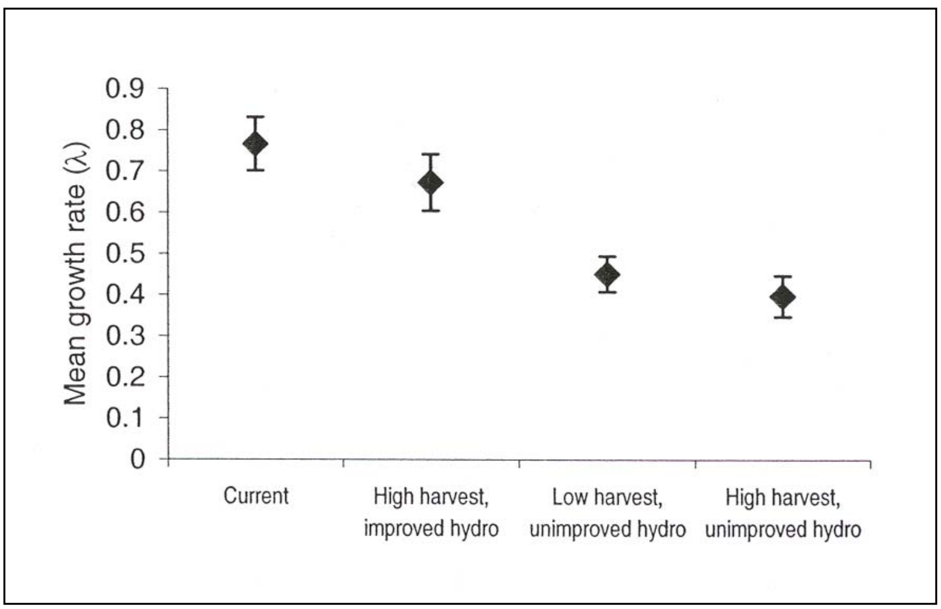


Figure 5.5-10. Effectiveness of Past Management Actions Targeting In-river Survival of Snake River Spring/Summer Chinook Salmon

Note: "Unimproved hydro" assumes current conditions except no transportation of juvenile fish and survival through the hydrosystem is set at rates estimated for 1997 to 1979; "high harvest" assumes current conditions, except harvest rates from 1960 to 1970 are used (error bars are ±1 SD) (Kareiva et al., 2000).

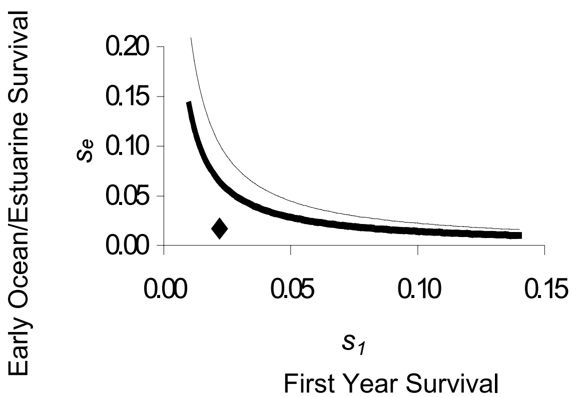


Figure 5.5-11. Isoclines Calibrating Improvements in First Year (s_1) and Early Ocean/Estuarine (s_e) Survival for Poverty Flat Index Stock of Snake River Spring/Summer Chinook Salmon

Note: Target λ - 1.0 (thick line) and 1.1 (thin line). To produce isoclines, first year survival was incrementally increased and values of early ocean/estuarine were searched for the smallest value causing λ to exceed the target λ. The black diamond is current Poverty Flats estimate. Current parameter values are shown for reference (Kareiva et al., 2000).

breaching, then the Snake River spring/summer chinook decline could be reversed (Kareiva et al., 2000). However, estimating the magnitude of any indirect mortality from passage through the Snake River dams is difficult and to date has not be done with needed accuracy to allow good estimations of the effects of these facilities. Also, even if the four Snake River dams were breached, fish would still need to pass another four dams on the Columbia River whose independent "extra mortality" factors also remain unknown.

Alternative 4—Dam breaching is unlikely to reduce substantially the risk of extinction unless survival below Bonneville Dam as a result of the breaching is increased substantially. While modest increases in first year survival and/or early ocean/estuarine survival could stop the decline of this ESU, the actual methods, mechanisms, and feasibility of these actions are out of the scope of this document. In conclusion, dam breaching by itself is not likely to recover this ESU unless this action has substantial effects on survival outside of the system. Information is currently not available to make this determination.

Fall Chinook Salmon

The matrix analysis for fall chinook salmon differs slightly from spring/summer chinook salmon because these two species have different life histories and harvest rates. Unlike spring/summer chinook salmon, fall chinook salmon migrate to the ocean in their first summer and spend more time rearing in the mainstem lower Snake River and ocean. Another major difference is that fall chinook salmon have a much higher harvest rate in both the ocean and river.

NMFS developed a sensitivity analysis to determine what effect a reduction of 10 percent in the rate of mortality for specific life stages would have on the overall population growth rate (λ). The results of a sensitivity analysis, that addressed the question of what effect saving "1 in 10 fish" (10 percent reduction in mortality) by life stage, would have on annual population growth rate (λ) are presented in Figure 5.5-12. The effect of reducing mortality in the first year of life by 10 percent had by far the largest effect on population growth rate. Reducing mortality for this life stage was estimated to increase λ by over 80 percent, while a 10 percent reduction in mortality in any of the other life stages would increase λ by less than 5 percent. The first year of life includes more periods of major mortality for fall chinook salmon than for spring/summer chinook salmon. This life stage includes egg-to-smolt mortality, estuarine/early ocean mortality, and downstream passage mortality. Generally, because this life stage can encompass a large portion of potential total lifecycle mortality, saving 10 percent of these fish would include many more fish than any other modeled matrix life stage for the same rate of reduced mortality.

Based on results of the demographic matrix analysis, a reduction in harvest rates of fall chinook salmon could achieve the objective of reducing the probability of extinction to meet NMFS survival and recovery criteria. Increasing λ by only 4 percent would result in the extinction probability being reduced to the NMFS risk threshold probability level of 1 percent in 100 years. Even though harvest rates have been greatly reduced since 1993, the NMFS recommended annual population growth rate could be achieved by reducing either current ocean or mainstem harvest rates by 75 percent, or by reducing

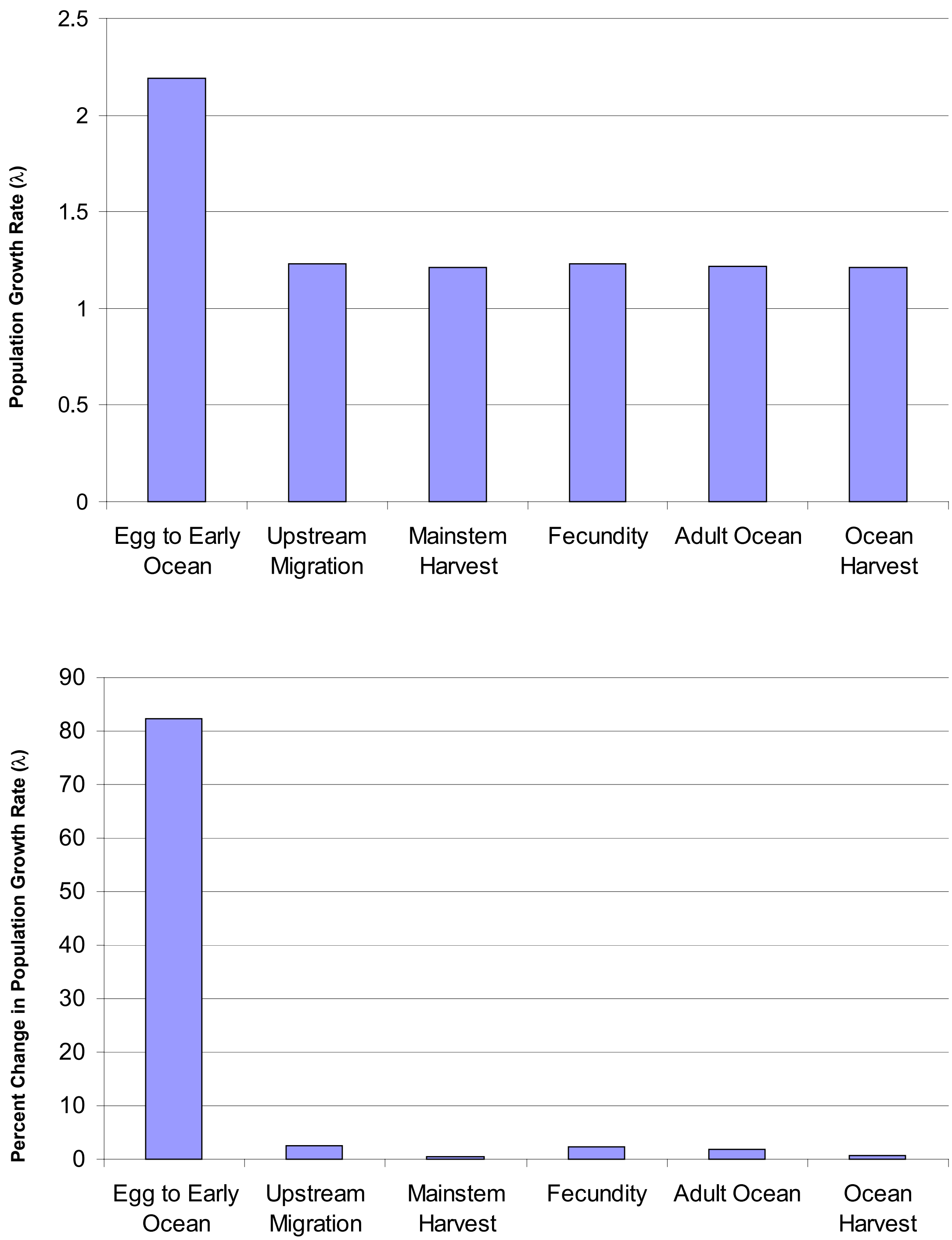


Figure 5.5-12. Population Growth Rate (λ) for Fall Chinook Salmon and Percent Change in Population Growth Rate with 10 percent Reduction in Mortality During Different Life Stages

both by 50 percent each (Figure 5.5-13). Thus, harvest reduction is a biologically reasonable management option for recovery of Snake River fall chinook salmon.

Assessing the effects of Alternative 4—Dam Breaching is more difficult because there is a paucity of data on downstream passage survival and portion of fish transported. However, most benefits from this alternative would likely occur during the first year of life, which includes downstream migration and estuarine/early ocean rearing, where any latent effects (e.g., delayed transport mortality, extra mortality) of the hydrosystem may occur. Currently, the lower Snake River is primarily a migration corridor for subyearling fall chinook salmon with some rearing in the lower Snake River reservoir. Some fall chinook may pass through the lower Snake River as premature smolts to rear in either the lower Snake River or the McNary reservoir (Paulson, 1998 and Peters et al., 1999). The utility of these areas as sustainable rearing areas in the future is relatively uncertain. However, it could include some of the fish that have been documented to overwinter and outmigrate as yearling fall chinook salmon from this system. If this were to occur, overall smolt to adult returns for these fish may increase as indicated by the few fish that have been observed as yearling fall chinook salmon. The effects on λ from changes in survival of this life stage, for example, range from about 2.5 percent in λ for a 10 percent increase in survival, to about 16 percent for an increase in λ for a survival increase of about 80 percent (Figure 5.5-14). If dam breaching was to result in a 20 percent increase in survival for the juvenile freshwater/early ocean life stage, a 4 percent increase in λ would occur. This would achieve the NMFS threshold value of less than 1 percent chance of extinction in 100 years (Figure 5.5-14). The likelihood of this level of improvement occurring from dam breaching remains relatively uncertain. However, as noted in earlier sections, dam breaching would also have the advantage of enhancing fall chinook salmon production by providing about 34 miles of additional spawning habitat suitable for an estimated 5,000 additional spawners in the newly unimpounded river reach. However, presence of spawning habitat in this reach may cause problems for native Snake River fall chinook salmon. Because of the high rate of straying that currently occurs into the lower Snake River, it is possible that these non-native stocks may utilize this newly developed spawning area, possibly mixing with native stocks and ultimately changing the genetic characteristics of the native stock.

Steelhead

There was insufficient steelhead data to conduct a demographic matrix analysis similar to the one conducted for spring/summer and fall chinook salmon. However, as discussed earlier, NMFS evaluated what level of change in λ would be needed to reduce the risk of extinction to 5 percent in 100 years. As noted in Table 5.5-10, an increase of λ of only 1.0 percent would achieve this level of reduced extinction risk. The estimated population growth of the ESU is 0.91, indicating a declining trend. The estimated current harvest rate for the aggregate steelhead stock is 0.2. If this harvest were eliminated, λ would increase by 4.4 percent (McClure et al., 2000). This level of increase would reduce the risk of extinction within 100 years to less than 5 percent. However, the growth rate is estimated to remain at 0.95, which indicates the population would remain in decline. Also, the harvest rates of the two runs (A and B) are likely different. Additionally, Run B has a lower growth rate. Run B needs an estimated 5 percent increase in λ to reduce the risk of extinction to 5 percent in 100 years. If hatchery fish currently contribute to production (see earlier discussion), the needed increase in λ would be even greater.

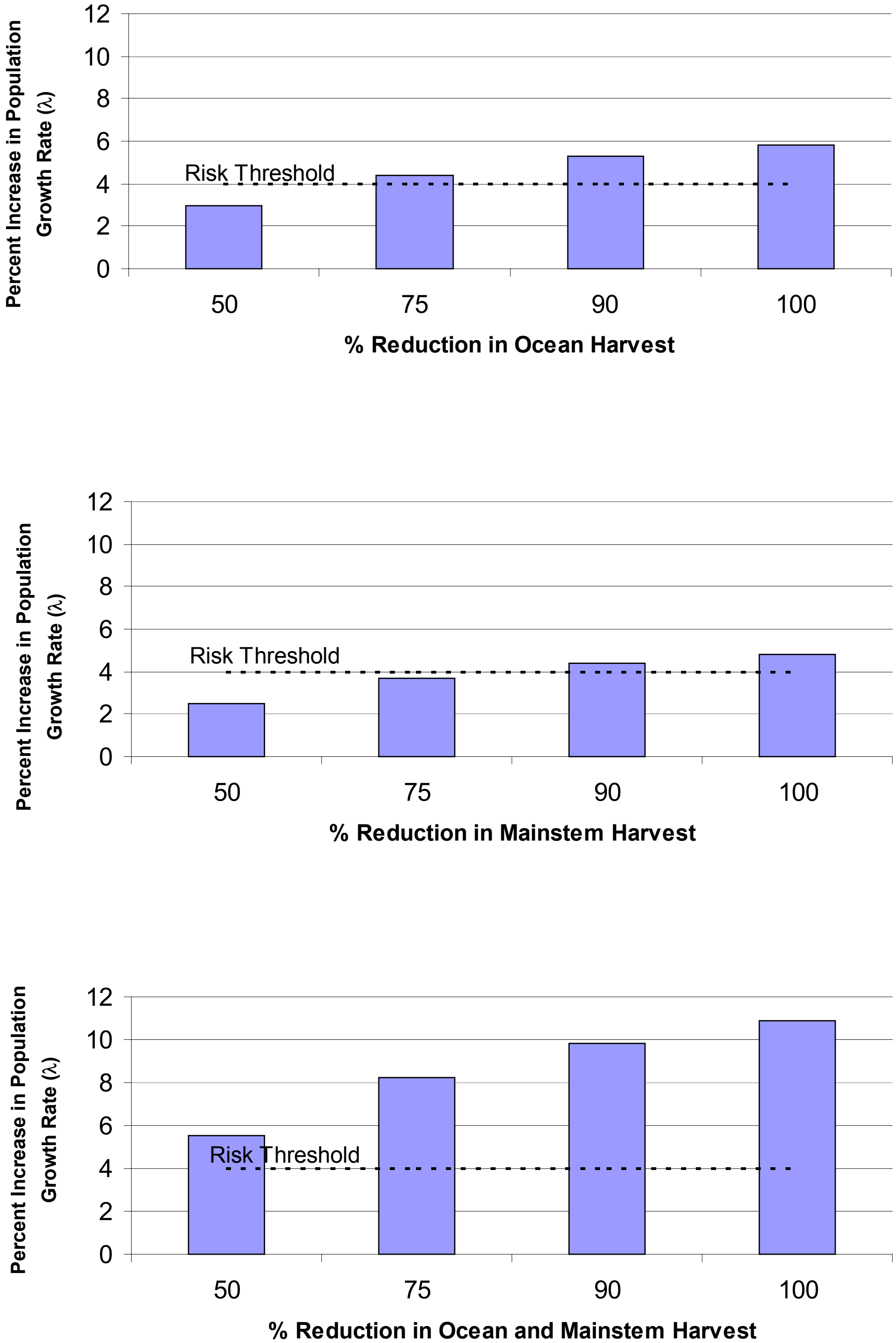


Figure 5.5-13. Percent Increase in Fall Chinook Salmon Population Growth Rate (λ) Relative to an Extinction Risk Threshold over a Range of Ocean and Mainstem Harvest Reductions

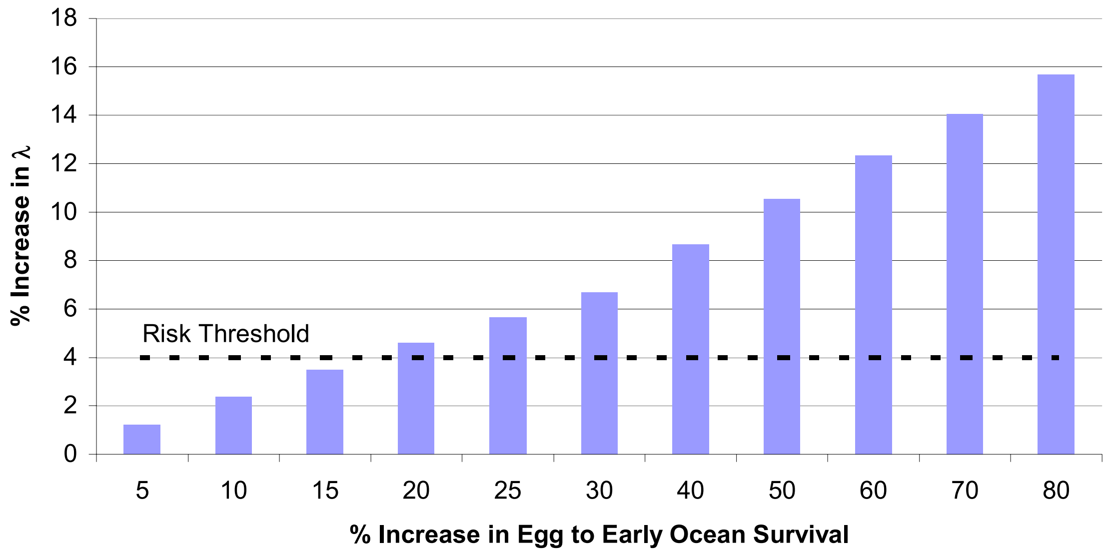


Figure 5.5-14. Percent Increase in Fall Chinook Salmon Population Growth Rate (λ) Relative to an Extinction Risk Threshold Over a Range of Relative Increases in Egg to Early Ocean (First Year) Survivals

These results suggest that even if all harvest could be eliminated, this ESU would at least continue to markedly decline and some stocks could possibly have an unacceptable risk of extinction within 100 years.

The impact of dam breaching on steelhead is much harder to evaluate because the steelhead lifecycle is complicated and data on other life stage survival rates are almost entirely non-existent. While dam breaching would increase in-river passage survival, the overall effect on survival and ultimately any increase in λ cannot be determined by CRI analysis as to whether it would be sufficient to restore this ESU without harvest reduction. By analogy, if the result is similar to spring/summer chinook even if total direct passage survival were increased to 100 percent from breaching, it would not be sufficient to restore runs without improved survival from other actions (e.g., harvest reduction, increased first year survival from habitat improvements). Restoration from this action alone would only occur if dam breaching resulted in reduction of "indirect mortality" or in substantial increases in early ocean/estuary survival.

Limitations of CRI Analysis and Summary

NMFS noted several limitations to the CRI analysis. Generally, the analysis does not deal directly with many of the details that are and can be analyzed by the PATH and does not account for potential changes in production with changing abundance. For example, it does not include effects of flow and individual hydrosystem changes at dams on population growth rate. Also, it does not have a mechanism for incorporating changes to the demographic matrix from specific management actions. It is also not able to incorporate factors like potential changes in ocean condition or catastrophic events.

Also, comments on the CRI analysis point out that the probability of extinction is not equivalent to the probability of recovery, and the rate would need to be higher for λ to achieve recovery. These and other limitations are explained in more detail in Appendix A, Anadromous Fish Modeling.

Several conclusions can be drawn from the CRI analysis:

The CRI analysis indicates that no amount of improvements in in-river survival, including those estimated for dam breaching (Alternative 4—Dam Breaching), alone can stop declines of spring/summer chinook. To reverse current trends Alternative 4—Dam Breaching would have to result in an early ocean/estuarine reduction in mortality of 5 to 10 percent (i.e., 5 to10 fish out of every 100 fish that now die in the estuary would need to survive). This is a very optimistic scenario about how much latent mortality, not measured during in-river downstream migration, could be improved with dam breaching.

The CRI analysis does indicate that a combination of improvements spread throughout the lifecycle and attained by mixture of different management actions (e.g., habitat restoration, reduced predation, manipulation of timing of releases, hatchery modifications, harvest restrictions, water quality improvements, and, of course, dam breaching) could provide adequate annual population growth for spring/summer chinook salmon.

For fall chinook salmon, dam breaching alone could recover these stocks, but only if at least a 20 percent improvement in survival below Bonneville Dam occurs as a result of this action. This analysis also indicates that a harvest moratorium or reduction could have the same effect relative to recovery. Although not included in the CRI analysis, dam breaching would also increase mainstem river habitat for fall chinook salmon.

For steelhead, the effects of dam breaching alone are unclear relative to recovery of this ESU. Like spring/summer Chinook, it may require substantial additional survival benefits below Bonneville Dam for this stock to recover. However, harvest reductions alone could have a greater role in recovery of this ESU than for spring/summer chinook.

The critical uncertainty in both the CRI and PATH analysis is the level of differential delayed transport mortality and extra mortality that can be assigned to the hydrosystem. The determination of these factors strongly affects evaluation of the efficacy of dam breaching to recover spring/summer chinook salmon.

The CRI analysis, in agreement with PATH analysis, concluded that further improvements in spill, bypass systems, or transportation (e.g., Alternatives 2 and 3) are unlikely to be adequate to rebuild the listed Snake River stocks.

CRI also highlighted the potential benefits of gains in overall production from improvements in various life stage survivals (e.g., early freshwater rearing, estuary/early ocean survival) from habitat improvements or changes in management actions. Whether such changes could be implemented or would have the modeled effect is unknown.

The latest CRI analysis also pointed out the uncertainty of the contribution of hatchery fish to estimates of wild stock production. Lack of good knowledge on the contribution of hatchery fish on recruits to natural spawning grounds greatly increases the uncertainty about the rate of population declines and extinction risk for all Snake River stocks.

If hatchery fish do not contribute substantially to production, the CRI analysis indicated that the short-term (24 years) extinction risk is low for most stocks of spring/summer chinook, fall Chinook, and steelhead (only one spring/summer chinook stock with greater than 1 percent probability of extinction during this period). However, over the long term (100 years), the chance of extinction increases substantially. For spring/summer Chinook, 4 of 7 index stocks have a chance of extinction of 17 to 78 percent, fall chinook 40 percent and steelhead 13 percent. Additionally, the Run B steelhead has a 93 percent chance of extinction during this period. This analysis is incapable of evaluating individual stocks of steelhead, some of which would likely have even greater risk. Should hatchery fish contribute substantially to spawning stocks, risks would be greater than these estimates.

5.5.1.7 Cumulative Effects

All of the effects analysis presented in Sectio 5.5.1 is cumulative in nature because anadromous fish live only portions of their lifecycle in the lower Snake River and effects in other aspects of their lifecycle are considered throughout this analysis. The Cumulative Risk Assessment done by NMFS in particular, Section 5.5.1.6, highlights the cumulative nature of anadromous fish. Table 5.5-1 provides a summary of potential effects that is cumulative based.

5.5.1.8 Uncertainties in Potential Anadromous Fish Effects

Uncertainties remain about whether, and to what degree, any of the alternatives will result in increases in the likelihood of survival and recovery of the listed Snake River ESUs. These uncertainties could contribute to the risk of selecting a sub-optimal alternative. At the same time, delays in selecting an alternative incur the risk of continued declines in listed stocks. Several factors contribute to these uncertainties.

The primary factor is uncertainty about the degree to which declines in stocks, which coincided with the construction and operation of dams, have been caused by these actions. Other factors such as relatively unfavorable ocean conditions, habitat degradation (spawning, rearing, estuary), hatchery production (competition, disease, predation, negative influences on gene pools of wild fish), harvest, predation (terns, resident fish, marine mammals), and climate cycles (droughts) have also been coincident with, and could have contributed to, stock declines.

This primary uncertainty factor is due to many individual factors such as:

- Inherent variability in returns from year to year; anadromous fish evolved to deal with highly variable environmental conditions (precipitation, fresh-water temperature, ocean temperature, local habitat changes, etc.). Large sample sizes are needed for many years to characterize this natural variability in returns.
- Uncertainty about the true variability of returns due to sampling/counting error/sample size.
- Uncertainty about the relative contribution of hatchery fish to annual production of ESUs
- Losses of juvenile fish migrating through the LSR project are not high enough to account for the depressed stocks. Some form of "extra mortality" has been postulated to lead to losses once fish have migrated past the dams. There is no direct evidence of this 'delayed mortality' therefore this hypothesis is an additional source of uncertainty.

- Direct losses of juvenile fish that have been transported from the LSR to beyond Bonneville Dam are very low (2 percent or less). Some form of 'differential delayed mortality' has been postulated to account for the low returns of transported fish (although most years transported fish do better than non-transported fish). Efforts to estimate this "differential delayed mortality," or D, by comparing PIT-tagged in-river and transported fish, have been hampered by small sample sizes and therefore very large uncertainties.
- Efforts to compare the dam breaching alternative with non-breaching alternatives depend significantly on values of D assumed to hold for transported fish.

Additional uncertainties are introduced by modeling efforts. Models constructed by PATH are sensitive to uncertainties in assumptions about effects of temperature, predation, travel time, the historical time period selected for analysis, and the contribution of D to returns.

5.5.2 Resident Fish

This section discusses the likely short-term and long-term effects of Alternative 1—Existing Conditions and three action alternatives to resident fish species and other aquatic fauna (see Section 3.0, Plan Formulation, for details). These action alternatives are:

- Alternative 2—Maximum Transport of Juvenile Salmon (using existing and currently planned system improvements)
- Alternative 3—Major System Improvements
- Alternative 4—Dam Breaching.

Table 5.5-11 summarizes the potential effects of these alternatives on resident fish.

Table 5.5-11. Summary of the Potential Effects of the Alternatives on Resident Fish

Alternative 1	Alternative 2	Alternative 3	Alternative 4
No detectable short-term, long-term negative, or cumulative effects are expected.	Same as Alternative 1.	Same as Alternative 1.	• Short-term negative effects could include stranding, increased predation in off-channel mitigation ponds and other embayments, changes to spawning habitat, and initial increased turbidity that could reduce feeding, growth, and reproduction and could have lethal effects for limited periods. • Long-term effects include significant changes in the amount and type of resident fish habitat, corresponding changes in the structure of the fish community that thrives in the reach, and some increased effects from flow augmentation.

Under Alternatives 1, 2, and 3, existing and currently planned system improvements would be implemented, such as extended submerged bar screen (ESBS) improvements, the replacement or rehabilitation of turbines and generators, fish separators, fish barges, adult fish attraction ladder pumps, and dewatering screens (see Table 3-1 and Section 3, Plan Formulation, for details). Under Alternative 3—Major System Improvements, additional major improvements would include a surface bypass collector (SBC) at Lower Granite Dam and new ESBSs at Ice Harbor and Lower Monumental Dams. Alternative 2—Maximum Transport has the objective of loading all juvenile salmonids collected from bypass systems onto trucks or barges and transporting them downstream for release below Bonneville Dam; consequently, no volunteer spill would occur under either of these alternatives except at Ice Harbor Dam. The primary differences between Alternative 2—Maximum Transport and Alternative 3—Major System Improvements is that a higher proportion of juvenile salmonids could be collected under Alternative 3—Major System Improvements compared to Alternative 2—Maximum Transport of Juvenile Salmon. For this analysis, it was assumed that augmentation under the 1995 and 1998 Biological Opinions would continue. Also, Alternative 3 incorporates an adaptive migration approach, which provides flexibility in either transporting fish or passing downstream for in-river migration.

The system configuration for the Lower Snake River Project (all four dams) would be identical under Alternatives 1 and 2, but only a portion of the juvenile salmonids would be transported under Alternative 1—Existing Conditions according to the annual Fish Passage Plans and the Corps' Juvenile Fish Transportation Program; the remainder would be released in the tailrace of each dam. Alternative 1—Existing Conditions includes volunteer spill (outlined in the 1995 and 1998 Biological Opinions) to reduce the proportion of fish that would pass through turbines.

Alternative 4—Dam Breaching foregoes any major system improvements, and instead breaches portions of the four dams, thereby allowing the river to be drawn down to a natural level. Under Alternative 4—Dam Breaching, water storage would continue upstream of the lower Snake River. Therefore, unlike the changes in channel morphology that would occur downstream of the confluence of the Snake and Clearwater Rivers, flow releases and regimes are not expected to change and no native resident fish habitat would be recovered upstream.

Under current operating procedures, up to 1.4 million acre-feet (MAF) of water can be used from the Dworshak reservoir (Corps) and the Brownlee reservoir (Idaho Power Company) to meet target flows at Lower Granite Dam. All of the alternatives include an additional 427 thousand acre-feet (KAF) of flow augmentation during the juvenile salmonid outmigration period. These additional required flows are derived from the upper Snake River (i.e., above the Hells Canyon complex) as described in the 1995 and 1998 Biological Opinions. However, agreements on flow augmentation have expired (see Section 2.1.7) and new agreements are being discussed under a separate ESA Section 7 consultation.

The timing and source of river flows are important to both migrating juvenile salmon and resident fish populations in the lower Snake River, but are unlikely to have any substantial effects on benthic invertebrates. The Dworshak reservoir has selective-depth withdrawal structures that allow cool, deepwater outflows to be available for release downstream. In contrast, water from the upper Snake River generally does not have a cooling effect. Consequently, releases from the Dworshak reservoir during low flow years tend to moderate temperatures in the lower Snake River. The effect of using Dworshak reservoir water is more pronounced in the Lower Granite reservoir because temperatures equilibrate as the waters mix and flow downstream. The effect is also less pronounced during normal and high flow years because of the greater proportion of upper Snake River water at the confluence with the Clearwater River.

Not all of the proposed measures are expected to affect resident fish species. The alternative analysis for resident fish focuses on measures affecting the following attributes:

- Total dissolved gas (TDG) supersaturation
- Spill and entrainment
- River level (drawdown).

Changes in these attributes are expected to have the greatest effect on the abundance and diversity of the resident fish currently inhabiting the reservoirs and habitat downstream of the project. The following sections describe how proposed measures would affect these attributes and, correspondingly, resident fish.

5.5.2.1 Total Dissolved Gas

The production and physiological effects of water supersaturated with TDG on anadromous fish are discussed in Section 4.4, Water Resources. Similar effects (i.e., gas bubble trauma) have been observed for resident fish species in the mid-Columbia River (Dell et al., 1975) and lower Clearwater River (Cachnauer, 1995) during periods of spill. However, no resident fish collected from upper areas of the Little Goose reservoir were observed with symptoms of gas bubble trauma (GBT) during short-duration spills from Lower Granite Dam (Bennett et al., 1994). Overall, the available information suggests that the current incidence of GBT has not resulted in detectable population changes for resident fish species.

Nevertheless, measures that would reduce the level of TDG or duration of super-saturation (when TDG levels exceed 100 percent) events would likely reduce the incidence of GBT in resident fish. Measures that would affect TDG levels or duration include the volume and duration of spill, the construction of spillway flow deflectors, and raising the elevation of stilling basin floors. Spillway flow deflectors are already installed for most spillways at the four lower Snake River dams. However, measures are being considered to determine if deflectors can be added effectively at outside spillbays where they are not currently present, and to see if deflectors at the older dams can be reconfigured to improve their efficiency (see Section 3.0, Plan Formulation).

5.5.2.2 Spill and Entrainment

Passage of juvenile salmonids and resident fish through lower Snake River dams can occur by any of three main routes: through spillways, via bypass structures (e.g., fish collection and transport facilities, fish ladders), and through turbines. In addition, intermittent releases occur when navigation locks are operated. Modifying volumes of spilled water during the outmigration season is one type of measure being considered under the various alternatives. Unfortunately, increasing spill also increases the risk of TDG to concentrations that exceed regulatory thresholds. Currently, dissolved gas concentrations are monitored closely at dam tailraces to maintain concentration below 120 percent saturation, a criterion based upon physiological effects to salmonids, but which also appears to be adequate for resident fish. Because of this operational limit, measures with higher concentrations of spill are unlikely to have severe impacts on resident fish from GBT. In contrast, alternatives with lower levels of spill are believed to have a higher risk of mortality to resident fish from entrainment through turbines or a higher level of passage by entrainment into a bypass structure. Unlike the anadromous salmonids, the number of resident fish and any associated mortality have not been quantified for any of the three routes. Consequently, confidence in the positive or negative direction of the effect on resident fish is high, but the magnitude of the effect is uncertain.

5.5.2.3 Dam Breaching

Several different scenarios are under consideration for breaching the four lower Snake River dams and returning the river to a more natural elevation. Three scheduling scenarios are under consideration: one dam per year, two dams per year, or all dams at once. The breaching schedule would likely affect the magnitude and duration of short-term effects to water quality and erosion. The most likely schedule is two dams per year over a 2-year period. Numerous tasks (see Section 3.4, Alternative 4—Dam Breaching) would be required to implement dam breaching that would be completed prior to drawdown. Overall, it is expected that about 9 years would be required to complete the process to breach all four dams (including design, contracting, and construction). In order to minimize negative effects, many of the activities would only occur between August and March, including any required excavations, levee construction, and the actual drawdown. In addition, substantial portions (25 to 50 percent) of the current channel length would require the addition of riprap to protect roads, railroads, and bridges which would reduce the amount of riparian zone available for restoration.

In order to describe the expected amount and type of riverine habitat available following drawdown, several models were developed (see Appendix B, Resident Fish). The models used historical data representing depth, substrate, and current velocity measurements taken in 1934 at transects along the lower Snake River. Output from the models included estimated river gradient, depths, velocities, substrate types, and surface area of habitat types (assuming 24 kcfs summer flows) used for habitat-use guilds described in Section 4.5, Aquatic Resources. Substantial uncertainty exists in the results because the historic data were collected under a predominately unregulated flow regime while the future system would continue to have substantial regulation from upstream projects. Nevertheless, the results of the models are the best available information to assess the long-term effects of breaching the lower Snake River dams to resident fish.

One of the results of the geomorphological analysis was the predicted average gradient in 1-mile segments (see Appendix B, Resident Fish). The overall river gradient for the lower Snake River is predicted to be fairly low (0.053 percent) and would vary little along the 140-mile reach from Ice Harbor Dam to the confluence of the Snake and Clearwater Rivers (ranging from 0.051 to 0.059 percent). Consequently, no steep rapids and relatively few long pools are expected. The steepest segments having gradients greater than 0.19 percent are expected to occur between Silcott Island and Clarkston, Washington (RM 136-137), and near Texas Rapids (RM 66-67). Gradients greater than 0.09 percent are also expected near Fishhook Park (RM 16-18), between the Palouse and Tucannon rivers (RM 59-61), and below Nisqually John Landing (RM 125-127).

River depths are expected to be mostly less than 14 feet deep at the modeled flow (25 to 35 kcfs depending upon the reach), but depths are expected to occasionally exceed 25 feet near the channel thalweg. Three pools are expected near Fishhook Park (RM 14-26) interspersed with the steeper section mentioned above. Two of these pools are expected to be greater than 50 feet in depth. A third deep pool greater than 50 feet in depth is expected just upstream of the Palouse River. Other pools about 1 mile in length, but less deep are expected sporadically throughout the lower river except between RM 26 and 66, where no pools are expected.

Modeled habitat types suggest that deep, slow, or standing water habitat (Types E, F, G, respectively) would be rare in the unimpounded river and would account for little more than 2 percent of the surface area (Table 5.5-12). In contrast, over 90 percent of the surface area in-river would have velocities exceeding 2.0 feet/second (Type A). The proportional distribution of water velocities greater than 2.0 feet/second within different river reaches is depicted in Figure 5.5-15. About 30 percent of the river is expected to have relatively swift velocities greater than 5.0 feet/second (ft/sec). The most noticeable exception is the portion of the McNary reservoir that is in the Snake River. The majority of this lower reach (73 percent) is expected to have velocities less than 2.0 feet/second resulting primarily from the low gradient. In addition to the simple habitat types, complex habitat types such as islands, braided channels, or backwaters are expected to occur in seven areas between RM 13 and RM 34, and in seven areas between RM 72 and RM 102.

Prediction of habitat types and substrate distribution was not linked in the models. However, substrates are expected to be coarser in steeper, high-velocity sections and finer in the deeper, slower-velocity pools. Substrates in the lower river are expected to range from gravel/sand (dominant/subdominant) to bedrock/cobble. The types of substrate are expected to be more homogeneous upstream of Little Goose Dam with gravel/sand accounting for most of the reach, interspersed by short areas of bedrock/cobble or gravel/cobble. The substrate is expected to be coarser in the reach between Lower Monumental and Little Goose Dams. Most of this reach is expected to include a cobble/gravel substrate interspersed by sections of bedrock/cobble and gravel/sand. The upper two-thirds of the reach between Ice Harbor Dam and Lower Monumental Dam are expected to be gravel/sand, while the lower third is expected to be a combination of cobble and gravel.

Most substrate currently in the river channel is highly embedded as a result of sediment deposition during up to 37 years of impoundment. Mobilization and flushing of the finer sediments that surround (i.e., embed) gravels, cobbles, and larger substrates could take several years of high flows (>200 kcfs). It is expected that most of the fine sediments would be deposited into the McNary reservoir over a 5 year period following breaching of the four dams; however, some low-gradient reaches (e.g., near RM 120) could retain sediments for up to 10 years (Appendix B, Resident Fish).

5.5.2.4 Effects of the Alternatives

The following sections describe the expected short-term, long-term, and cumulative effects of the alternatives to resident fish and other aquatic features. Short-term effects occur immediately because of implementing measures or within 5 to 10 years. Long-term effects could also begin shortly after implementing measures, but could have long-lasting effects on the structure of the resident fish populations. Cumulative effects include both the effects of the alternative measures and the effects of ongoing and future expected measures likely to affect the resident fish in the project area.

Table 5.5-12. Summary of the Amount of Expected Habitat Types in a Near-natural Lower Snake River after Dam Breaching, Assuming Summertime 24 kcfs Flows

Snake River Segment	Surface Area (acres) Reservoir	Surface Area (acres) Riverine	Riverine Habitat Types[1/]	Individual Habitat Surface Area Acres	Individual Habitat Surface Area percent
Upper McNary Arm	1,989	1,989	A	559	28.1
			B	216	10.5
			C	966	48.6
			D	91	4.6
			E	157	7.9
			F	0	0.0
			G	28	1.4
Ice Harbor	8,375	3,475	A	3,087	88.8
			B	260	7.5
			C	54	1.5
			D	70	2.0
			E	4	0.1
			F	0	0.0
			G	20	0.6
Lower Monumental	6,590	3,191	A	2,931	91.9
			B	200	6.3
			C	21	0.6
			D	40	1.2
			E	1	0.0
			F	0	0.0
			G	8	0.2
Little Goose	10,025	3,754	A	3,367	89.7
			B	283	7.6
			C	33	0.9
			D	68	1.8
			E	2	0.1
			F	0	0.0
			G	13	0.4
Lower Granite	8,900	2,742[2/]	A	2,494	91.0
			B	157	5.7
			C	42	1.5
			D	46	1.7
			E	3	0.1
			F	0	0.0
			G	11	0.4
Total Reach	**33,890**	**13,162**	**A**	**11,879**	**90.3**
			B	**900**	**6.8**
			C	**150**	**1.1**
			D	**224**	**1.7**
			E	**10**	**0.1**
			F	**0**	**0.0**
			G	**52**	**0.4**

1/ Key to riverine habitat types:
A=velocity > 2.0 ft/s; all depths.
B=velocity = 0.5-2.0 ft/s; depths < 10 ft.
C=velocity = 0.5-2.0 ft/s; depths > 10 ft.
D=velocity < 0.5 ft/s; depths < 10 ft.
E=velocity <0.5 ft/s; depths 10-35 ft.
F=velocity <0.5 ft/s; depths > 35 ft.
G=velocity <0.1 ft/s; all depths to 35 ft.

2/ Area estimate does not include section from Lewiston to Asotin.

Note: Upper McNary reservoir arm shown for comparison.
Acreage numbers in this table do not reflect official real estate numbers because a different base mapping was used.

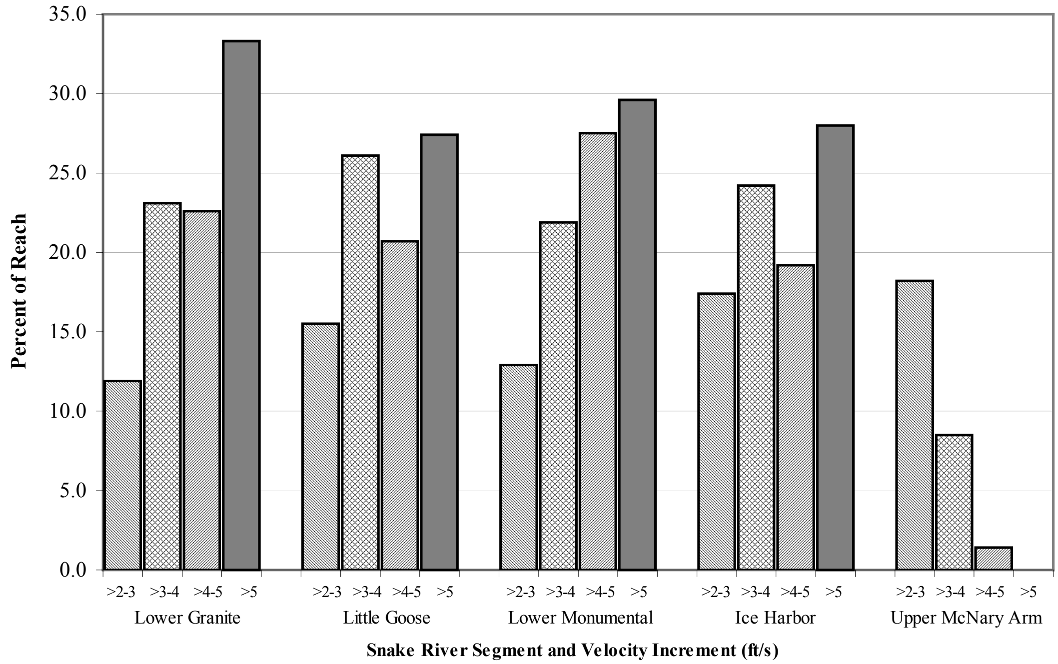


Figure 5.5-15. Proportional Distribution of Predicted River Velocities in a Near-natural Lower Snake River Determined by a Two-Dimensional Model

Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, currently planned structural modifications to the dams would be implemented, flows and other operating procedures would continue according to the 1995 and 1998 Biological Opinions, and juvenile salmonid transport levels would continue according to annual Fish Passage Plans under the Corps' Juvenile Fish Passage Program.

No detectable short-term, long-term negative, or cumulative effects are expected from this alternative relative to the current resident fish population structure (Appendix B, Resident Fish). Alternative 1—Existing Conditions has the highest level of spill of the four alternatives and consequently has the highest risk of high TDG concentrations. However, monitoring for TDG combined with the presence of spillway flow deflectors should minimize this risk below a detectable level for resident fish.

As described above and in Section 3.0 (Plan Formulation), summer flow augmentation using water from Dworshak would continue to have potential negative effects to resident fish spawning success in the Lower Granite reservoir, depending upon the timing, magnitude, and duration of the releases. However, flow augmentation is included in all of the alternatives. The effects of flow augmentation are expected to be similar for Alternatives 1, 2, and 3, but different for Alternative 4—Dam Breaching as a result of river volumes. However, flow augmentation effects in Alternative 4—Dam Breaching would be small relative to other components of the alternative (dam breaching) and cannot be considered an important distinguishing factor.

Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Under Alternative 2—Maximum Transport of Juvenile Salmon, currently planned structural modification to the dams would be implemented while major system improvements would be implemented under Alternative 3—Major System Improvements. Both alternatives would have flows and other operating procedures continued according to the 1995 and 1998 Biological Opinions. Juvenile salmonid transport proportion would be maximized under Alternative 2—Maximum Transport, but would be optimized under an adaptive migration strategy with Alternative 3—Major System Improvements. Under Alternative 3—Major System Improvements, the major system improvements would allow greater flexibility in either transporting fish or passing them downstream for in-river migration. In order to maximize transport under Alternative 2—Maximum Transport or optimize it under Alternative 3—Major System Improvements, spill levels would be minimized during the outmigration period.

Similar to Alternative 1—Existing Conditions, no detectable short-term, long-term, or cumulative effects are likely to occur to resident fish under Alternatives 2 and 3 (Appendix B, Resident Fish). A lower level of spill could reduce the negative effects from TDG, but could include a concurrent increase in negative effects from entrainment, particularly to suckers, catfish, carp, peamouth, and white crappie. Neither of these potential sources of mortality are known to have a significant effect on the resident fish populations and community structure under current conditions. Maximized juvenile transport could reduce the salmonid component in the resident fish diets, but this is not expected to have detectable changes in resident fish demographics.

In addition, potential changes as a result of Alternatives 2 or 3 are not likely to be detectable (Appendix B, Resident Fish).

Alternative 4—Dam Breaching

Implementation of Alternative 4—Dam Breaching would result in breaching the earthen portions of the four lower Snake River dams, resulting in a 140-mile unimpounded reach. Of the four alternatives, Alternative 4—Dam Breaching is expected to have the largest effect on the current resident fish community structure. The short-term negative effects to resident fish are expected to result from rapid lowering of the water surface elevation and high turbidity. In contrast, the long-term effects would result from major changes in the amount and type of resident fish habitat present in the reach and a higher magnitude effect of flow augmentation.

Short-term Effects

Rapidly lowered water surface elevations are expected to have the largest unavoidable short-term effect on resident fish and benthic invertebrates. Current plans call for lowering reservoir levels about 2 feet per day. For Lower Granite, the deepest of the four reservoirs at the dam, this represents about an 8-week drawdown period. During this period, off-channel mitigation ponds, backwaters, and other embayments would drain, leaving many fish stranded. Areas with shallow impoundments would become stagnant and eventually subject to desiccation. A temporary drawdown of Lower Granite Dam in 1992 resulted in the stranding of an estimated 15,000 fish. Negative effects of stranding were highest for largemouth bass (Schuck, 1992). Overall, the short-term effects are expected to be most severe for those species and life stages that prefer shallow, low-velocity habitat types. These species include largemouth bass, crappie, sunfish, yellow perch, carp, bullheads, and the juvenile life stage of northern pikeminnow and smallmouth bass.

An indirect effect of lowered water surface elevations would be changes in the availability and density of forage. Concentrations of predators and prey in smaller volumes of water can result in increased predation levels. Increased predation from birds and other fish on prey items in mitigation ponds was observed during the Lower Granite reservoir test drawdown (Schuck, 1992) and should be expected under Alternative 4— Dam Breaching. One additional negative effect expected is the stranding and loss of crayfish and other benthic invertebrates that are an important source of food for several of the resident fish species.

Water velocity is expected to increase as water surface elevations drop and accumulated sediments along the banks and bottom of the reservoirs are expected to erode and contribute to turbid flows. Erosion is expected to be particularly high at deltas that form at the mouth of the rivers and streams draining into the lower Snake River. As water levels drop, new channels would be cut through sediment deposits as fluvial processes re-establish a fluvial river morphology. During the initial 15 year period, coarse substrate would become exposed and potentially available for spawning salmonids, including resident salmonids. However, the quality of spawning habitat could be low in some areas until substantial amounts of previously deposited sands and fines are transported downstream and a more natural sediment regime develops.

The severity of suspended sediment effects is related to its concentration and duration of exposure to fish (Newcombe and Jensen, 1996). Sub-lethal effects to warm-water fish that reduce feeding, growth, or reproduction have been observed at concentrations ranging from 62.5 to 144.5 mg/l experienced over a period of 30 days (Buck, 1956, as cited in Newcombe and Jensen, 1996). In contrast, Wallen (1951) (cited in Newcombe and Jensen, 1996) observed only limited behavioral effects up to concentrations of 20,000 mg/l and acute lethal effects above 175,000 mg/l. Lethal events usually occur by suffocation because gills become coated with sediment. Overall, it appears that resident fish can withstand moderate to high turbidity, at least for short periods.

The magnitude of turbidity expected during the drawdown period is not known with certainty. However, as a reference point, the 1992 drawdown test of the Lower Granite reservoir, produced suspended sediment observed up to 2,000 mg/l (Appendix C, Water Quality). Suspended sediment is expected to be highest during the first year following breaching and decline thereafter. The magnitude of peak spring flows and its timing relative to the breaching schedule can affect the severity of erosion. Peak flows for a high water year or heavy rainfall following breaching could cause a higher magnitude of erosion because vegetation would not have had sufficient time to become established.

For the current analysis, sediment models were developed for predicting the number of days per year that suspended sediment would exceed 25 mg/l (Appendix C, Water Quality). This criteria was used for SOR (BPA et al., 1995) and was selected for protecting salmonids based upon a review of pertinent literature. During the first year following dam breaching, suspended sediment levels were predicted to exceed the 25 mg/l criteria for approximately 131 days. During the following 15 years, sediment levels were predicted to exceed the criteria an average of 91 days per year. Based upon the experience from the Lower Granite reservoir drawdown test and suspended sediment modeling, lethal effects are expected to be localized and infrequent while sub-lethal effects could affect growth and year-class strength of resident fish for several years following dam breaching (Appendix B, Resident Fish).

Long-term Effects

While the effects of sediment suspension from channel cutting are expected to decline and substrates are expected to become coarser following dam breaching, the development of a new channel morphology and fish habitat characteristics would have long-lasting beneficial effects on the community structure of native resident fish. Although it is unlikely that introduced fish species would disappear, their prevalence is expected to decline. Overall, the community is expected to have higher representation of the high velocity riverine species historically present in-river while habitat generalists such as smallmouth bass are also expected to persist and thrive under natural river conditions. Similarly, the food web would be based more upon attached and drift forage species (benthic algae, mayflies, caddisflies, etc.) rather than emergent vegetation, phytoplankton, zooplankton, and benthic forage species (earthworms, mussels, etc.).

No quantitative information is available on the fish community in the lower Snake River prior to construction of the four dams. Consequently, information from the unimpounded reach of the Snake River above Asotin is presented to provide some indication of how biomass might change if Alternative 4—Dam Breaching is implemented (Table 5.5-13). The data in Table 5.5-13 should be viewed with the understanding that biomass is depicted in units of pounds per mile of river length and pounds per acre (standing crop). Total biomass on a per mile basis is likely to decline by more than half under free-flowing conditions. However, total standing crop would increase by more than half.

This apparent discrepancy results because the surface area of the lower Snake River would decrease from 33,236 acres to 19,464 acres, a decline of 58 percent. Consequently, if the total weight of a species declined by less than 58 percent, standing crop would increase even though the linear biomass declines. Caution is also warranted because river conditions downstream of Asotin are substantially influenced by the Clearwater River. In particular, water temperature regimes could be markedly different between the two reaches, especially during low flow years.

In contrast to fish community changes predicted in Appendix B (Resident Fish), a study by Petersen et al. (1999) suggests that smallmouth bass abundance will decline by half and northern pikeminnow abundance will double if Alternative 4—Dam Breaching is implemented. The two studies conclude opposite effects for these two species. Consequently, there does not appear to be scientific consensus on how dam breaching will affect the resident fish community.

The type of effects (delay and disruption of spawning, reduced growth) from cold-water flow augmentation from the Dworshak reservoir under Alternative 4—Dam Breaching would be similar to Alternatives 1, 2, and 3. However, the magnitude of the effects could be higher under drawdown conditions because smaller water volumes in the lower Snake River would reduce the heat capacity currently available in the reservoirs. Consequently, cold-water releases from the Dworshak reservoir under Alternative 4—Dam Breaching are expected to result in lower water temperatures that persist further downriver compared to the other alternatives, particularly under low-flow conditions (Appendix B, Resident Fish; Appendix C, Water Quality).

In summary, the long-term changes in the habitat types, temperature regime, and forage base are expected to result in the decline of biomass for crappies, peamouth, pumpkinseed, bluegill, yellow perch, bullheads, and largemouth bass. In contrast, species expected to benefit from more natural river conditions include chiselmouth, redside shiners, speckled dace, suckers, sculpin, white sturgeon, northern pikeminnow, and smallmouth bass. The one species not expected to have a large change in density is channel catfish (Appendix B, Resident Fish). Mountain whitefish, rainbow trout, and bull trout are expected to increase their utilization of the lower Snake River on a seasonal basis, especially if water temperature fluctuation rates and peak magnitudes can be lowered. Naturally high water temperatures from mid-summer to early-fall are expected to create unsuitable habitat for these species during that period.

Table 5.5-13. Comparison of Estimated Biomass for Native and Introduced Fishes in the Free-flowing Snake River above Asotin and in the Lower Granite Reservoir

Species	Free-flowing Snake River lbs/acre	Free-flowing Snake River lbs/mi	Lower Granite Reservoir lbs/acre	Lower Granite Reservoir lbs/mi	Areal Change (percent)	Linear Change (percent)
Native						
Sucker spp.	37.4	2,116.0	25.4	5,799.9	47	-64
Northern pikeminnow	7.1	403.1	3.1	712.1	129	-43
Chiselmouth	5.3	302.3	4.5	1,017.6	20	-70
White sturgeon	4.5	251.9	0.4	77.3	1,150	226
Peamouth	1.8	100.8	2.7	610.6	-33	-83
Mountain whitefish[1/]	2.7	151.1	0.1	22.4	2,900	576
Rainbow trout[1/]	1.8	100.8	NA	NA		
Redside shiner	0.9	50.4	NA	NA		
Bull trout[1/]	0.1	5.0	NA	NA		
Other cyprinids; sculpins	2.2	126.0	0.3	61.0	733	106
Non-native						
Common carp	3.6	201.5	1.6	360.1	122	-44
Smallmouth bass	6.2	352.7	0.9	207.6	600	70
Catfish/bullheads	1.3	75.6	2.5	573.7	-46	-87
Crappie spp.	0.1	5.0	0.3	67.1	-67	-93
Other centrarchids[2/]	0.4	25.2	1.2	264.7	-62	-90
Yellow perch	NA	NA	2.6	580.1		
Total	**75.4**	**4,267.2**	**45.3**	**10,354.1**	**66**	**-59**

[1/] Seasonal residents

[2/] Pumpkinseed, bluegill, warmouth

Source: Appendix B, Resident Fish

5.5.2.5 ESA-listed Resident Fish Species

Alternatives 1, 2, and 3 are not expected to have any effect on bull trout. The U.S. Fish and Wildlife Service Biological Opinion on Federal Columbia River Power System Operations (December 20, 2000) concluded that continued operations of the Federal Hydroelectric System would not jeopardize the continued existence of bull trout. In contrast, Alternative 4—Dam Breaching is expected to have a small but beneficial effect on bull trout. Similar to the other resident salmonids, bull trout can be expected to increase their seasonal use of the lower Snake River. It is unlikely that year-round residency would occur because water temperatures are expected to naturally exceed bull trout temperature requirements during summer months. Discussion of the effects of the alternatives on other ESA-listed fish species is provided in Section 5.5.1, Anadromous Fish.

5.5.2.6 Cumulative Effects

Effects on resident fisheries would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching, there could be some increased predation, increased turbidity, and other negative effects for limited periods following drawdown. Long-term effects include chages in the amount and type of fish habitat and corresponding changes in fish community structure.

5.5.2.7 Uncertainties in Potential Resident Fish Effects

There is some uncertainty about the time required for post-breaching resident fish populations to stabilize and the degree to which they will resemble populations upstream of the dams. The rate and extent of movement and redistribution of sediments, consequent substrate changes, and the effects of future operations on temperature regimes will be key factors.

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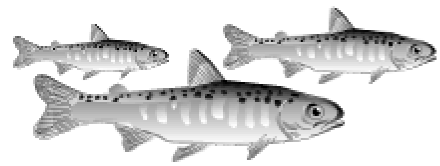

5.6 Terrestrial Resources

A summary of potential effects of the alternatives on vegetation and wildlife is presented in Table 5.6-1.

5.6.1 Vegetation

This analysis of impacts on terrestrial resources is based on several assumptions. First, the effects are summarized using two time periods–short term and long term. These time periods are not mutually exclusive nor do they represent the same span of time for every habitat type or species group. They are simply a tool to present general trends in effects over time. In general, the dividing line between short term and long term for vegetation was 10 years, and the threshold for wildlife species was 4 years (approximate period of construction). Again, this is not meant to be a strict definition. Second, this analysis assumes that irrigation will be maintained on those Habitat Management Units (HMUs) where it is currently provided. Finally, under a drawdown scenario, this analysis assumes that the Corps will initiate extensive vegetation management to maximize the growth of native species. This effort would include physical and chemical control of noxious weeds, planting of native vegetation, and erosion control measures on the newly exposed islands.

Table 5.6-1. Summary of Potential Effects of the Alternatives on Terrestrial Resources

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Vegetation	No change from current conditions.	No change from current conditions.	No change from current conditions.	• Short-term (< 10 years) losses of some habitat types, including forbland and planted grassland, mesic shrub, palustrine forest, palustrine scrub-shrub, and emergent wetlands would be expected (Table 5.6-2). • Almost all of these short-term habitat losses would be expected to be overcome by long-term (30 to 50 years) restoration of pre-inundation habitat acreages, with the exception of palustrine emergent wetlands and ponds, which are currently more widespread than pre-impoundment (Table 5.6-2). • If Alternative 4 is chosen, an aggressive vegetation management plan would be created to manage for the predicted flush of noxious weeds and exotic species that would be released on approximately 13,772 acres of newly exposed soils.
Wildlife	No change from current conditions.	No change from current conditions although fewer fish in the river could reduce prey for some bird species.	No change from current conditions although fewer fish in the river could reduce prey for some bird species.	• Short-term loss of wetland and riparian habitats (Table 5.6-2) would have negative effects on some species, particularly amphibians, reptiles, small mammals, and deer. • Increased distance between the habitat along the old shoreline and the water's edge would have short-term negative effects on game birds. • Loss of open water habitat would have short-term negative effects on waterfowl. • Increased mudflats and open islands would have short-term positive effects on shorebirds and colonial-nesting birds. • Long-term positive effects on most wildlife groups through the expected development of a more contiguous riparian zone and increased area of other habitat types, such as shrub-steppe and grassland.

5.6.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the existing operating system would remain the same and, therefore, no changes would be expected in vegetation communities. In the future, however, vegetation communities could change in response to management activities on HMUs and other project lands, natural vegetation development along reservoir shorelines, and acquisition of additional project lands along the lower Snake River.

Riparian Mosaic/Emergent Wetland Communities

The amount of riparian mosaic and emergent wetland communities is not anticipated to change in the future since most of the previously planted riparian mitigation areas have matured and the Corps has met the acreage requirements for habitat acquisition approved under the Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan).

Future reservoir operations may increase or decrease riparian mosaic and emergent wetland communities within the study area depending on timing, duration, and frequency of water level changes. Any future changes in riparian areas are expected to be dependent on reservoir operations, ecological factors, and irrigation of HMUs. Additionally, development of emergent wetland habitat may occur due to sedimentation near the mouth of the main tributaries, and within some of the backwaters, impoundments, and other shoreline areas of the reservoirs (Downs et al., 1996). Little, if any, changes in amounts of emergent wetland vegetation would be expected elsewhere under current reservoir management, unless wetland management activities are initiated on project lands. Future changes in mesic perennial forb and grassland communities are expected to be relatively minor; however, this will be dictated by land management activities.

Upland Community

Acreages of upland habitats are not expected to change substantially in the future under the current operations since no new acquisitions of lands by the Corps are anticipated. Additionally, agricultural land acreages should remain about the same since the Corps is already attempting to achieve optimal agricultural benefits for wildlife based on the Habitat Evaluation Procedure (HEP). It is unlikely that any additional expansion of wildlife lands will occur. The quality of vegetation of upland range habitat would likely improve over time, as grazing restrictions are continued and habitat continues to improve. These grazing restrictions currently include limiting cattle access to existing shorelines except through 60 fenced cattle corridors.

5.6.1.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Under these alternatives, the transport of juvenile salmon by truck and barge would be maximized (Alternative 2—Maximum Transport of Juvenile Salmon) and major system improvements would occur (Alternative 3—Major System Improvements). These actions would not cause significant changes in existing water levels on the lower Snake River, or cause any additional ground-disturbing activities on study area lands. Therefore, no measurable short-term effects to vegetation resources should occur and the long-term effects would be limited to the continued development of existing habitat. See Appendix L, Lower Snake River Mitigation History and Status for a description of mitigation of habitat gains and losses accomplished for all alternatives.

5.6.1.3 Alternative 4—Dam Breaching

Alternative 4—Dam Breaching would result in the drop of the average surface water levels from between 94 feet below minimum operating pool (MOP) at Ice Harbor to 110 feet below MOP at Lower Granite. The river drawdown would create 140 miles of near-natural river, exposing approximately 13,772 acres of bare substrate (mainly silt and sand) in the process. Associated dam decommissioning activities such as stockpiling and haul road construction, subsequent diversion dam construction, and shoreline stabilization efforts would also impact lands within the project boundaries.

Dam breaching would have both short- and long-term effects on riparian and wetland areas. Most of these habitat types within the project boundaries are supported by the hydrologic regimes (water levels) associated with current dam operations. Therefore, dam breaching would likely cause rather large-scale short-term effects (potential losses/changes) to existing vegetation communities. These short-term effects are more easily identifiable due to existing knowledge of current environmental conditions and proposed actions, and current studies associated with this FR/EIS.

Despite the extensive revegetation measures that would be implemented by the Corps if Alternative 4—Dam Breaching were chosen (see Annex K of Appendix D, Natural River Drawdown Engineering), some unavoidable adverse impacts to plant communities would occur in the short term, including direct loss due to scouring and sloughing and indirect loss due to competition from exotic species. These effects are described in more detail below.

The long-term effects to vegetation communities are more difficult to determine, and can only be inferred through historical conditions data, professional judgement, and limited research involving test drawdowns studies within the study area. Although it appears that short-term losses of wetland and riparian communities would occur initially after dam breaching, in the long-term, under the near-natural river condition and land management measures proposed by the Corps under this alternative, increases in the amount or quality of wetland and riparian habitat would likely result. Various factors including biological, physical, and hydrologic conditions, and land management decisions would dictate these future vegetation communities.

Riparian Mosaic and Emergent Wetland Zones

Short-term Effects

Dam breaching would result in the loss and subsequent conversion of much of the existing shoreline riparian and wetland vegetation to upland vegetation. Plant species in riparian zones that would be particularly sensitive to drawdown include shallow rooting plants such as willows, false indigo, and white alder. Areas of the existing riparian zone that would likely be retained after dam breaching would include riparian areas along tributaries, streams, seeps, springs, and the irrigated HMUs. Additionally, small amounts of well-established riparian areas dominated by more drought-tolerant riparian plant species may be retained in areas associated with higher precipitation levels in the study area (nearer to the mouth of the Snake River). Retention of riparian vegetation associated with the established HMUs would depend on future irrigation practices by the

Corps; termination of these practices would result in the loss and subsequent conversion of most of these riparian areas to upland habitats.

Lower water levels that would occur under dam breaching would result in the loss of most emergent wetland areas associated with current embayments, backwaters, other still-water areas, and fringe areas along the reservoir and island shorelines (353 acres). Most wetland-associated areas would succumb to desiccation quickly (Corps, 1994).

The types (i.e., native/non-native) and species of plants that would initially colonize the approximately 13,772 acres of mudflats after dam breaching would mainly be dictated by the distribution and species of seed stocks within the substrate in the exposed areas, the presence of wind/water-borne seeds, and hydrologic conditions. Robberecht (1998) found that there is a sufficient seed bank in the shallow areas of the reservoirs (i.e., less than 15 feet water depth) to allow for rapid colonization of exposed banks. Below that depth, the viability and abundance of seeds diminishes, and active restoration of the desired plant community would be required.

Existing stands of purple loosestrife, a non-native invasive plant species, would likely decline significantly immediately after dam breaching because it is a wetland-associated plant. However, newly exposed, low-gradient shorelines would provide habitat for this species that may accelerate the development of purple loosestrife (Thompson, 1989).

Findings from a seed bank study performed in exposed river areas in the project area during the test drawdown (Robberecht, 1998) suggest that plant communities would develop rapidly on newly exposed shorelines above 15 feet water depth without active restoration or other types of vegetation management. Furthermore, it was suggested that newly established plant communities would likely be initially composed of native herbaceous species. However, it is important to note that significant amounts of non-native plant species seeds were identified within the substrates in the exposed areas. Due to the presence of these exotic species, and the potential for wind/water-dispersed invasive plant seeds within the project area, it is possible that non-native species would revegetate and dominate the exposed mudflats. Some of the more widespread exotic plant species identified by Robberecht (1998) include prickly lettuce, puncture vine, curly dock, common yellow sweetclover, water-cress, Russian thistle, and bull thistle. Factors such as river fluctuations, precipitation, and groundwater would also influence floral compositions.

Portions of the exposed areas may need to be irrigated, and actively managed using chemical and physical removal of non-native species after drawdown to ensure native species establishment (Robberecht, 1998). To encourage the development of native vegetative communities and reduce soil erosion due to wind and rain, the Corps has developed a reservoir management plan. The plan includes initial seeding during the dam breaching period, reseeding and manual placement of woody species during the following year to vegetate areas where seeds did not take during the initial seeding, and annual vegetation management for a period of 10 years (Appendix D, Natural River Drawdown Engineering). This plan includes an aggressive noxious weed control management program to control the spread of these plants in the newly exposed soils after drawdown.

Long-term Effects

The success of long-term establishment of vegetation communities would be mainly determined by the frequency and duration of inundation in the floodplain, land management actions (including restoration), and the presence of and distribution of invasive plant species in and associated with the exposed areas. Additionally, future vegetation communities would be influenced by factors such as the distribution, composition, and fate of existing sediments following dam breaching.

Based on historical area of riparian habitats along the lower Snake River (3,285 acres; Table 4.6-1 in Section 4.6, Terrestrial Resources) an increase in riparian mosaic habitats would result from dam breaching, and a decrease in emergent wetland habitat would occur, unless emergent wetland restoration and establishment measures are undertaken. HEP analyses calculated that the long-term gain in riparian habitat with dam breaching would be 1,481 acres for a net gain of approximately 292 acres (Table 5.6-2). These additional acres will provide more habitat to benefit migration over the existing condition, spawning, and feeding of all fish, as well as additional breeding and foraging habitat for a multitude of riparian dependent species. Conditions of the exposed areas should be more conducive for quality riparian mosaic development since soils would be deeper and more productive than the rocky, shallow soils along most of the current reservoir shorelines. Also, shoreline slopes should be flatter than the current steep slopes which may support conditions more conducive to riparian and wetland habitat development. Additionally, river processes (erosion, nutrient storage and transport, and deposition) associated with the near-natural river should produce conditions favorable for the development of quality riparian and wetland habitats.

The released sediments that lie behind the current dam structures, in association with sediment deposition along newly exposed shorelines resulting from dam breaching, may create conditions conducive to the development (elevated substrate) of emergent wetland habitats or riparian habitats in downstream portions of the lower Snake River. Much of the sediment that would be released after dam breaching would likely be deposited in the McNary pool near the mouth of the Snake River (Appendix C, Water Quality). Small wetland and riparian habitats may be supported on any newly formed islands resulting from sediment deposition. However, it appears that the majority of the sediment would likely be contained and deposited in the main river channel within the impoundment. If this occurs, due to the depth of the McNary pool (>20 feet), most of the sediment would lie well below the waterline and, therefore, would not result in significant increase of potential wetland or riparian habitats. None of the sediments released have been found to be at toxic levels, because there has not been much spraying in the basin. There may be some short-term negligible effects on bottom-dwellers, but no long-term effects are expected. Water quality will be monitored based on the 1992 drawdown test which provided information on sediment testing and monitoring.

As the transportation infrastructure moves further away from the river, small wetlands associated with this infrastructure will dry up and disappear unless effort is made to maintain them in their existing locations. In addition, new small wetlands will appear during the course of implementing the new infrastructure. The amount and location of these small wetlands are unable to be quantified at this time.

Table 5.6-2. Estimated Short-term Habitat Losses and Long-term Habitat Gains in the Study Area Under Alternative 4—Dam Breaching

Habitat Type	Short Term Losses [1/] (acres)	Long Term Gains [2/] (acres)
Upland		
Cropland and Pasture	0.00	4,336.20
Grassland	0.00	3,852.30
Forbland and Planted Grassland	462.50	1,265.20
Shrub-steppe	0.00	2,342.60
Exposed Rock and Rock Talus	0.00	642.90
Total Upland Habitat	***462.50***	***12,439.20***
Riparian		
Mesic Shrub	324.30	85.20
Palustrine Forest	272.30	251.70
Palustrine Scrub-shrub	592.30	1,144.30
Total Riparian Habitat	***1,188.90***	***1,481.20***
Wetland		
Palustrine Emergence	353.20	0.00
Palustrine Open Water (ponds)	315.70	0.00
Total Wetland Habitat	***668.90***	***0.00***
Reservoir/River [3/]	**13,772.00**	**0.00**
Total Project Lands	**2,320.30**	**13,920.40**

1/ These are gross numbers. They do not factor in potential mitigation through maintenance of irrigation in HMUs or continued development in XYZ lands (see Appendix L, Lower Snake River Mitigation History and Status for more information).

2/ Long term gains are based on the assumption that habitats will return to their pre-project distribution. It does not assume that HMUs or XYZ lands will be maintained. Exact distribution of habitat types following drawdown is not quantifiable.

3/ Not included in the total.

Source: HEP Analyses, 1995

Upland Community

Short- and Long-term Effects

Shrub-steppe and grassland habitat acreages would increase under Alternative 4—Dam Breaching as current water levels drop within the river, and much of the existing riparian areas convert to upland habitats. Approximately 12,440 acres would be expected to return to upland habitat. The vegetation plan that would be implemented by the Corps following drawdown would include seeding of upland grasses.

Haul roads and stockpile areas associated with dam decommissioning would disturb approximately 2,000 acres of the existing upland habitat in the short term. Most of this area would likely revegetate over time; however, the roaded portions (approximately 70 acres of impact, based on a 30-foot right-of-way) are likely to remain unvegetated in the long term. To avoid possible damage by cattle to habitat and spawning areas along the new river, new cattle corridors could be grouped where possible, and wells could be installed providing water via solar powered pumps to stock watering tanks (for more detail, see Appendix D, Natural River Drawdown Engineering). Upland habitats elsewhere in the project area would likely improve as cattle continue to be fenced out of project lands, and as habitat continued to recover. Agricultural land acreages should not increase in the future because the Corps is attempting to achieve optimal agricultural benefits for wildlife based on HEP. Most of this increase would help meet upland gamebird habitat requirements.

5.6.2 Wildlife

This analysis of impacts on terrestrial resources is based on several assumptions. First, the effects are summarized using two time periods – short term and long term. These time periods are not mutually exclusive nor do they represent the same span of time for every habitat type or species group. They are simply a tool to present general trends in effects over time. In general, the dividing line between short and long term for vegetation was 10 years, and the threshold for wildlife species was 4 years (period of construction). Again, this is not meant to be a strict definition. Second, this analysis assumes that irrigation would be maintained on those HMUs where it is currently provided. Finally, under a drawdown scenario, this analysis assumes that the Corps would initiate extensive vegetation management to maximize the growth of native species. This effort would include physical and chemical control of noxious weeds, native willow plantings, and erosion control measures on the newly exposed islands.

In general, the short-term and long-term effects of Alternatives 1—Existing Conditions, 2—Maximum Transport of Juvenile Salmon, and 3—Major System Improvements on wildlife would be expected to be minimal because structural and management changes proposed under these alternatives are targeted specifically at juvenile salmon and would not substantially modify water levels of the reservoirs. The only alternative that would be expected to have significant effects on terrestrial wildlife would be Alternative 4—Dam Breaching. This alternative would be expected to have short-term negative impacts and long-term positive effects compared to Alternative 1—Existing Conditions. These effects are described in more detail below.

5.6.2.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would be expected to have little or no significant short- or long-term impacts on terrestrial wildlife resources within the study area. Continued operation of the Lower Snake River Project would be expected to maintain current habitat conditions. For instance, the current lack of mature riparian vegetation along the river would continue. However, the size and structural complexity of the vegetation that does exist would be expected to slowly improve, which would be expected to indirectly benefit wildlife such as cavity-nesting species by providing additional nesting and foraging habitat. Riparian and upland habitat in the irrigated HMUs would be expected to continue to slowly improve. Problems with exotic species and disease would be expected to persist.

Under Alternative 1—Existing Conditions, the Corps would proceed with completion of its terrestrial wildlife mitigation requirements for the original construction of the Lower Snake River Project. The Corps has met the acreage requirements for habitat acquisition approved under the Comp Plan. However, despite extensive land purchases and intensive development (e.g., irrigation and habitat improvement) of selected HMUs, the

Corps is still approximately 21,000 habitat units (HUs) short of meeting California quail habitat goals. The Corps is also short by lesser amounts of HUs for other species including the downy woodpecker, yellow warbler, ring-necked pheasant, and Canada goose (Appendix L, Lower Snake River Mitigation History and Status [Table 3]). However, this imbalance would be reduced as conditions of mitigation lands managed as compensation for quail and pheasant hunting opportunities lost by inundation of the reservoirs (see Appendix L, Lower Snake River Mitigation History and Status) continue to improve into the future. Currently, work is being initiated to start a final HEP evaluation to determine the HU status of the terrestrial wildlife portion of the Comp Plan. BPA, through the Northwest Power Planning Council, has agreed to assume responsibility, with coordination with the Corps, for the terrestrial wildlife portion of the Comp Plan, based on this formal HEP analysis, once that evaluation is complete.

If existing conditions continue, and the number of salmon returning to spawn in the lower Snake River and in other rivers and streams farther upstream does not increase, some wildlife species could suffer potential long-term, indirect negative effects. For instance, any grizzly bears reintroduced into central Idaho might be indirectly negatively affected by a lack of salmon prey during certain times of the year (Hilderbrand et al., 1996). However, the USFWS believes that sufficient alternative sources of food, such as kokanee salmon and trout, as well as herbaceous forage, are available to offset the reduced availability of salmon in the region (see Appendix M, Fish and Wildlife Coordination Act Report).

5.6.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

The major difference between Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 1—Existing Conditions is that transport of juvenile salmon by truck and barge would be maximized under Alternative 2—Maximum Transport of Juvenile Salmon. Therefore, the impacts on wildlife under Alternative 2—Maximum Transport of Juvenile Salmon would be expected to be the same as under Alternative 1—Existing Conditions.

It is not known how many more juvenile salmon would be removed from the river under this alternative. However, in 1996, 98 percent of all fish collected at Lower Granite Dam were transported, leaving approximately 100,000 fish that were bypassed (of the fish collected) (Corps, 1996b). Thus, Alternative 2—Maximum Transport of Juvenile Salmon would be expected to remove about another 100,000 juvenile salmon each year from the river, particularly since this alternative might be implemented with additional management activities such as altered spill scenarios. This would reduce the number of juvenile salmon available as prey for some bird species such as the double-crested cormorant, white pelican, and Caspian tern. However, these species consume a wide variety of fish species, and their populations would not be expected to decline if fewer juvenile salmon were available.

5.6.2.3 Alternative 3—Major System Improvements

The primary difference between Alternative 3—Major System Improvements and Alternative 1—Existing Conditions is the addition of various fish bypass structures to the existing dam facilities under Alternative 3—Major System Improvements. The installation of these major system modifications would be expected to result in very few migrating juvenile salmon left in the river between Lower Granite and Ice Harbor (see Section 4.5.1, Anadromous Fish).

Similar to Alternatives 1—Existing Conditions and 2—Maximum Transport of Juvenile Salmon, Alternative 3—Major System Improvements would reduce the number of juvenile salmon available as prey for aquatic and avian predators in the three reservoirs below Lower Granite. However, this indirect negative effect would not be expected to significantly impact any wildlife species because they would be expected to substitute other fish as prey.

5.6.2.4 Alternative 4—Dam Breaching

The remainder of this section focuses primarily on the anticipated effects of Alternative 4—Dam Breaching on wildlife resources in the study area. Effects of this alternative on different species groups (e.g., waterfowl, big game, raptors, and furbearers) are addressed separately. Potential effects on threatened and endangered species are addressed last.

Under Alternative 4—Dam Breaching, the existing reservoirs in the study would be drawn down to pre-dam river levels. This means a drop in elevation of the operating pool from between 94 and 110 feet. The alternative would expose approximately 13,772 acres of previously inundated land. As described in Section 5.6.1, Vegetation, this alternative would be expected to have a negative impact on riparian habitat. Most riparian habitat outside of the irrigated HMUs (which would be maintained under Alternative 4—Dam Breaching) would be expected to desiccate and return to upland habitat within a few years. Also, most of the existing emergent wetland habitat along the current reservoir shoreline would be expected to disappear (Table 5.6-2). This change in habitat would be expected to produce short-term negative effects on wildlife, including direct mortality to wildlife susceptible to desiccation (such as amphibians) and indirect mortality due to loss or change in habitat (otter, riparian-associated bird species). Conversely, some wildlife would be expected to receive short-term benefits from the drawdown alternative, such as shorebirds (who would benefit from thousands of acres of exposed mudflats) and colonial-nesting terns and gulls (who would have more area of exposed islands for nesting). Maintenance of the irrigated HMUs combined with an active vegetation management plan (including aggressive native tree and shrub planting combined with control of noxious weeds) would be expected to minimize and mitigate for some of these short-term negative effects and hasten the long-term benefits that would be expected to accrue for many species with the restoration of a more continuous, functioning riparian zone in the study area.

Under Alternative 4—Dam Breaching, a new mitigation plan would likely be developed for the Lower Snake River Project. The old mitigation as described in Appendix L, Lower Snake River Mitigation History and Status would end. The new mitigation would likely continue to use HEP to evaluate the status of mitigation along the lower Snake River. The baseline for the new mitigation could be the same as the current mitigation. HEP values based on 1958 air photos (Salther-Blair, et al., 1991) would provide the baseline. The irrigation intakes at existing irrigated HMUs may have to be modified so the vegetation on these sites could be maintained. The additional lands which were purchased and developed would also need to be maintained to provide some interim habitat value until the lower Snake River lands could reestablish riparian vegetation. Appendix L, Lower Snake River Mitigation History and Status shows the potential acreage and HU of habitat lost and the amount of habitat currently being compensated on irrigated sites in the Lower Snake River Project, and the additional lands managed by the WDFW.

Game Birds

As described in Section 4.6-2, Wildlife, the major game bird species in the study area are the ring-necked pheasant, chukar, quail, and mourning dove. Dam breaching under Alternative 4—Dam Breaching would initially create a large barren gap in vegetation between the restored river and current riparian and upland vegetation. This gap would increase the exposure of game birds to predators while foraging, breeding, or seeking water along the edges of this gap. Landscape-level increases in edge habitat have been shown to increase mortality during the spring breeding period of ring-necked pheasants in agricultural landscapes (Schmitz and Clark, 1999). There would be no natural cover for roosting, feeding, escaping, or nesting along the approximately 13,772 acres of exposed shorelines, mudflats, and islands for an undetermined amount of time following dam breaching. Although extensive revegetation efforts are planned, natural cover would be expected to be limited for at least 5 to 10 years.

In the short term, activities associated with removal of earthen embankments at each dam and the subsequent construction of diversion dams (such as stockpiling and haul road construction) would be expected to have minor direct negative effects on upland game bird habitat and indirect negative effects on species using that habitat for nesting or cover. It is estimated that approximately 2,000 acres of upland habitat would be negatively impacted by construction activity at all four dams (Appendix D, Natural River Drawdown Engineering). Construction activity includes stockpile areas for imported and exported materials (riprap, fill from earthen dams, levee material), haul roads, equipment storage areas, and staging areas. These areas would be expected to have an average use time of 2 years (dam breaching would occur over a span of 4 years, 2 years at each pair of dams). However, these negative effects would be minimized by locating the staging areas in previously impacted areas outside of irrigated HMUs.

Regardless of the amount of restoration along the old and new shorelines, a significant change in the character of the vegetation along the river would be expected to occur. These changes may include: 1) loss of woody vegetation along the old shoreline due to lack of water (270 acres), 2) increased invasion of exotic species along the exposed ground, 3) loss of vegetation due to sloughing and erosion, and 4) restoration of a more contiguous riparian zone along the new river channel. These changes would undoubtedly have some indirect negative effects on game birds in the short term. An increase in exotic species would be expected to benefit game birds.

However, in the long term, it is likely that Alternative 4—Dam Breaching would have significant positive benefits for game birds. The WDG (1984) describes how upland game populations were “severely reduced” due to the loss of riparian habitat as a result of the 4 lower Snake River dams, with rough estimates of 120,000 individuals (including pheasant, quail, chukar, gray partridge, mourning dove, and cottontail) being lost.

Approximately 12,240 acres of upland habitat would be expected to be restored in the study area in the long term (Table 5.6-2). Thus, where a series of isolated irrigated HMUs exist now to provide habitat, a more continuous band of riparian habitat would be created, with populations likely to increase. Furthermore, the revegetation plan would include approximately 300 additional acres of food plots and approximately 5,000 acres of bunchgrass grassland to meet mitigation goals for upland game birds.

Waterfowl

Alternative 4—Dam Breaching would be expected to have short-term negative effects on waterfowl in the four reservoirs, including elimination of much of their current shallow-water habitat at the edges of the existing reservoirs. In both the short and long term, the lowering of the reservoirs would likely create land bridges to existing islands, (New York and Silcott Islands). Even islands that are not connected to the new shoreline would likely have increased predation because of the access that shallow water would provide for predators such as coyotes, raccoons, and others. Asherin and Claar (1976) found that when a decrease in water level elevation in the McNary pool in 1975 exposed land bridges to Badger and Foundation Islands, as well as three of the five Hat Islands, coyotes destroyed all nesting attempts and killed four adult geese on Hat Islands. Under Alternative 4—Dam Breaching, this effect would likely be offset by the exposure of former nesting habitat that was inundated by the reservoirs. Over 50 islands larger than 5 acres in size were inundated behind the lower Snake River dams (Corps, 1988). These islands supported approximately 100 goose nesting sites on nearly 1,500 acres (WDG, 1984). However, there would likely be a delay in any increased reproduction from the newly exposed islands until appropriate vegetation for nest-building and cover is established.

Similar to its effect on game birds, the exposed drawdown zone would be expected to increase exposure of waterfowl broods to predation as they travel to water. Also, it is likely that while the flush of new growth would be likely to increase short-term forage, the combination of exposed mudflats, heavy weedy growth, and riprap could create barriers to young waterfowl. Furthermore, all current goose nesting boxes would be located farther from water. It is likely that many of these tubs currently being used would be abandoned when the water level dropped significantly. Also, dam breaching would expose shorelines that are likely to experience sloughing and erosion, posing further barriers to waterfowl broods.

Higher water velocities would be expected under a near-natural river scenario. This would minimize the potential establishment of submerged aquatic plants such as pondweeds and waterweeds which would be eliminated by drawdown. Overall, in the short term, Alternative 4—Dam Breaching would eliminate these potential food sources for waterfowl. In the long term, higher water velocities in the river would interfere with the establishment of submergent aquatic vegetation in some areas. However, other shallow-water areas would be exposed and, over an undetermined amount of time, would establish new submergent aquatic vegetation. Waterfowl such as diving ducks, the American coot, and the American widgeon would be most affected by this change.

The waterfowl population of the lower Snake River would be expected to decline in the short term as the result of dam breaching. It is likely, however, that many of these birds would move to nearby slackwater areas such as McNary Reservoir and McNary Wildlife Refuge. This movement would be encouraged by the fact that no hunting is allowed in the McNary reservoir from the mouth of the Snake River to Ice Harbor Dam. However, many of the shallow-water habitats of the McNary pool are expected to experience considerable deposition of sediment released by breaching the Snake River dams. Most (over 50 percent) of this deposition would be expected to occur north of Wallula Gap, on the eastern shore of the reservoir (Appendix F, Hydrology/Hydraulics and Sedimentation). It is unknown how or if this deposition would potentially affect waterfowl displaced from the Snake River reservoirs.

Similar to the effects on upland game birds, it is likely that Alternative 4—Dam Breaching may have short-term negative impacts on waterfowl. However, Alternative 4—Dam Breaching would also have significant positive long-term benefits, as all the islands inundated in the past may reemerge unless eroded. These islands may eventually provide more nesting and brooding habitat for Canada geese and other waterfowl, potentially similar to what existed prior to dam construction (Asherin and Claar, 1976). In addition, the large sediment loads currently stored behind the dams could provide source material for new sandbars and shallow areas as the river establishes a new channel. Although wintering waterfowl would experience disturbance during the actual drawdown process, after it is complete, there would potentially be an increase in the amount of shallow water areas available for foraging and resting. With island exposure, no new habitat development would be required. Some island management would be needed to promote a vegetation community that is attractive to waterfowl nesting.

Shorebirds

Alternative 4—Dam Breaching would be expected to have positive short-term indirect effects for shorebirds, as the amount of mudflats (which provide foraging and nesting habitat) would increase significantly in the short term. However, this benefit would decrease as these mudflats revegetated. Under Alternative 4—Dam Breaching, approximately 13,772 acres of mudflats would be exposed. In the short term these exposed areas could provide foraging and nesting habitat for migrating and resident shorebirds (Taylor and Trost, 1992). However, this effect should only last a few seasons until the flush of regrowth from the seed bank and the planned restoration activities have begun. The seed bank along the lower Snake River has been shown to have the potential for rapid recolonization of these exposed areas above 15 feet below the old reservoir level (Robberecht, 1998). Abundance and species richness of migratory shorebirds would likely increase during the first few years following dam breaching, but then their abundance should return to pre-project levels. Nesting habitat for the few breeding shorebird species in the study area (mainly killdeer and spotted sandpiper) should increase in the short and long term as more mudflats would be exposed under near-natural river conditions under Alternative 4—Dam Breaching.

Colonial-nesting Birds

Colonial-nesting birds are currently uncommon along the lower Snake River, with the exception of cliff and bank swallows (see Section 4.6.2.4). Under Alternative 4—Dam Breaching, drawdown of the reservoirs would increase the amount of exposed areas available as nesting habitat for bank swallows in the short term. Similarly, abandonment of the four dam structures would reduce disturbance thereby improving nesting conditions for cliff swallows that utilize various portions of these structures as nesting habitat.

There are only two large islands in the reservoirs at this time, New York and Silcott, and neither of these islands supports nesting populations of terns or gulls. Some suitable nesting habitat for terns and gulls may be created in the short term by the exposure of additional island habitat along the river. However, this habitat is not likely to remain suitable in the long term due to easy access for predators (due to shorter water crossing distances), the encroachment of woody vegetation such as Russian olive, cottonwood, and black locust as well as native trees and shrubs that would be planted as part of the vegetation management plan. Notably, large nesting colonies of gulls and terns on islands in the Columbia River (e.g., Rice Island in the lower Columbia) are suspected of causing significant mortality of salmon smolts through predation (Appendix M, Fish and Wildlife Coordination Act Report). For this reason, reduction in suitable nesting habitat along the river for these bird species is pursuant to the goals of the measures evaluated in this Feasibility Study.

In contrast to habitat for gulls and terns, long-term development of mature riparian habitat along the new river under Alternative 4—Dam Breaching would be expected to improve the suitability of the study area for nesting by heron species. The Corps has no known observations of this species currently nesting along the lower Snake River above Ice Harbor Dam (Corps, 1999b; Rocklage and Ratti, 1998). Finally, Alternative 4—Dam Breaching may eventually provide the habitat features (such as increased nesting and roosting structures) necessary to allow double-crested cormorants to nest in the study area, which they did prior to inundation (Weber and Larrison, 1977). Also, more islands would increase the nesting opportunities for the white pelican, a state endangered species currently known to nest only on Crescent Island.

Raptors

The major impact on raptor species from the dam breaching under Alternative 4—Dam Breaching would be indirect effects on prey availability. Anticipated reduction in abundance of waterfowl (as described previously) and small mammals (see Small Mammals section below) in the study area would be expected to have negative effects on the availability of prey for raptors. Also, loss of riparian trees and shrubs would have a direct negative effect on red-tailed hawks by reducing potential nesting habitat. These negative impacts would be expected to be short term while a new riparian zone establishes. There would be no cover for animals drinking from the river. Maintaining irrigation in the HMUs would minimize these effects. Reduction of the water level in the reservoirs may increase the availability of cliff nesting for some raptor species. In the long term, development of a mature riparian forest would provide more tree-nesting, roosting, and perching opportunities for some raptor species, particularly owls. Owls and other cavity-nesting raptors would also benefit from the creation of snags along the old shoreline. Also, the long-term gain of 12,440 acres of upland habitat would increase the availability of open foraging habitat for species such the American kestrel and northern harrier. Overall, there would be long-term increases in fish-eating raptors, especially, because there would be better and more perch sites available as well as more exposed mud flats. In the short term, there may be some losses of perch sites, however.

Other Non-game birds

Negative effects to other non-game birds from Alternative 4—Dam Breaching would be due to the short-term elimination of riparian habitat that would result from drawdown. Riparian habitat along the existing shoreline has by far the greatest species richness and bird abundance of habitats along the river, with the irrigated HMUs exceeding all other riparian habitats (Asherin and Claar, 1976; Rocklage and Ratti, 1998). Much of the existing riparian habitat would be permanently lost, approximately 1,189 acres, except in the irrigated HMUs (Table 5.6-2). As a result, the populations of some breeding birds could decline in the short term, including northern orioles, song sparrows, willow flycatchers, yellow-breasted chats, and yellow warblers (Rocklage and Ratti, 1998). In the long term, there may be an increase in the quality of riparian habitat (e.g., size of trees, diversity of structure, etc.), but not for 20 to 50 years. Species that may benefit from the development of a mature riparian forest and thus increased availability of nesting and foraging habitat include the downy woodpecker, yellow warbler, and song sparrow. Other species that would be expected to benefit include Lazuli's bunting, black-capped chickadee, northern oriole, and western screech owl. Some of these species may benefit from the presence of cavity-bearing snags before then.

The elimination of most emergent wetlands and marshes along the margins of the current reservoirs would have minor negative impacts on bird species dependent on those habitats for nesting, such as marsh wren and yellow-headed and red-winged blackbird. There are less than 400 acres of emergent wetlands in the study area currently (see Section 4.6.1.2, Riparian and Wetland Habitats). Other bird species that forage in the vicinity of these habitats would also be negatively impacted. To compensate for losses of riparian species, it is estimated that 800 acres of riparian forest (cottonwood), 500 acres of mesic shrubland (hawthorn, hackberry), and 1,500 acres of palustrine scrub-shrub (willow) plantings may have to be established after drawdown.

Big Game

Negative effects on riparian habitat from the dam breaching under Alternative 4—Dam Breaching would be expected to reduce the abundance of mule and white-tailed deer in the canyon in the short term. Riparian habitat outside irrigated HMUs would be expected to deteriorate following drawdown. This would eliminate much of the suitable forage and cover along most of the existing shoreline. In the long term, lowering the reservoirs would likely improve the suitability of the canyon as winter range for deer by increasing the amount of brush and tree vegetation that would provide cover. WDG (1984) estimated that habitat capable of supporting 1,200 deer was lost following inundation of prime wintering habitat along the lower Snake River. Although it is estimated that approximately 1,189 acres of riparian habitat would be lost in the short term, approximately 1,481 acres would be expected to develop in the long term along the new river channel (Table 5.6-2). Furthermore, the revegetation of the exposed shorelines would be expected to provide new opportunities for forage once suitable habitat has developed. The creation of land bridges under Alternative 4—Dam Breaching would facilitate access by predators to fawns being raised on existing islands; however, currently only New York Island provides potential suitable cover for fawning. In contrast, there would be more newly exposed islands available where deer could seek refuge during fawning once suitable cover has developed.

Alternative 4—Dam Breaching would have little or no effect on other, more rare big game animals along the river such as elk, bighorn sheep, black bear, and mountain lion. These species occur in very low numbers in the canyon or are not associated with the riparian zone (i.e., bighorn sheep). Creating a more contiguous riparian zone would potentially improve the suitability of the study area as a travel corridor for some of these species; however, there is no evidence that these species are more than occasional transients in the study area. No additional habitat developments would be needed for big game.

Small Mammals

In the short term, small mammals would potentially be negatively affected under Alternative 4—Dam Breaching by the elimination of riparian habitat along the existing shoreline and the increased distance to water. Based on the fact that Rocklage and Ratti (1998) found more individuals and species of small mammals in the irrigated HMUs than in any other habitat type (including upland or grassland), maintenance of irrigation at these sites would be expected to minimize this negative impact. Another potential negative impact is the potential for increased exposure to predators both along the existing shoreline and for any individuals foraging on sprouting vegetation in the drawdown zone. However, these potential short-term negative effects would be expected to diminish in the long-term as new riparian vegetation develops along the new river channel, providing habitat that may be less fragmented, have a higher percentage of native species (which would be encouraged by active vegetation management by the Corps), and cover more area (1,481 acres gained versus 1,189 lost – Table 5.6-2). Any small mammal species associated with upland habitats (e.g., grassland, shrub-steppe) such as Ord's kangaroo rat or bushy-tailed woodrat, would be expected to gain significant benefits from drawdown because upland habitat would be expected to increase by approximately 12,440 acres in the study area (Table 5.6-2).

Alternative 4—Dam Breaching would be expected to have some potential negative effects on bats. The reduction in water surface would eliminate some foraging habitat as well as breeding habitat for invertebrate prey species. Many of the embayments and side channel ponds that would be exposed by drawdown are presumed to currently support breeding insect populations. The species most likely to be affected are the Townsend's big-eared bat and the Yuma myotis, because both of these species are associated with water (see Section 4.6.2.9 for more information). Also, the elimination of any riparian vegetation along the existing shoreline would be expected to potentially eliminate some roosting and foraging habitat for bats. However, these potential negative effects may be mitigated by the following potential benefits of drawdown: 1) creation of snags along the existing shoreline that may be used as roosting sites, 2) exposure of cliff habitat that could be used by species such as the western pipistrelle for roosting or hibernacula (approximately 650 acres of rock will be exposed under Alternative 4—Dam Breaching; Table 5.6-2), and 3) the long-term development of riparian vegetation along the new river channel combined with maintenance of the irrigated HMUs.

Furbearers

Under Alternative 4—Dam Breaching, terrestrial furbearers such as coyote, raccoon, and bobcat would be expected to indirectly benefit from anticipated short-term increases in the availability of prey as waterfowl, invertebrates, and small mammals become more vulnerable due to the receding water and the lack of cover along the new shoreline. However, loss of riparian habitat in turn would reduce the availability of resting and denning habitat for these species.

Similarly, aquatic furbearers would be expected to have increased availability of prey such as fish and crayfish in the short term. However, in the long term they would likely experience negative effects from the increased distance between water and vegetation, the lack of cover at the water's edge, and the reduction in wetland habitat (loss of approximately 669 acres; Table 5.6-2). The otter is one of the few species that has actually become more abundant due to the establishment of the reservoirs, which provide substantial denning habitat in the riprap along the shores. The dam breaching under Alternative 4—Dam Breaching would isolate these current dens from the new shoreline, creating some negative disturbance effects.

Substantial amounts of additional riprap would be placed along the exposed banks (Appendix D, Natural River Drawdown Engineering), but the linear riprap coverage would be reduced from the current length of about 97 miles of shoreline to about 51 miles. Muskrat and beaver would be expected to be more negatively impacted than otter. Muskrat are more closely associated with emergent riparian habitat, almost all of which would be eliminated in the short term under Alternative 4—Dam Breaching (Table 5.6-2). The long-term effect would depend on how quickly riparian habitat develops along the new river channel. Beaver would lose access to food sources immediately adjacent to the river. They would be able to travel upslope to access stands of shrubs or trees along the old shoreline or in irrigated HMUs, but this would increase their exposure to predation. However, this negative effect on beaver could in turn reduce grazing pressure on any woody stems planted as part of revegetation efforts. In general, however, populations of terrestrial and aquatic furbearers would likely stabilize and recover from the dam breaching in the long term as the riparian zone and aquatic prey base recover. No additional habitat development would be required for river otter and other furbearers.

Amphibians and Reptiles

Alternative 4—Dam Breaching would be expected to have significant direct and indirect negative effects on amphibians in the short term. It is likely that the permanent removal of water and loss of riparian and wetland habitats would eliminate many amphibians through desiccation and exposure to predators. Loper and Lohman (1998) experimentally showed that amphibian eggs exposed to desiccation for little more than a day are no longer viable. Thus, amphibian populations would be expected to be severely impacted in the short term under Alternative 4—Dam Breaching, potentially including the loss of the entire population along some stretches of the river. However, in the long term, the amphibian assemblages along the new river channel may recover to pre-impoundment levels through the creation of more extensive shallow water habitats and more extensive riparian habitat. The establishment of new riparian vegetation may create dispersal corridors for these species as well as provide more extensive areas for egg-laying and escape from predators.

Reptiles are generally more mobile than amphibians and less dependent on aquatic habitat, except for turtles. Therefore, it is unlikely that Alternative 4—Dam Breaching would have any significant indirect or direct effects on reptiles. However, revegetation efforts following dam breaching would hasten the development of habitat suitable for cover for both amphibians and reptiles. In particular, some special consideration may need to be given to the isolated western painted turtle population at the Chief Timothy HMU. The pond that supports this small population may dry up under the drawdown scenario, which would eliminate habitat for this population.

5.6.3 Species with Federal Status

5.6.3.1 Plant Species

This section discusses the potential effects of the alternatives on five plant species with Federal status under the Endangered Species Act (ESA) that may occur in the study area. These plants are water howellia, McFarlane's four-o'clock, Ute ladies'-tresses, Howell's spectacular thelypodium, and basalt daisy. Potential effects to plant species of concern are not addressed separately within this section but instead are addressed by the overall effects on vegetation communities in Section 5.6.1, Vegetation. Potential effects of the proposed project on Federally listed species are described in more detail in a separate biological assessment, as required by Section 7 of the ESA, that was completed by the BPA, Corps, and BOR in 1999 (BPA et al., 1999).

Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements

As discussed earlier in this section, no significant changes would occur to existing vegetation associated with project activities, therefore, no impacts are anticipated to occur to potentially occurring threatened or endangered plant species or their habitat types.

Alternative 4—Dam Breaching

Water Howellia

Under Alternative 4—Dam Breaching, potentially suitable habitat for water howellia (seasonal wet areas) would be expected to be lost in the short and long term. Approximately 669 acres of wetlands are expected to be lost under Alternative 4—Dam Breaching (Table 5.6-2). However, the nearest population of water howellia is approximately 60 miles north of the study area, in Spokane County, Washington. Thus, the likelihood of negative effects to populations of this Federally threatened species is low. The new river channel may provide more potentially suitable habitat for this species than the current shoreline due to naturally fluctuating water levels. However, this would depend on future biological, physical, and hydrologic conditions, and on land management decisions.

Ute Ladies'-tresses

This Federally threatened species is associated with wetland and riparian areas. Alternative 4—Dam Breaching would be expected to eliminate some potentially suitable habitat for this species in the study area in the short and long term. However, the nearest populations are in southeastern Idaho and northern Washington. Thus, the likelihood of this species occurring in the study area is low. Similar to water howellia, Ute ladies'-tresses may benefit from the potential long-term development of wet areas beside the new river channel. However, this would depend on future biological, physical, and hydrologic conditions, and on land management decisions.

McFarlane's Four-O' Clock

No effects are anticipated to occur to this species since it is not expected to occur within the study area, and is associated with upland habitats, most of which are unaffected by project activities. The nearest population is in Hells Canyon, Idaho. Effects to potential populations of this species under this alternative could include habitat destruction related to ground-disturbing activities associated with dam decommissioning. Construction of haul roads and stockpiling could impact unrecorded populations or potential habitat for the species. Upland habitat elsewhere within the project boundary should improve as grazing restrictions are maintained.

Howell's Spectacular Thelypodium

This plant species is proposed for Federal listing. Suitable habitat for this species is very limited in the study area (wet alkaline meadows in valley bottoms). Also, the nearest population is approximately 100 miles away near Haines, Oregon. Alternative 4—Dam Breaching would be expected to have no effect on this species because of the low probability of occurrence in the study area.

Basalt Daisy

This plant species is a candidate for Federal listing. Suitable habitat for this species (basalt rock faces) does occur in the project area. The nearest population is approximately 90 miles from the study area. Alternative 4—Dam Breaching would be expected to have no negative effects on this species, but potentially suitable habitat would be exposed after drawdown. Approximately 660 acres of rock habitat would be gained with drawdown (Table 5.6-2).

5.6.3.2 Wildlife Species

Only one Federally listed wildlife species is known to occur in the study area–the bald eagle. Four additional Federally listed species, the gray wolf, Oregon spotted frog, Canada lynx, and the grizzly bear, are not known to occur but could potentially occur as transients.

Bald Eagle

In the short term, Alternative 4—Dam Breaching would be expected to indirectly benefit wintering bald eagles by increasing the availability of stranded salmon and other fish prey as water levels recede. In the intervening years as the natural vegetation recovers, some potential eagle perching trees could die from lack of water. However, in the very long term (greater than 50 years), large trees would be expected to develop along the restored river channel, which would be expected to substantially improve habitat suitability for eagles along the lower Snake River.

Gray Wolf

As described in Section 4.6.3.2, it is possible that members of the reintroduced, experimental population of gray wolves living in central Idaho could disperse into the study area. However, this is highly unlikely given the current levels of human activity and the relatively high road density. Thus, Alternative 4—Dam Breaching would be expected to have no impact on gray wolves.

Grizzly Bear

Alternative 4—Dam Breaching would be expected to have no significant direct effect on grizzly bears, which do not occur near the study area. If dam breaching results in a sustained long-term increase in native salmon runs in upstream tributaries of the Snake River (e.g., Clearwater River), it could indirectly benefit any experimental population of grizzlies that may be established in central Idaho.

Oregon Spotted Frog

Alternative 4—Dam Breaching would be expected to have no direct effects on the Oregon spotted frog since the nearest known population is in Klickitat County, Oregon. Approximately 669 acres of potentially suitable habitat (wetlands) would be lost in the long term under Alternative 4—Dam Breaching (Table 5.6-2).

Canada Lynx

Alternative 4—Dam Breaching would be expected to have no direct effects on Canada lynx, because there is no suitable habitat in the study area and there are no known observations of this species in the study area.

5.6.4 Cumulative Effects

Terrestrial resources would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Existing programs under the Comp Plan would be continued. Also, existing habitat conditions would continue to exist.

Under Alternative 4—Dam Breaching, the potential effects and conditions described in the previous subsections would be anticipated. In the long term (> 10 years), habitat conditions would stabilize to conditions that are representative of a near-natural flowing river. Also over the long term, elements of the Comp Plan would likely be revised to adapt to the changed conditions. In addition, it is likely that required flow releases from upstream sources would need to be evaluated and potentially revised to accommodate the near-natural flow conditions under this alternative.

5.6.5 Uncertainties in Potential Terrestrial Resources Effects

Although vegetation and wildlife would slowly shift from a reservoir to a river condition, the duration of short-term impacts from habitat loss and alteration and the time required for, and likely extent of, change to a river environment are uncertain.

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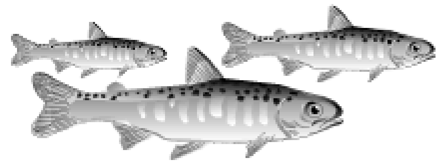


5.7 Cultural Resources

This section discusses the potential impacts on historic and cultural properties associated with the four alternatives. Short-term effects are associated with demolition-related activities, and shoreline fluctuations that would occur with a return to approximate near-natural river levels. Long-term effects are those that persist after geomorphic systems have stabilized (e.g., revegetation of exposed sediments, shoreline stabilization). This section also discusses mitigation measures to address impacts to sites resulting from dam breaching. The information provided in this section is primarily derived from Appendix N, Cultural Resources, and Appendix D of the System Operation Review Final EIS (BPA et al., 1995). See Table 5.7-1 for a summary of potential effects.

5.7.1 Cultural Resources Impact Issues

Changing water levels and flows can cause wave action, inundation, and exposure of reservoir drawdown zones, all of which can affect cultural resources. System operations can also have impacts on historic properties as a result of changes in the human use and aesthetics of the shore and drawdown zones. Impacts to archaeological deposits occur differently in each of the four reservoir zones: The

Table 5.7-1. Summary of Potential Effects of the Alternatives on Cultural Resources

Alternative 1	Alternative 2	Alternative 3	Alternative 4
No change from current conditions.	Slight increase in wave action impacts from additional barge traffic; otherwise, the same as Alternative 1.	Slight increase in wave action during installation of new systems, but this would be temporary; otherwise, the same as Alternative 1.	• Increased rate of site exposure and associated hazards. • Corresponding access for scientific research and cultural resources management. • Creation of conditions that would allow the theft of cultural or historic properties, damage and destruction of valuable cultural resources, and associated law enforcement problems. • Extensive costs incurred for cultural resource evaluations. • Renewed access to traditional cultural practices and traditional fishing areas by Tribes.

littoral zone (exposed beach), wave-action zone, inundation zone, and shore zone (Figure 5.7-1).

Exposed archaeological deposits within the littoral zone are subject to impacts that are mechanical, human, and animal in origin. Erosion is the primary concern for cultural resources in this zone and in the wave-action zone. Generally, soils on which the lower Snake River hydropower facilities are located are derived from glacier and flood deposits. They are light soils, highly susceptible to erosion by water and wind. In addition, the lower Snake River reservoirs have steep slopes that are somewhat susceptible to slumping and landslides.

Because inundation removes vegetation, wind and water (runoff) erosion deflates archaeological sites in the littoral zone. Deflation is the removal of the archaeological soils, leaving heavier items and artifacts in place. Water running over unvegetated slopes also causes erosional rills and gullies and moves artifacts. The movement of artifacts and site features within or away from a site decreases its scientific integrity and value because it becomes more difficult to reconstruct the site's original features and placement of artifacts. The littoral zone is also subject to repeated cycles of wetting and drying, which can cause organic deposits, such as bone, and some artifacts, such as ceramics, to deteriorate. Erosion from livestock trampling and wallowing may also occur in this zone.

In the wave-action zone, wind- and powerboat-generated wave action erodes and deflates archaeological sites. It may also stimulate geomorphological changes that can destroy intact archaeological deposits. These changes can include slumping, scouring, terracing, and piping (see Section 10, Glossary, for definitions of these terms).

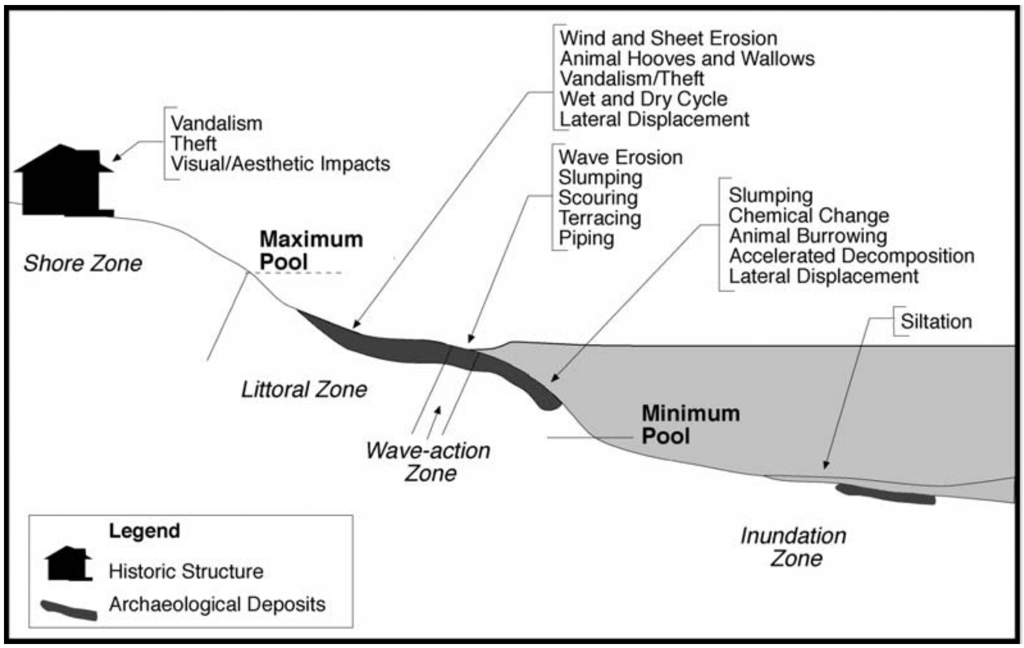


Figure 5.7-1. Reservoir Impact Zones and Potential Impacts on Historic and Cultural Properties

Impacts on archaeological deposits in the inundation zone include sedimentation, erosion, chemical change, and accelerated decomposition. In general, sedimentation in the project reservoirs tends to enhance cultural resource preservation by providing a sediment buffer against mechanical impacts (e.g., wave action). However, cultural resources buried under a deep silt and water column are no longer accessible for research, and little is known about the long-term impacts of deep sediment burial on fragile cultural deposits. There have been no definitive studies of the impacts of heavy silt deposit on cultural resources; but it is prudent to assume that soil saturation, soil movement, and other processes may result in some adverse impacts to cultural resources. Underwater landslides and sediment shifts are known to occur in the permanently inundated zones of reservoirs (Ware, 1989).

Cultural resources in the inundation zone that are not completely covered with silt are subject to underwater currents that displace materials and artifacts. Archaeological deposits can also be disturbed and moved by aquatic organisms such as burrowing clams. Reservoir water can degrade cultural resources. It dissolves organic materials and ceramics, and changes chemical attributes, such as pH, phosphate, and nitrogen levels of deposits. An accumulation of organic acids accelerates the decomposition of organic materials and ceramics.

Impacts to historic and cultural properties due to system operating strategies also result from human use of the shore and littoral zones. For example, reservoir operations affect the attractiveness of the reservoir for recreation, and thereby influence the number of people visiting these zones. The devegetation and deflation of archaeological sites in the littoral zone, furthermore, make them more visible to the public. When more people are present and archaeological sites are more visible, there is a greater likelihood of vandalism and artifact theft.

Land management actions not related to system operations can also affect human activities at the reservoirs, and different uses can have different effects on archaeological and historic sites near project reservoirs. Decisions to develop or permit camping or hiking trails, for example, may lead to increased impacts on historic and archaeological sites from human-caused erosion, vandalism, and artifact theft.

Project operations that change land uses might also change the integrity or association of a historic or cultural property. For example, change in nearby recreational uses might adversely affect a traditional cultural property such as a Native American ritual site, by increasing sights and sounds incompatible with ritual use. Reservoir drawdown might destroy the visual integrity of a historic site or traditional cultural property by introducing an element that is inconsistent with its historic or cultural character.

5.7.2 The Alternatives and Their Impacts

5.7.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. For the most part, geomorphic processes have reached a near-equilibrium under operations since the impoundment of the reservoirs. Ongoing erosion has stabilized to some extent on the reservoirs. Some of this effect is due to bank stabilization structures that have been placed at various locations to slow or halt erosion. Stable systems would not be altered under this alternative. Therefore, the positive and negative impacts associated with this alternative are considered long term.

Within the inundation zone, cultural resources are considered protected, but not preserved. The dominant effects on cultural resources are from inundation and the biochemical processes active in that environment. Sedimentation and underwater erosion processes are active, but secondary factors. The greatest adverse impact on cultural values has been inaccessibility due to inundation and permanent burial in sediment.

Within the reservoir fluctuation area (the area between the minimum and maximum pool levels which includes the littoral, wave-action, and inundation zones), the predominant impact is erosion resulting from wind, ice, waves, currents, and water level changes. Wave action poses the most serious threat in this area. The erosional processes that predominate in the reservoir fluctuation area include mass wasting, sheetwash, channeled flow, wave wash, ice gouging, and deflation. Depositional processes active in this area include mass wasting (mostly in the form of bank caving and sloughing), fluvial deposition from tributary streams, and, when the pool is elevated, sediment deposition from the reservoir. Air-borne deposition is also an important sedimentary process in areas of reservoir fluctuation.

The area of fluctuation is also subject to biochemical and human-caused impact. These impacts are greater in this area than in any other reservoir area. Biochemical activity is accelerated in the shallow waters of the reservoir because of higher light, dissolved oxygen levels, and ambient temperatures. These conditions will support more organisms that may degrade perishable cultural materials. Similarly, the potential for human and animal impacts is greater in the reservoir fluctuation area than in any other reservoir area. Reservoir environment recreation and all its attendant impacts are concentrated at the reservoir shoreline: boat launch ramps, swimming beaches, campgrounds, and power boats with potentially destructive wakes are all potential sources of adverse impacts to fragile cultural resources. Recent archaeological surveys have been completed within the fluctuation zone for Ice Harbor, Lower Monumental, and Little Goose pools. Few new archaeological sites have been recorded in the fluctuation zone. It is not currently known whether the low numbers of new recorded sites is related to silt aggradation which would obscure cultural materials, other erosional processes, or a lack of archaeological materials.

The shore zone lies above the normal high water line. It is primarily affected by susceptibility of the soils to erosion and mechanical impacts stemming from human use of the land. Although this zone is seldom or never in direct contact with the reservoir pool, reservoir levels directly influence such things as human access to the zone, stability of backshore soils, groundwater fluctuations, and biological composition. Sediment issuing from this zone makes a major contribution to the total sediment load entering the reservoir. Erosion is the primary geomorphic process acting in the shore zone. Potential adverse effects are mostly from mass wasting, sheetwash, channeled flow, and direct rainfall impact. Human use and visitation of the lakeshore increases the possibility of vandalism and theft.

Unavoidable adverse impacts under this alternative relate to the continued inundation of numerous cultural resource sites. Sites within the inundation zone would continue to be affected by sedimentation and underwater erosion processes. Sites located in the reservoir fluctuation area would continue to be subject to fluvial erosion and deposition processes. Human use and visitation to the lakeshore would remain unchanged.

5.7.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, existing juvenile fishway systems would be operated to maximize fish transport. This would result in an increased number of fish being transported downstream by trucks or barges. Wave action impacts would be slightly increased due to additional barge trips up and down the river. However, that number is very small; therefore, the expected change in number of barge trips would have little effect on potential wave action impacts. Otherwise, impacts to cultural resources under this alternative would be identical to those described for Alternative 1—Existing Conditions.

5.7.2.3 Alternative 3—Major System Improvements

Structural enhancements to improve downstream migration of juvenile salmon would be added to each of the four lower Snake River dams under this alternative. Impacts to cultural resources under this alternative would be identical to those described for Alternative 1—Existing Conditions.

5.7.2.4 Alternative 4—Dam Breaching

Under Alternative 4—Dam Breaching, reservoirs behind the four lower Snake River dams would be permanently lowered by removing the earth-filled section of each dam to create a 140-mile near-natural river. This would expose archaeological sites that have been inundated for decades. This alternative would have both short-term and long-term effects on cultural resources.

Alternative 4—Dam Breaching would cause a higher rate of site exposure than the other alternatives. The current set of cultural resource management issues for the four lower Snake River dams in large part would be exchanged for another set. Potential long-term effects on newly exposed sites in this reservoir system could include: vandalism, theft, surface erosion, slumping along river banks and hill slopes, lateral displacement, trampling/wallowing by hoofed animals, rodent burrowing, climatic/precipitation cycles, and biochemical soil changes. It is expected that water flow events such as caused by spring upland releases would have no greater effects than current reservoir fluctuation impacts. Effects would be re-focused to the meandering zone of the near-natural river course, typically along the river edge.

Under this alternative, short- and long-term river behaviors would re-expose sites to periodic flood events, and river movements that alter terrace structures and river bed channel locations. Such river movements would occur within the limits of the lower Snake River's natural meander zones, which generally are expected to be at lower elevations than the current reservoirs' fluctuation zone. Some sites and portions of sites would be re-exposed with an overlying sediment load of variable thickness due to a 20-plus year period of reservoir inundation conditions. Consequently, sites in these circumstances would remain partially or prohibitively inaccessible.

Many of this alternative's most significant impacts to cultural resources would be short term. Although most known archaeological sites would be exposed in a non-vegetated zone following the reservoir drawdowns, in time, the reservoir landscape would be re-vegetated and other site protective measures established. Modifications to existing recreation facilities, such as the extension of boat ramps or the development of new recreation facilities, could potentially affect existing archaeological sites or other historic properties. Potential modifications will be evaluated for effects to cultural resources. Benefits to most reservoir resources would include their renewed access for scientific research, direct cultural resource management (e.g., site evaluations, National Register of Historic Places [NRHP] nominations), and traditional cultural practices.

Assuming that the culmination of effects for inundated cultural resources and shoreline erosion to sites is often worse than site exposure, it can be said that alternatives that increase site exposure are possibly best for the resource. Drawdown would remove the previously constant effects of shoreline erosion at the four reservoirs in exchange for near-natural river behaviors within the river's meander/flood zones. The net long-term effect on cultural and historic properties could be positive. However, a cultural resource management plan (CRMP) with aggressive resource treatments and preservation strategies would need to be funded and implemented.

5.7.3 Cultural Resources Management

Cultural resources management would continue largely as it currently exists for all project alternatives except for Alternative 4—Dam Breaching. Under this alternative, cultural resources management responses would address newly exposed lands and resources as a special circumstance with many unknowns as to site locations, conditions, and preservation needs. A comprehensive resources inventory to identify and assess resource conditions would be necessary to manage the lower Snake River. The Corps would meet its Section 106 obligations on an as-needed basis for projects that result from management needs due to breaching. Given the uncertainties surrounding cultural resources issues under Alternative 4—Dam Breaching, the extent of possible unavoidable adverse impacts is unknown at this time.

Under a comprehensive resource management strategy, the Corps would gather as much information as possible about the nature and condition of the cultural and historic properties located on its lands. To that goal, the Walla Walla District formed the *Payos Kuus T'cuuKwe'* cooperating group (formed through the Federal Columbia River Power System) to assist with the Federal compliance responsibilities for cultural resource protection and management.

5.7.4 The Cultural Resources Protection Plan

The Federal responsibility to protect and preserve cultural properties under Alternative 4—Dam Breaching could be met by developing and carrying out an effective management plan. The usual subjects of cultural resources management are NRHP-eligible sites threatened by adverse impacts such as construction, inundation, erosion, or vandalism. The majority of inventoried cultural sites in the reservoirs of the lower Snake River dams have not been evaluated (through Determinations of Eligibility for the NRHP). Mitigation or treatment planning hinges on this site evaluation process. Actual treatment of identified sites may vary. The cultural, historic, and scientific importance of cultural sites can be preserved by various physical means. The engineering aspects of the physical CRMP are discussed in Annex N of Appendix D, Natural River Drawdown Engineering). Measures other than site armoring are discussed below. Strategies for individual site protection could include one or many protective measures.

5.7.5 Avoidance or Protection

Identified sites would be surveyed and evaluated. This would be followed by consultation with appropriate parties concerning mitigative and protection measures.

Some measure of protection can be secured by measures including bank stabilization programs, protective levees, covering sites, and erecting barriers. In some cases, sites can be protected by stabilization efforts such as site capping, slumpage control, and streambank stabilization. Site protection also includes signage, public education programs, and law enforcement efforts.

5.7.6 Data Recovery and Curation

Data recovery and curation involve scientific excavation. Recovered materials and the associated documentation are curated in a facility that meets strict Federal guidelines. Data recovery may be required at the end of the NHRP evaluation process.

5.7.7 Consultation with Indian Tribes

Cultural resources mitigation or treatment efforts undertaken by the Corps require consultation with affected Indian tribes (see Appendix Q, Tribal Consultation and Coordination, for more information). Discussions to include resource management plans.

5.7.8 Coordination with Mitigation Efforts for Other Resources

If overlap occurs with mitigation plans for other resources, planners need to coordinate mitigation efforts so that actions benefiting one resource do not harm another.

5.7.9 Cultural Resources Monitoring

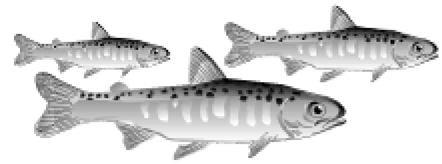
Site monitoring describes observations of site conditions and documents impacts or changes to cultural resources sites over time that can assist in the development of appropriate protection measures. Monitoring plans are developed in cooperation with regional Indian tribes and various interested parties.

5.7.10 Cumulative Effects

New effects on Cultural Resources would only be minor and not necessarily cumulative with implementation of Alternatives 2 or 3. Under Alternative 4 there would be increased rates of exposure of cultural sites susceptible to damage and possible research. There would also be renewed access to traditional cultural practices and traditional fishing areas by Tribes.

5.7.11 Uncertainties in Potential Cultural Resources Effects

It is uncertain if cultural sites exposed as a result of dam breaching could be fully protected from theft or vandalism. The threat of theft or vandalism would, however, be reduced over time as vegetation covers the sites. It is also uncertain to what degree sediments transported to the McNary reservoir might impact currently inundated cultural sites.



5.8 Native American Indians

This section is based on information from a number of sources. One specific source of tribal information is the Tribal Circumstances report prepared for this FR/EIS by Meyer Resources, Inc. in association with the Columbia River Intertribal Fish Commission (CRITFC) (Meyer Resources, 1999). The Tribal Circumstances report, prepared as part of the DREW process, focuses on input from specific tribes and sets forth their perspectives. The specific tribes which participated are the Nez Perce, Umatilla, Yakama, Warm Springs and the Shoshone-Bannocks.

As discussed at the beginning of Section 4.8, the tribes and American Indian communities considered to be most directly influenced by the proposed alternatives include the Umatilla, Yakama, Nez Perce, and Colville Tribes and the Wanapum Indian community. The Colville and the Wanapum were not part of the Meyer Resources study, but are known to have comparable cultures and interests in the health/availability of aquatic resources and habitats as the tribes discussed in the Tribal Circumstances report. Therefore, the findings presented in the Tribal Circumstances report and summarized in the following section are likely to be broadly representative of the Colville and Wanapum.

The Tribal Circumstances report assesses impacts to tribal circumstances in terms of: 1) tribal ceremonial, subsistence, and commercial harvests of salmon and steelhead; and 2) tribal access to flooded lands valuable to tribes. The analysis of salmon recovery and harvest levels presented in the Tribal Circumstances report is based on preliminary numbers, as noted in the following section. See the Tribal Circumstances report for tribal views with regard to beneficial effects to salmon, estimated time of removal of salmon from the Endangered Species List, and other related issues.

5.8.1 Tribal Salmon Harvest

5.8.1.1 Projected Harvest Numbers

The Plan for Analyzing and Testing Hypotheses (PATH) measured the effect of the proposed alternatives on seven index salmon stocks. The discussion of alternatives presented below is based on preliminary PATH data weighted by PATH's panel of independent experts and extended by the DREW Anadromous Fish Workgroup to represent all Snake River wild and hatchery stocks. The Tribal Circumstances report presents tribal harvest recovery rates based on this preliminary PATH data and converts these rates into pounds, assuming average weights of 20.1 pounds per salmon for spring and summer chinook, 19.1 pounds per salmon for fall chinook, and 8.5 pounds per fish for steelhead. Results are discussed below for the 30-year and 50-year benchmarks. Due to concerns associated with the weighting process, unweighted PATH results were used in all other analyses for this feasibility study.

Tribal harvest data are presented for wild salmon and steelhead only in Table 5.8-1. Data are presented for both wild and hatchery salmon and steelhead in Table 5.8-2. The Tribal Circumstances report suggests that these forecasts may be overestimates because the PATH analysis is built from present-day conditions and fails to incorporate long-term negative trends in Columbia River/Snake River stock sizes. The report also suggests that the year 0 assumptions used by the DREW Anadromous Fish Workgroup (see Appendix I, Economics), likely exceed PATH's present conditions by approximately 34 percent for spring/summer chinook and 43 percent for fall chinook (Meyer Resources, 1999).

Two additional points should be noted. First, the preliminary PATH data used in the Meyer Resources report were the most current available during the DREW process. Additional analysis has been conducted since, resulting in the final PATH results released in 1999 and the CRI analysis. Second, the assumptions used by the DREW Anadromous Fish Workgroup have important implications for the amount of hatchery fish estimated to be available for tribal harvest. These issues are discussed in the following paragraphs and Appendix I, Economics, Section 5.

Final PATH Analysis and CRI Model Results

The Scientific Review Panel (SRP), which was tasked to review the PATH analysis methods, found inconsistencies in the results of both the fall chinook and later the spring/summer chinook analyses developed by PATH. Adjustments made to a number of factors of concern in the original PATH analysis resulted in higher adult return predictions under Alternatives 1 through 3, which reduced the net difference between these alternatives and Alternative 4—Dam Breaching.

The adjusted PATH 1999 results were supported by the CRI modeling results. The CRI analysis differed from PATH by not estimating the probability of achieving survival and recovery adult return standards, and by estimating the chance of extinction occurring. The CRI indicated that the PATH results for all four alternatives were optimistic. The CRI results suggest there are few remaining survival improvements that can be achieved from modification of the hydrosystem

Table 5.8-1. Estimated Tribal Harvest of Wild Snake River Stocks in Pounds by Species

Alternative/ Project Year[1/]	Spring/Summer Chinook ('000 lbs)	Fall Chinook ('000 lbs)	Summer Steelhead ('000 lbs)	Total ('000 lbs)	Total Change from Year 0 ('000 lbs)	Total Change from Year 0 (%)
Alternative 1—Existing Conditions						
0	10.7	8.9	13	32.6		
10	28.2	16.8	19	64	31.4	96.3
30	54.7	21.9	93.6	170.2	137.6	422.1
50	62.4	21.5	94.8	178.7	146.1	448.2
Alternative 2—Maximum Transport of Juvenile Salmon						
0	10.7	8.9	13	32.6		
10	26.8	16.8	18.4	62	29.4	90.2
30	46.1	21.9	90.7	158.7	126.1	386.8
50	48.2	21.5	91.1	160.8	128.2	393.3
Alternative 4—Dam Breaching						
0	10.7	8.9	13	32.6		
10	27.2	24.6	18.9	70.7	38.1	116.9
30	149.3	133.1	113.1	395.5	362.9	1,113.2
50	174.6	133.6	117.6	425.8	393.2	1,206.1

1/ The Tribal Circumstances report does not address Alternative 3—Major System Improvements, but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2—Maximum Transport of Juvenile Salmon.

Source: Meyer Resources, 1999 (Table 50)

Table 5.8-2. Estimated Tribal Harvest of Wild and Hatchery Snake River Stocks in Pounds by Species

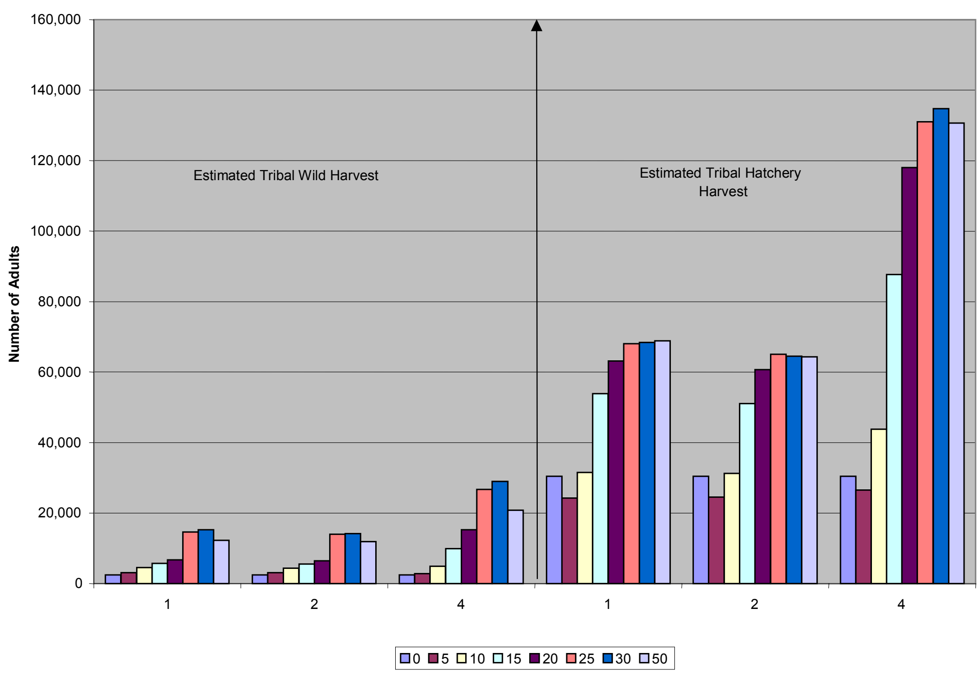
Alternative/ Project Year[1/]	Spring/Summer Chinook ('000 lbs)	Fall Chinook ('000 lbs)	Summer Steelhead ('000 lbs)	Total ('000 lbs)	Total Change from Year 0 ('000 lbs)	Total Change from Year 0 (%)
Alternative 1–Existing Conditions						
0	20.6	36.2	255.7	312.5		
10	36.7	41.2	272.3	350.2	37.7	12.1
30	97.0	58.2	639.1	794.3	481.8	154.2
50	110.8	65.1	660.6	836.5	524.0	167.7
Alternative 2—Maximum Transport of Juvenile Salmon						
0	20.6	36.2	255.7	312.5		
10	35.3	41.2	269.9	346.4	33.9	10.8
30	82.4	58.2	606.2	746.8	434.3	139.0
50	86.4	65.1	618.3	769.8	457.3	146.3
0	20.6	36.2	255.7	312.5		
Alternative 4—Dam Breaching						
10	43.1	87.9	356.3	487.3	174.8	55.9
30	304.2	650.7	951.5	1906.4	1593.9	510.0
50	355.0	668	990.4	2013.4	1700.9	544.3

1/ The Tribal Circumstances report does not address Alternative 3—Major System Improvements but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2— Maximum Transport of Juvenile Salmon.

Source: Meyer Resources, 1999 (Table 50) (i.e., Alternatives 1—Existing Conditions, 2—Maximum Transport of Juvenile Salmon, and 3—Major System Improvements). The CRI results indicate that while Alternative 4—Dam Breaching has a slight benefit over the other alternatives, these benefits are inadequate by themselves to prevent extinction of all stocks.

Hatchery Fish Assumptions

The DREW Anadromous Fish Workgroup assumed that current hatchery releases would be maintained into the future under each alternative. Using this assumption, a much larger harvest of hatchery fish is projected under Alternative 4—Dam Breaching than under the other alternatives (Figure 5.8-1). They also assumed that hatchery survival would increase in proportion with the increase of wild fish survival for all alternatives and stocks. If dam breaching were to occur, the original purpose of these hatcheries, many of which were built as mitigation for the lower Snake River dams, would be removed. The status of future hatchery operations has not been determined for Alternative 4—Dam Breaching. This raises questions about the magnitude of the hatchery fish projected to be available for tribal harvest. Hatchery fish account for 80 percent, 51 percent, and 88 percent of projected total tribal harvest of fall chinook, spring/summer chinook, and steelhead, respectively.



Source: Compiled from Meyer Resources, 1999 (Tables 48 and 49).

Figure 5.8-1. Estimated Tribal Harvest of Wild and Hatchery Salmon and Steelhead

5.8.1.2 The Alternatives and Their Effects

The following sections summarize the findings of the Tribal Circumstances report with respect to the effects that the proposed alternatives would have upon tribal harvest and also the likelihood that salmon populations would meet salmon recovery standards. These conclusions are supplemented with information from the Final PATH results and CRI, which were not completed in time to be included in the analysis presented in the Tribal Circumstances report. In addition, following the Tribal Circumstances report, comparison is made for Alternative 4—Dam Breaching with current study tribe harvests from all Columbia-Snake River System steelhead stocks. The Tribal Circumstances report estimates that current study tribe harvest from all Columbia-Snake River System steelhead stocks is about 1,338,000 pounds.

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would maintain existing conditions with scheduled improvements. The Tribal Circumstances reporting of PATH's assessment indicates that this alternative would not alter declines in Snake River salmon population trends toward extinction. The CRI analysis also found this. Meyer Resources (1999) states that based upon PATH there would be a 35 to 42 percent probability that wild spring/summer chinook would be removed from an endangered species listed status after 48 years, with limited changes for reaching salmon recovery thereafter. The data presented in the Tribal Circumstances report indicate that an estimated 32,600 pounds of wild Snake River stocks and 312,500 pounds of hatchery and wild stocks could be available for tribal harvest at year zero. Harvest of wild salmon and steelhead could increase by 96.3 percent by the 10-year benchmark and by 12.1 percent for both wild and hatchery fish (Tables 5.8-1 and 5.8-2).

The PATH 1999 analysis concluded that all hydrosystem actions would permit fall chinook stocks to meet the 1995 NMFS recovery standards with a greater than 0.7 probability of exceeding survival escapement thresholds regardless of influences from estuary and ocean on the survival rate of transported fish. The CRI analysis indicated that this alternative would not meet ESA guidelines as defined by the CRI analysis (NMFS, 2000) for steelhead or fall chinook recovery and has only the potential to meet recovery for spring/summer chinook.

Alternative 2—Maximum Transport of Juvenile Salmon

The smolt transport assumptions used by PATH indicated that Alternative 2—Maximum Transport of Juvenile Salmon would produce lower stock populations than Alternative 1—Existing Conditions. The Tribal Circumstances reporting of the PATH assessment indicates that this alternative would not alter declines in fish population trends toward extinction for Snake River salmon stocks and would result in lower salmon and steelhead stock populations than Alternative 1—Existing Conditions. The CRI analysis also found this to be the case. According to the preliminary PATH data, this alternative offers a 30 to 40 percent probability that spring/summer chinook would be delisted after 48 years and would be unlikely to meet tribal salmon sustainable harvest objectives (CRITFC, 1995).

The data presented in the Tribal Circumstances report indicate that harvest of wild salmon and steelhead could increase by 90.2 percent by the 10-year benchmark and by 10.8 percent for both wild and hatchery fish (Tables 5.8-1 and 5.8-2). Based on these data, tribal harvest of wild Snake River stocks under this alternative would potentially be about 7 percent lower than under Alternative 1—Existing Conditions and 6 percent lower for wild and hatchery stocks together.

The PATH 1999 analysis concluded that all hydrosystem actions would permit fall chinook stocks to meet the 1995 NMFS recovery standards with a greater than 0.7 probability of exceeding survival escapement thresholds regardless of influences from estuary and ocean on the survival rate of transported fish. The CRI analysis indicated that this alternative would not meet ESA guidelines for steelhead or fall chinook and has only the potential to meet recovery for spring/summer chinook.

Alternative 3—Major System Improvements

The Tribal Circumstances report does not address Alternative 3—Major System Improvements, but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2—Maximum Transport of Juvenile Salmon. According to the PATH 1999 analysis, transported fall chinook expected to have a high relative survival would meet recovery standards by maximizing transportation. If transported fish are assumed to have relative low survival, then allowing all smolts to migrate in-river through the current hydrosystem would achieve fall chinook recovery standards. However, transportation would not result in as high a probability of fish survival as dam breaching. CRI supports PATH's revised 1999 evaluation suggesting Alternative 3—Major System Improvements would result in a higher probability of recovery than Alternative 2—Maximum Transport of Juvenile Salmon due to provisions for in-river operations in Alternative 3—Major System Improvements.

Alternative 4—Dam Breaching

The Tribal Circumstances reporting of the PATH assessment indicates that wild fish stocks of spring/summer and fall chinook salmon and steelhead would likely be stabilized and in the long-term lead to increases in the populations to near recovery following breaching of the four lower Snake River dams. The CRI analysis also found this. Preliminary PATH information suggests that this alternative may offer an 80 percent probability that spring/summer chinook would be delisted after 48 years (Meyer Resources, 1999). The Tribal Circumstances report concluded that only Alternative 4—Dam Breaching would redirect actions influencing aquatic resources toward significant improvement of resource conditions and the socioeconomic circumstances of the five study tribes.

The data presented in the Tribal Circumstances report indicate that harvest of wild salmon and steelhead could increase by 116.9 percent by the 10-year benchmark and by 55.9 percent for both wild and hatchery fish (Tables 5.8-1 and 5.8-2). This was estimated to mean that Alternative 4—Dam Breaching could result in 2.4 times more tribal harvest opportunities of Snake River wild and hatchery fish than Alternative 1—Existing Conditions (Meyer Resources, 1999). However, as noted above, the large projected increase in hatchery fish available for tribal harvest under Alternative 4—Dam Breaching is unlikely to occur.

Breaching the four lower Snake River dams may increase population estimates for Pacific lamprey and sturgeon by removing passage barriers, reducing fish passage stress, and restoring critical juvenile rearing and adult spawning habitat given suitable river flow levels.

5.8.2 Tribal Land Use

5.8.2.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions would continue current land management practices and would not change the current land use of the tribes.

5.8.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Alternative 2—Maximum Transport of Juvenile Salmon would continue current land management practices and would not change current tribal land use.

5.8.2.3 Alternative 3—Major System Improvements

Alternative 3—Major System Improvements would continue current land management practices and would not change current tribal land use.

5.8.2.4 Alternative 4—Dam Breaching

This alternative would drain the four lower Snake River reservoirs, and could potentially create substantial benefits for affected tribes. According to the Tribal Circumstances report, the study tribes feel that this would allow tribal communities to renew their close religious/spiritual connection with approximately 14,000 acres of lands where their ancestors lived and are buried, and allow them to properly care for their grave sites. Dam breaching would expose more than 600 to 700 locations where they lived; fished; hunted; harvested plants, roots and berries; conducted cultural and religious ceremonies; and pursue other aspects of their normal traditional lives.

Renewed access to traditional places would in part be contingent on the physical condition of such lands following erosion control and land rehabilitation programs.

The Tribal Circumstances report indicates that tribal benefits associated with lands that are presently inundated could be obtained under Alternative 4—Dam Breaching, in the following ways if these actions were implemented:

- by restoring Treaty-based tribal access rights to usual and accustomed fishing places along the restored river sides
- by restoring Treaty-based tribal access rights to hunt and gather on ceded, open, and unclaimed public lands alongside the restored river sides
- by making it possible to return any tribal individual allotment lands in the reservoir area, acquired by the Federal government when the reservoirs were built, to tribal hands (i.e., to the Native American families that may have held any such allotments)

- by making it possible to transfer uncovered reservoir lands to tribes. (Congressional legislation would be needed for implementation of this action.)

Although project lands would no longer be used for commercial navigation or hydropower if dam breaching were to occur, a significant portion of these lands would likely be needed to meet other existing or newly authorized uses. Significant acreage is, for example, leased to state and local governments and private entities for recreation or fish and wildlife management. It is expected that many of these lessees would choose to continue their operations under a dam breaching scenario. It is also anticipated that continued cohesive management of a significant portion of public lands would be necessary to protect the environmental benefits to salmon associated with dam breaching. Restoration of previously submerged lands is also likely. It would be expected that new authorizing legislation would include provisions to meet restoration objectives. If any lands were no longer required, they could be reported to the General Services Administration (GSA) for disposal. GSA would then screen the lands with other Federal agencies to determine whether there is another Federal requirement for the property. If not, GSA would then dispose of the lands to other eligible public or private entities or individuals.

5.8.3 Cumulative Effects

According to the Tribal Circumstances report, selection of Alternatives 1 through 3 would, from a cumulative effects perspective, continue to contribute to existing detrimental tribal contributions. Reservoir lands would continue to be inundated and, according to the Tribal Circumstances report, these alternatives do not offer reasonable prospects of a restored tribal salmon fishery for 50 years or more. A strategy that commits to “further study” is seen by the tribes as a delay in enacting more substantial recovery measures and would, therefore, also commit to continuing current tribal suffering.

The Tribal Circumstances report states that selection of Alternative 4—Dam Breaching would have the opposite effect on cumulative trends. It offers the highest rates of recovery for wild salmon and steelhead and would also expose approximately 14,000 acres of currently inundated lands. These lands were used prior to settlement by non-Indians in the mid to late 19th century, and are still valued, by the tribes for cultural, material, and spiritual purposes. Under the other three alternatives, these lands would remain inundated by the four reservoirs and inaccessible by tribes. Numerous sites of cultural, material, and spiritual importance to the tribes, including burial grounds, would remain inaccessible.

The Tribal Circumstances report requests remedial actions that are beyond the scope and the timeframe of this FR/EIS. Although the tribes would benefit if reservoir lands were transferred to them, as discussed above, there are no plans at this time to transfer these lands to any entity. The area would need to be revegetated, monitored for cultural resources, and critical habitat would need to be protected for an undetermined length of time.

According to the Tribal Circumstances report, removal of the four lower Snake River dams could have positive long-term impacts on many aspects of tribal life, including the distribution of wealth, health, material well-being, spiritual and religious well-being, and tribal empowerment. The salmon is a defining element of tribal religious and cultural practices. The five study tribes believe that recovery of salmon populations would generate wealth in these areas and in tribal economies as a result of increased harvests. Improved economies would help reverse current adverse health and nutrition circumstances. Access to highly valued, presently inundated, lands would increase opportunities for tribes to partake in religious, cultural, and economic practices. Finally, the Tribal Circumstances report states that salmon recovery resulting from Alternative 4—Dam Breaching would increase feelings of empowerment and self-worth among tribal peoples.

The potential effects of the proposed alternatives on low-income and minority groups, including Native Americans, are addressed in Sections 4.14 and 5.14, Social Resources. These sections address these potential effects from an Environmental Justice perspective.

5.8.4 Uncertainties in Potential Effects on Native American Indians

The Tribal Circumstances report (Meyer Resources, 1999) identifies dam breaching as providing benefits to Native American Indians because of potential access to ancestral fishing, hunting, and harvesting areas and because of expected increases in potential harvests. Both of these potential benefits are uncertain. Potential future ownership of previously inundated lands has not been determined and the increases in harvests anticipated in the Tribal Circumstances report are highly uncertain. The estimates of potential future tribal harvests presented in the Tribal Circumstances report and summarized in the preceding sections are based on the preliminary PATH results. The risk and uncertainty associated with these results and their use in the economic evaluations conducted for this study are discussed in Appendix I, Economics, Section 8.3. Concerns also exist with the hatchery release assumptions employed by the DREW Anadromous Fish Workgroup to estimate the amount of salmon and steelhead available for tribal harvest under each alternative.

Additional analysis has been conducted since the DREW process was completed. The CRI results indicate that while Alternative 4—Dam Breaching has a slight benefit over the other alternatives, these benefits are inadequate by themselves to prevent extinction of all stocks. Uncertainties remain about whether, and to what degree, any of the alternatives would result in increases in the likelihood of survival and recovery of the listed Snake River stocks. These uncertainties are discussed in Section 5.5.1.7. It is uncertain that any selected alternative alone could be expected to lead to large potential increases in harvests in the forseeable future.

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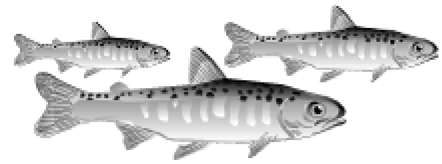


5.9 Transportation

The following subsections discuss the effects of Alternative 4—Dam Breaching on navigation, railroads, and highways. Existing navigation facilities would continue to operate under Alternative 1—Existing Conditions through Alternative 3—Major System Improvements. These alternatives are, as a result, represented as the base case condition in the following discussion. Navigation on the lower Snake River would no longer be possible under Alternative 4—Dam Breaching. Table 5.9-1 presents a summary of the potential effects of the alternatives on transportation.

5.9.1 Navigation

5.9.1.1 Methodology

Alternative 4—Dam Breaching would have significant effects upon navigation because barges would no longer be able to operate. Commodities currently transported by barge on the lower Snake River would need to be shipped by rail or truck. The Drawdown Regional Economic Workgroup (DREW) Transportation Workgroup conducted a transportation analysis as part of this Feasibility Study to identify and quantify the direct economic effects resulting from disruption of the existing transportation system. This analysis was designed to measure the effect that breaching the four lower Snake River dams would have on the costs of transporting products that are currently shipped on the Columbia-Snake Inland Waterway. The indirect or secondary changes that would occur at the local and regional level as a result of these changes are discussed in Section 5.14, Social Resources, and more fully in Appendix I, Economics, Section 6.

Table 5.9-1. Summary of Potential Effects of the Alternatives on Transportation

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Navigation	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Barges would no longer be able to operate. • An estimated 126.6 million bushels of grain would need to be transported via rail or truck. • The estimated associated cost increase to transport grain would average 18 cents per bushel. • The projected cost increases for other commodities are from 4.8 to 5.8 percent across selected years.
Railroads	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• An estimated 29 percent of the total diverted grain could shift from river to rail for transport. • Investment in railroad infrastructure would be necessary.
Highways	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• An estimated 71 percent of the total diverted grain could shift from river to roads for transport. • Investment in highway infrastructure would be necessary. • Increased traffic congestion and associated safety hazards could occur on affected routes.

The volumes of commodities that would be transported on the lower Snake River under base-case conditions were projected using existing commodity forecasts, historical data, and anticipated supply and demand trends. Projections were made for a 20-year period—2002 to 2022—in 5-year increments for each commodity group (Table 5.9-2).

Table 5.9-2. Waterborne Traffic Projections above Ice Harbor Lock 2002 to 2022 (in thousand tons)[1/]

Commodity Group	2002	2007	2012	2017	2022
Grain	3,647	3,799	3,798	3,892	4,052
Wood Chips and Logs	694	694	694	694	694
Wood Products	66	79	101	128	148
Petroleum	127	136	145	156	167
Other	97	110	128	148	167
Total	**4,631**	**4,817**	**4,865**	**5,018**	**5,228**

[1/] These projections are the medium or "most likely" values projected in the navigation analysis. The DREW Transportation Workgroup's analysis also provided low – "likely minimum" – and high – "likely maximum" – values for each year.
Source: DREW Transportation Workgroup, 1999 (Table 4-17).

Total traffic passing through Ice Harbor lock is projected to grow from 3.6 million tons in 1996 to 4.6 million tons by 2002, equaling the peak years of 1988 and 1995. Traffic is projected to level off between 2007 and 2012 at just over 4.8 million tons. Growth is then projected to resume at a modest rate through 2017 and 2022, reaching just over 5.2 million tons in 2022. These figures represent the medium or most likely projected values. Low and high scenarios were also projected for each year. Based on these projections, traffic in 2022 could range from a low of 3.4 to a high of 7.1 million tons, but these are projected to be the extreme ranges (DREW Transportation Workgroup, 1999).

The DREW Transportation Workgroup analysis compared the costs of transporting, storing, and handling existing and projected shipments under the base-case scenario with the costs that would be incurred if dam breaching were to occur. Grain accounted for approximately 75 percent of the tonnage passing through Ice Harbor lock in 1995 (see Table 4.9-4). The DREW Transportation Workgroup analysis assumed that regional grain modal, handling, and storage capacity could be expanded to meet geographic shifts in demand without significant increases in average costs. Similarly, the analysis assumed that grain elevator throughput capacity could be increased with little impact upon average costs. Storage and handling costs for non-grain commodities were assumed to be generally equivalent under either scenario. The analysis also assumed that shipment volumes of both grain and non-grain commodities remain constant from month to month.

The DREW Transportation Workgroup analysis measured direct economic effects in terms of opportunity costs rather than market rates. In other words, the costs developed in this analysis assume a perfectly competitive market and do not take into account possible increases in rail and truck transportation rates that may occur in the absence of navigation. It was also assumed that current and projected levels of exports from the region would continue under the dam breaching scenario.

The economic effects of the loss of navigation are addressed in terms of costs associated with both current and projected future traffic volumes. Alternative routings for existing and projected lower Snake River shipments were identified based on origin and destination data compiled for each shipment. Commodities would in most cases be either rerouted via truck to river elevators located on the McNary reservoir or shipped by rail directly to export elevators on the lower Columbia River. Where rail access is currently available at country elevators, grain would either shift to rail direct from these locations, or be moved by truck to a rail distribution point where unit trains could be assembled. The costs of transportation, storage, and handling were calculated for the alternative routings of each affected origin-destination pair.

The DREW Transportation Workgroup analysis covers a period of 100 years. The initial year of project implementation is assumed to be 2007 with effects measured from 2007 through 2106. Based on this long-term perspective, the analysis assumes that the majority of grain-producing land within the region would ultimately remain in production. It is, however, possible that in the short-term some marginal land with a navigation-associated transportation cost advantage could be forced out of production if dam breaching were to occur. In the long run, it is assumed that this land would be purchased at a lower overall cost and, and likely still be used for agricultural production.

5.9.1.2 The Alternatives and Their Effects

Under Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements, existing and projected waterborne traffic would be transported by barge on the lower Snake River. The projected volumes are presented by commodity group and 5-year increments in Table 5.9-2. The following discussion compares the effects of Alternative 4—Dam Breaching with this base-case condition. The DREW Transportation Workgroup analysis does not distinguish between the short- and long-term navigation effects associated with dam breaching. Costs are presented for selected years and then extended over the 100-year period of study and converted to average annual amounts using three different rates of interest. There is, however, some uncertainty regarding the length of time that would be required for the regional transportation system to adapt to a dam breaching scenario. Loss of barge transportation would be an unavoidable adverse impact under Alternative 4—Dam Breaching.

The following discussion, which is based on the DREW Transportation Workgroup analysis, focuses upon grain and then addresses the remaining commodity groups.

Grain

If dam breaching were to occur, an estimated 126.6 million bushels or 3.8 million tons of grain would be diverted from transportation via the lower Snake River annually. Of this volume, approximately 1.1 million tons (36.6 million bushels or 29 percent) would shift from the river to rail for transport. The remaining 2.7 million tons (90.0 million bushels or 71 percent) would move by truck to river elevators on the McNary pool and then by barge to deep-water terminals. These projected changes are presented in bushels by state for the year 2007 in Table 5.9-3.

Table 5.9-4 presents grain transportation costs under the first three alternatives and under Alternative 4—Dam Breaching and identifies the increases in transportation costs that would be associated with dam breaching. The DREW Transportation Workgroup estimates that the average cost increase to transport grain that would be displaced to more costly modes of transportation if dam breaching were to occur would be approximately 18 cents per bushel (Table 5.9-4).

Table 5.9-3. Grain Diverted from the Lower Snake River in 2007 under Alternative 4—Dam Breaching

	Truck-Barge (Bushels)[1/]	Rail (Bushels)	Total (Bushels)
Idaho	11,569,804	20,720,137	32,289,941
Montana	6,537,310	-	6,537,310
North Dakota	2,458,172	-	2,458,172
Oregon	980,218	-	980,218
Washington	68,459,852	15,895,177	84,355,029
Total	**90,005,536**	**36,615,314**	**126,620,670**
Percent	**71.1**	**28.9**	**100.0**

[1/] The Truck-Barge category addresses grain that would move by truck to river elevators on the McNary pool and then by barge to deep-water terminals.
Source: DREW Transportation Workgroup, 1999 (Table 7-8).

According to the DREW Transportation Workgroup's analysis, grain shipments that originate in Washington state account for about 64 percent of the total increase in grain-related transportation costs (Table 5.9-5). Shipments originating in Idaho account for about 29 percent, with shipments originating in Oregon, North Dakota, and Montana accounting for the remaining 7 percent. Grain originating in Washington state accounts for 69 percent of grain shipments on the lower Snake River, with 60 percent of total shipments originating in five Washington counties—Adams, Garfield, Spokane, Walla Walla, and Whitman. Whitman County alone accounts for about 41 percent of the Washington total. The percentages of diverted grain and increased transportation costs are presented by state in Table 5.9-5 and shown graphically in Figures 5.9-1 and 5.9-2. Idaho shippers would assume a disproportionate percentage of increased cost— about 29 percent of the cost compared to 22 percent of the total shipments—due to more costly alternative transportation modes.

Other Commodities

Grain accounts for about 76 percent of the waterborne traffic projections for the lower Snake River. About 18 percent of projected shipments are wood chips and logs. Wood products, petroleum products, and other commodities comprise the remaining 6 percent. Transportation costs for non-grain commodities under the base case and dam breaching scenarios are presented for 2007 in Table 5.9-6. The projected non-grain cost increases associated with dam breaching range from 3 percent for wood chips and logs to 24 percent for wood products. In comparison, the projected average change in grain transportation costs is 19 percent (Table 5.9-4).

Table 5.9-4. Grain Transportation Cost Comparison by State for 2007

		Alternatives 1-3		Alternative 4		Cost Difference		
State	**Bushels**	**Total Cost ($)**	**Cost Per Bushel ($)**	**Total Cost ($)**	**Cost Per Bushel ($)**	**Total Cost ($)**	**Cost Per Bushel ($)**	**% Increase**
Idaho	32,289,941	22,883,707	0.71	29,143,370	0.90	6,259,663	0.19	27
Montana[1/]	6,537,310	46,381,513	7.10	47,757,544	7.31,	1,376,031	0.21	3
North Dakota	2,458,172	3,262,017	1.33	3,523,573	1.43	261,556	0.11	8
Oregon	980,218	331,837	0.34	393,165	0.40	61,328	0.06	18
Washington	84,355,029	49,255,647	0.58	63,159,551	0.75	13,903,904	0.17	29
Total	**126,620,670**	**122,114,721**	**0.96**	**143,977,203**	**1.14**	**21,862,482**	**0.18**	**19**

[1/] The high cost per bushel for Montana grain reflect the very high storage and handling costs included in the DREW Transportation Workgroup's analysis. This analysis conversely does not identify any storage or handling costs for Oregon or North Dakota. Although these estimated costs are unrealistic, they are handled consistently across the alternatives. As a result, the difference between Alternatives 1 through 3 and Alternative 4 is likely to be more realistic than the estimates for each case.

Source: DREW Transportation Workgroup, 1999 (Tables 5-13 and 6-3)

Table 5.9-5. Percentage of Diverted Grain and Increased Transportation Costs by State under Alternative 4—Dam Breaching

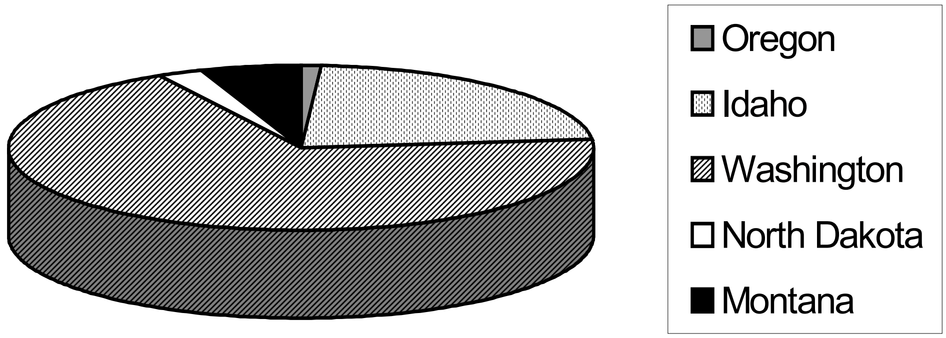
State of Origin	**% of Lower Snake River Barged Grain**	**% of Increased Transportation Costs**
Idaho	22.2	28.6
Montana	5.5	6.3
North Dakota	2.6	1.2
Oregon	1.0	0.3
Washington	68.6	63.6

Source: DREW Transportation Workgroup, 1999 (Table 7-11).

Table 5.9-6. Non-Grain Commodity Transportation Cost Comparison for 2007

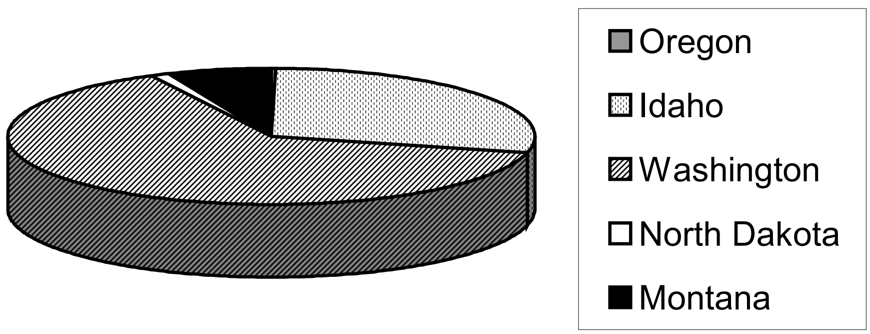
		Alternatives 1-3		Alternative 4		Cost Difference		
	Tons	**Total Cost ($)**	**Cost Per Ton ($)**	**Total Cost ($)**	**Cost Per Ton ($)**	**Total Cost ($)**	**Cost Per Ton ($)**	**% Increase**
Wood Chips and Logs	694,000	47,879,179	68.99	49,320,040	71.07	1,440,861	2.08	3.01
Wood Products	79,000	5,242,586	66.36	6,516,753	82.49	1,274,167	16.13	24.30
Petroleum	136,000	15,893,106	116.86	16,441,562	120.89	548,456	4.03	3.45
Other	110,000	6,946,350	63.15	7,533,960	68.49	587,610	5.34	8.46
Total	**1,019,000**	**75,961,221**	**74.54**	**79,812,315**	**78.32**	**3,851,094**	**3.78**	**5.07**

Source: DREW Transportation Workgroup, 1999 (Tables 5-15 and 6-5).



Source: DREW Transportation Workgroup, 1999 (Table 7-11)

Figure 5.9-1. Percent of Lower Snake River Barged Grain by State



Source: DREW Transportation Workgroup, 1999 (Table 7-11)

Figure 5.9-2. Percent of Increased Transportation Costs

5.9.2 Railroads

If dam breaching were to occur, an estimated 3.8 million tons of grain would be diverted from transportation via the lower Snake River annually. About 1.1 million tons, 67.7 million bushels, or 29 percent of this total would shift from the river to rail for transport. These projected changes are presented in bushels by state for the year 2007 in Table 5.9-3. Although not directly related to actions under Alternative 1—Existing Conditions, the continued presence and operation of the lower Snake River portion of the Columbia-Snake Inland Waterway may continue to exert pressure on the viability of railroads and historic trends in railroad abandonment may continue throughout the lower Snake River region.

The DREW Transportation Workgroup analysis assumed that regional modal, handling, and storage capacity could be expanded to meet geographic shifts in demand without significant increases in average costs. In the case of rail, there is some uncertainty as to whether sufficient capacity exists to accommodate the projected increase in demand associated with Alternative 4—Dam Breaching. The following sections address potential effects to mainline and short-line railroads, railcar capacity, and unloading capacities at export and country elevators.

5.9.2.1 Mainline Railroads

Both mainline railroads, Burlington Northern-Santa Fe (BNSF) and Union Pacific, would be impacted by dam breaching through the shift of grain and other commodities from the lower Snake River to rail. The DREW Transportation Workgroup analysis assumed that all commodities shifted to rail would eventually require the services of these mainline carriers to reach their final destinations at ports on the lower Columbia River. It is estimated that grain shipments alone would increase traffic on the mainline routes from about 840 to about 940 additional railcar-trips per month. Assuming a train size of 108 cars, this represents an increase of from about eight to nine additional trains per month destined to ports on the lower Columbia River. This would be a significant increase in rail traffic and improvements to the existing mainline system may be needed.

Estimates of diverted traffic and generic (or "rule of thumb") measures were used by civil engineers at the University of Tennessee's Transportation Center to estimate the costs of construction or modification of mainline railroad infrastructure. Costs to modify or construct line-haul rail trackage were estimated to range from $14 to $24 million. These cost estimates, which were discussed with engineering professionals from a number of railroads, discussed with experts from private construction firms routinely engaged in rail project construction, and reviewed by local rail officials from BNSF, Union Pacific, and others, do not include rail line improvement costs at port or railhead facilities. Costs that would be required to stabilize roadbeds, embankments, bridges, and track in the event of dam breaching are also not included in this estimate. Stabilization costs are included in the cost of project implementation (see Appendix I, Economics, Section 3.8 for a discussion of implementation costs).

A study conducted by the Tennessee Valley Authority (TVA) and Marshall University evaluated the impact of the costs of projected infrastructure improvements on mainline railroads and concluded that these improvements could be made by the railroads without putting any upward pressure on long-run costs or rates (TVA and Marshall University, 1998). This study assumed that all commodities now moving on the lower Snake River would be diverted to rail, a worst-case scenario.

5.9.2.2 Short-Line Railroads

Detailed cost estimates of improvements that would be required for short-line railroads were not developed as part of the DREW Transportation Workgroup analysis. Information was, however, compiled from a transportation impact study prepared for the Washington State Legislative Transportation Committee (HDR Engineering, Inc. [HDR], 1999). Needed improvements that were identified include interchanges with mainline railroads, truck upgrading, and "other." Representatives of the potentially affected railroads were also contacted and asked to identify any improvements that might be required. The cost of improvements for Washington short-line railroads was estimated to range from $20 million to $24 million. To date, no needs have been identified for railroads in Idaho.

5.9.2.3 Rail Car Capacity

There is presently a large surplus of grain cars in the region. The grain car utilization rate for the BNSF railroad was, for example, only about 50 percent in June 1999. The DREW Transportation Workgroup assumed that additional cars would, however, be required in the long-run to accommodate the shift of 1.1 million tons of grain from barge to rail if dam breaching were to occur. A number of factors were considered in the analysis, including the size of the cars, the turn rate, and the cost per car. The cost of these additional cars would range from about $14 million to about $37 million.

5.9.2.4 Rail System Congestion

The TVA and Marshall University study also addressed the concern that the projected increase in rail traffic could potentially cause congestion on mainline railroads and at loading and unloading facilities. In the case of congestion at loading and unloading facilities, the DREW Transportation Workgroup concluded that there would not be increases in delays due to congestion if necessary system improvements are made. They also concluded that needed improvements could be made without increasing long-run original costs or putting upward pressure on rates. The potential for congestion was also reviewed by transportation analysts at the two mainline railroads (see Appendix I, Economics, Section 3.3.5.6).

5.9.2.5 Export and Country Elevators

Based on an analysis of monthly rail car unloadings at Columbia River elevators from 1988 to 1997, the DREW Transportation Workgroup concluded that existing unloading capacity would be sufficient to accommodate the increased rail shipments of grain that would occur under a dam breaching scenario (DREW Transportation Workgroup, 1999). Additional storage would, however, be necessary to accommodate from 140 to 325 additional railcars. The estimated costs associated with providing this storage range from $2.0 million to $4.1 million.

The DREW Transportation Workgroup also concluded that current capacity at country elevators would be adequate to accommodate changes in shipping patterns associated with Alternative 4—Dam Breaching. However, the costs for improvements to upgrade railhead facilities in Washington were estimated to range from about $14.0 million to $16.9 million. Loading and unloading facilities at railhead country elevators in Idaho are considered to be adequate to accommodate the increase in rail shipment without any improvements (DREW Transportation Workgroup, 1999).

5.9.3 Highways

5.9.3.1 Change in Highway Use

Under Alternative 4—Dam Breaching, about 3.8 million tons of grain would be diverted away from the lower Snake River each year. According to the DREW Transportation Workgroup's analysis, approximately 71 percent or 2.7 million tons of this volume would move by truck to river elevators on the McNary reservoir and then by barge to deepwater terminals. Changes in highway use were computed based on the change in truck miles if dam breaching were to occur.

Since rail transport would also require truck transportation to position grain at country and river elevators, the volume of grain that the truck mile estimate is based upon is equal to the total amount of grain that is currently transported on the lower Snake River. Projected changes in bushel-truck miles and truck miles are presented in Table 5.9-7. These changes range from a decrease of about 1.6 million bushel-truck miles in Idaho to an increase of about 3.4 million bushel-truck miles in Washington. The decrease in Idaho is explained by the shift of grain to rail, and the increase in Washington is explained largely by the change in the destination of truck shipments from ports on the lower Snake River to ports in the Tri-Cities area. Maintenance cost savings for Idaho were not estimated, and the change in truck miles for Oregon was considered to be too small to be significant. In the case of Washington, costs include miles for grain movements from Montana and North Dakota because the increase in truck miles would actually occur in Washington.

Table 5.9-7. Projected Changes in Truck Miles by State

State	Sum Of Total Bushels	Change in Bushel-Truck Miles	Change in Truck Miles
Idaho	32,289,941	(1,643,257,066)	(1,888,801)
Oregon	980,218	40,175,108	46,178
Washington	84,355,029	3,429,355,830	3,941,788
Montana[2/]	6,537,310	1,007,893,915	1,158,499
N. Dakota[3/]	2,458,172	352,942,345	405,681
Totals	**126,620,670**	**3,187,110,133**	**3,663,345**

[1/] For this analysis, number of bushels per truck equals 870.
[2/] Montana is divided into regions.
[3/] North Dakota is a single region.
Source: Appendix I, Economics (Table 3.3-17)

5.9.3.2 Highway Infrastructure Improvement Needs

Capital Costs

Highway improvements that were identified as necessary to maintain adequate highway performance and minimal travel delay include intersection improvements, pavement replacement or overlay, and more frequent maintenance. It is possible that intersection improvements and pavement replacement or overlay could have environmental effects. Additional, more-detailed engineering and traffic studies would be necessary to determine the highway improvements that would actually be needed. Therefore, it is not possible at this time to assess the potential environmental effects that might be associated with these improvements.

The report prepared for the Washington State Legislative Transportation Committee (HDR, 1999) estimated that one time capital costs for these improvements would range from about $84 million to $101 million. An annual increase in accident costs amounting to about $2 million was also estimated (HDR, 1999).

Operations and Maintenance Costs

Additional highway operations and maintenance (O&M) costs that would result from the increase in truck miles identified in Table 5.9-7 are not addressed by the DREW Transportation Workgroup or the Washington State Legislative Committee report (HDR, 1999). As a result these costs are not included in the DREW Transportation Workgroup's NED analysis. The following discussion is drawn from a transportation analysis prepared as part of the Eastern Washington Intermodal Transportation Study (EWITS) (Jessup and Casavant, 1998). The EWITS study was not conducted as part of the DREW analysis and does not use the same data as the DREW Transportation Workgroup study or include grain movements from states other then Washington. The following results do, however, provide an indication of the lower level of annual costs needed to maintain Washington highways.

If dam breaching were to occur, truck wheat shipments would no longer collect in corridors to river ports on the lower Snake River, but would instead rely on different highways to reach river ports located on or below the McNary reservoir. State Routes (SRs) 395 and 17 would likely support heavy wheat flows from the north, while SR 26 and SR 260 would likely support heavy east-to-west truck shipments. These state routes and Interstates 90 and 82 would also support heavy flows of barley heading to river ports at or below the Tri-Cities or cattle feedlots in the Columbia River Basin (Jesssup and Casavant, 1998).

The EWITS study estimated that if dam breaching were to occur, total wheat and barley highway flows originating in Washington State would increase from a base case condition of 436 million tonmiles to 724 million tonmiles, with annual O&M costs increasing by $2.621 million. State highway and Interstate O&M costs were projected to increase by $2.827 million and $0.023 million, respectively. County highway O&M costs were projected to decrease by about $228,000.

If dam breaching were to occur, grain shipments from Idaho, Montana, and North Dakota that are currently transported by barge from Lewiston, Idaho would be moved by truck to river ports below Ice Harbor Dam. Shipments of Idaho grain would concentrate along three primary highway corridors in Washington—SR 12 and County Road 124 (CR 124), SR 26 and SR 395, and Interstate/SR 395. Grain shipments from Montana and North Dakota would likely take the Interstate/SR 395 corridor. Multiplying the estimated increase in tonmiles per corridor by the cost coefficients from the EWITS study, which vary by type of highway, results in additional annual O&M costs of $1.924 million to accommodate increased truck traffic originating from outside Washington.

While Washington highways would experience substantial increases in tonmiles if dam breaching were to occur, the DREW Transportation Workgroup's analysis indicates that Idaho would experience a significant decrease in tonmiles under a dam breaching scenario. This is especially the case with grain that presently moves via I-95 to the Port of Lewiston.

5.9.3.3 River Elevator Improvements

The DREW Transportation Workgroup analysis suggests that about 2.7 million tons (90 million bushels) of grain diverted from the lower Snake River would be shipped via truck to the Tri-Cities area, where it would be loaded on barges and shipped to export elevators via the lower Columbia River. Additional grain storage capacity required in the Tri-Cities area would range from 10.8 million to 36 million bushels, depending on the storage turnover ratio. Costs to provide this storage are estimated to range from about $58.7 million to about $335.4 million depending on the type of facility and capacity. These estimates include the cost of rail trackage and access roads (DREW Transportation Workgroup, 1999).

5.9.3.4 Highway Traffic Congestion and Safety

Congestion

If dam breaching were to occur, traffic congestion could occur along the highway corridors that would experience significant increases in truck traffic. Potential congestion impacts are most likely to occur along the SR 395, SR 12/CR 124, and SR 26 corridors (Table 5.9-8). The data presented in Table 5.9-8 indicate that SR 26 from Colfax to the Tri-Cities could see the greatest relative increase in truck traffic. Projected increases along this route would increase existing truck traffic by about 81 percent and increase total traffic flows by about 10 percent.

Table 5.9-8. Traffic Increases for Selected Highways under Alternative 4—Dam Breaching

Affected highways	Estimated Increase in Average Trucks per day[1/]	Existing Truck Traffic[2/]	Existing Vehicle Traffic	% Increase in Existing Truck Traffic	% Increase in Existing Total Traffic
SR 395	45	3,360	12,700	1	<1
SR 12/CR 124	52	519	3,450	10	2
SR 26	97	120	1,010	81	10

[1/] These estimates assume that approximately 5 million bushels of wheat and barley that currently move through Lewiston would be diverted to alternate modes of transportation in southern Idaho. These estimates also assume that approximately 10.3 million bushels of displaced wheat and barley originating in Idaho and 12.1 million bushels originating in eastern Washington would move by rail to Portland rather than by truck to the Tri-Cities. This estimate does not include the movement of other commodities and is limited to grain.

[2/] Existing truck and vehicle traffic counts are from the 1996 Washington State Department of Transportation Average Daily Traffic counts. Traffic Estimates are from milepost 22 for SR 395, milepost 0 on CR 124 in Burbank, and milepost 294 on SR 26 near the SR 26/SR 260 intersection.

Source: DREW Social Analysis Workgroup, 1999.

Traffic in Idaho would decrease on U.S. 12 over Lolo Pass as would northbound traffic on U.S. 195 from southern Idaho to Lewiston. There would also be less traffic on local county roads that currently handle truck movements to lower Snake River ports.

Assuming a truck capacity of 1,000 bushels (30 tons) of grain per truck load, dam breaching would result in an increase of approximately 95,200 truck trips to the Tri-Cities area in Washington. The DREW Transportation Workgroup estimated that this would, in turn, result in an increase of 370 average daily truck trips, or about 45 trips per hour. With the implementation of the highway improvements identified in the

DREW Transportation Workgroup report, highway congestion should not increase. Additional, more-detailed engineering and traffic studies would, however, be required to determine the highway improvements that would actually be needed.

Safety

Accident rates for trucks are higher by several orders of magnitude than the corresponding accident rates for rail and barge transportation, which are almost identical. Accident rates for non-interstate roads in Washington are estimated at 1.9 accidents per million tractor semi-trailer and double trailer truck miles. About 50 percent of these accidents involve property damage and injury, with 1.37 percent resulting in fatalities (U.S. Department of Transportation, 1995). Total truck miles estimated by the Corps transportation model were converted to million truck miles and multiplied by the accident rate coefficients for those highways that would likely see the greatest increase in truck traffic under Alternative 4—Dam Breaching (Table 5.9-9). Total accident data for 1996 are also presented in Table 5.9-9 for comparison (Washington Department of Transportation, 1997).

The increased accidents presented in Table 5.9-9 are directly related to the increase in truck miles. As a result, the portion of SR 26 from Colfax to SR 396 would experience the greatest increase in accidents. Accidents in Idaho would likely decrease as truck traffic is diverted to closer rail loading facilities.

Table 5.9-9. Estimated Traffic Accidents by Selected Highway under Alternative 4—Dam Breaching

Main Alternative Highway	Total Bushels Shipped on the lower Snake River	Million Truck Miles	Projected Annual Accidents	Annual Fatalities	Annual Injuries	Annual Property Damage Incidents	Total 1996 Accidents	Projected Annual Accidents as a % of 1996 Accidents
Displaced to Rail	19,590,427	(2.91)	(5.53)	(0.08)	(2.73)	(2.76)	N/A	-
SR 395[1/]	15,860,145	1.29	2.45	0.03	1.21	1.22	145	1.7
SR 12/124 [2/]	22,309,052	0.95	1.80	0.02	0.89	0.90	318	0.3
SR 26[3/]	36,433,449	2.47	4.69	0.06	2.32	2.34	53	8.8
Total Change			**4.35**	**0.06**	**2.15**	**2.18**		**-**

[1/] From Ritzville, Washington to the Tri-Cities
[2/] From Clarkston, Washington to Burbank, Washington
[3/] From Colfax, Washington to the SR 26/U.S. 395 intersection
Source: DREW Social Analysis Workgroup (1999 [updated 2000])

5.9.3.5 Potential Spills

Commodity movement on the lower Snake River is dominated by grain. Wheat and barley made up approximately 75.1 percent of the tonnage passing through Ice Harbor lock in 1995. Petroleum products and chemicals comprised 3.1 percent and less than 1 percent of the total, respectively. The DREW Transportation Workgroup projected the volumes of commodities that would be transported on the lower Snake River under base case conditions using existing commodity forecasts, historical data, and anticipated supply and demand trends. The projections developed for petroleum products and chemicals are presented in Table 5.9-10. Shipment levels were projected to remain constant following 2022.

Table 5.9-10. Projected Shipments of Petroleum Products and Chemicals

Projected Shipments	2002	2007	2012	2017	2022
Petroleum Products (tons)	127,000	136,000	145,000	156,000	167,000
Trucks (26 tons/truck)	4,885	5,231	5,577	6,000	6,423
Barrels (6 barrels/ton)	762,000	816,000	870,000	936,000	1,002,000
Chemicals (tons)	34,000	36,000	36,000	36,000	38,000
Trucks (26 tons/truck)	1,308	1,385	1,385	1,385	1,462
Barrels (6 barrels/ton)	204,000	216,000	216,000	216,000	228,000

1/ The majority of petroleum products shipped on the lower Snake River originate in Portland and move upriver to a terminal at Wilma.

2/ The majority of chemical shipments originate in Portland and move upriver to terminals at Central Ferry (80 percent) or Wilma (20 percent). Chemicals shipped by barge on the lower Snake River are mostly fertilizer (generally nitrogenous fertilizer) or ammonia.

Source: Table 5.9-2; DREW Transportation Workgroup, 1999 (Table 4-16)

Under Alternatives 1 through 3, the lower Snake River dams would remain in place and the projected shipments identified in Table 1 would be transported via barge. Potential spills associated with these shipments are identified in Table 5.9-11. This analysis suggests that total annual spills could range from 0.008 to 0.009 spills per year.

If dam breaching were to occur, the projected shipments identified in Table 1 would be diverted from the lower Snake River. Following breaching, shipments of petroleum products and chemicals could be transported by truck all the way from Portland or they could be transported via barge as far as McNary Dam and then by truck for the remaining distance. Potential spills of petroleum products and chemicals associated with truck transportation are presented for three scenarios in Table 5.9-12. This analysis suggests that the number of truck-related spills of petroleum products and chemicals under Alternative 4—Dam Breaching could range from 0.55 spills/year to 1.81 spills/year.

Table 5.9-11. Potential Spills of Petroleum Products and Chemicals from Barge Transportation under Alternatives 1 through 3

Leaks and Ruptures/Year		2002	2007	2012	2017	2022
Petroleum Products	Leaks	0.005	0.006	0.006	0.006	0.007
	Ruptures	0.001	0.001	0.001	0.001	0.001
Chemicals	Leaks	0.001	0.001	0.001	0.001	0.002
	Ruptures	0.000	0.000	0.000	0.000	0.000
Total	Leaks	0.007	0.007	0.007	0.008	0.008
	Ruptures	0.001	0.001	0.001	0.001	0.001

1/ Estimates of leaks and ruptures per year were based on the following coefficients:
Leaks (spills not involving hull rupture) – 6.81 x 1E-09/barrel transported.
Ruptures (spills involving hull rupture) – 1.3 x 1E-09/barrel transported.
There is no distance variable associated with this coefficient.

2/ The maximum size of a spill from a barge can be equal to the loaded capacity of the vessel, which is assumed to be 875,000 gallons in this analysis.

Source: Table 5.9-10; USDA Forest Service and Washington State Energy Facility Site Evaluation Council, 1998, Appendix A.

Table 5.9-12. Potential Spills of Petroleum Products and Chemicals from Truck Transportation under Alternative 4 – Dam Breaching

Spills/Year		2002	2007	2012	2017	2022
Petroleum Products	Maximum	0.46	0.49	0.52	0.56	0.60
	Minimum	1.14	1.22	1.30	1.40	1.50
	Midpoint	0.68	0.73	0.78	0.84	0.90
Chemicals	Maximum	0.09	0.10	0.10	0.10	0.10
	Minimum	0.28	0.29	0.29	0.29	0.31
	Midpoint	0.18	0.20	0.20	0.20	0.21
Total	Maximum	0.55	0.59	0.62	0.66	0.70
	Minimum	1.42	1.52	1.60	1.70	1.81
	Midpoint	0.87	0.93	0.98	1.03	1.10

1/ The maximum scenario assumes that all of the projected shipments of petroleum products and chemicals would shift from barge to truck transportation. One-way truck distances from Portland to Wilma and Central Ferry are estimated to be 354 and 314 miles, respectively.
2/ The minimum scenario assumes that all of the projected shipments of petroleum products and chemicals would be transported by barge to McNary Reservoir and then by truck. One-way truck distances from McNary Reservoir to Wilma and Central Ferry are estimated to be 142 and 96 miles, respectively.
3/ The midpoint scenario assumes that half the projected shipments would be transported entirely by truck, with the other half transported by barge to McNary Reservoir and then by truck.
4/ Truck miles were calculated by multiplying the number of trucks identified in Table 1 by the estimated mileages identified in footnotes 1 and 2, above.
5/ Estimated spills/year were calculated based on the following coefficient:
3.51×10^{-6} accidents/truck mile x 0.188 releases/accident = 6.5988E-07
6/ The maximum size release from a tanker truck is the entire contents of the truck, approximately 8,000 gallons. Historical spill data suggest that the maximum quantity is released 25 percent of the time that there is a release.
Source: Table 5.9-10; USDA Forest Service and Washington State Energy Facility Site Evaluation Council, 1998, Appendix A.

There is a higher potential for a spill to occur under Alternative 4—Dam Breaching than under the other three alternatives because petroleum products and chemicals formerly transported via the lower Snake River could be transported by truck.

5.9.4 Summary of Transportation-Related Economic Effects

5.9.4.1 Transportation Costs

Projected increases in transportation costs are shown for all commodities for the year 2007 in Table 5.9-13. These costs include shipping, handling, and storage costs. Costs are projected to increase by approximately $100,655,797 under Alternative 4—Dam Breaching.

Table 5.9-13. Total Transportation Cost Comparison for 2007

	Alternatives 1-3	Alternative 4	Cost Difference
Grain	122,114,721	143,977,203	21,862,482
Non-grain Commodities	1,019,000	79,812,315	78,793,315
Total	123,133,721	223,789,518	100,655,797

Source: Data compiled from Tables 5.9-4 and 5.9-6.

5.9.4.2 Infrastructure Capital Costs

As discussed in the preceding sections, expenditures on transportation infrastructure would be required to increase the capacity of the system prior to actual implementation of dam breaching. These costs would not be part of the cost of the Federal project to breach the four lower Snake River dams, but would be required as a direct result of implementation of dam breaching. The shipping, handling, and storage costs included in Table 5.9-13 and discussed elsewhere in this section include the amortized capital and operating costs of all of the components of the transportation system. A key assumption in the DREW Transportation Workgroup's analysis is that capacity can be added to the system at a cost that is no higher than the cost of the capacity that now exists. On this basis, the annual cost of infrastructure improvements is already embedded in the shipping, storage, and handling costs used in the analysis. Therefore, infrastructure costs are not included in the estimated transportation costs identified for Alternative 4—Dam Breaching (Table 5.9-13). Summaries of the infrastructure improvements that would be needed prior to dam breaching and estimated ranges of costs are provided in Table 5.9-14.

During review of the Draft FR/EIS, questions were raised about the assumption that grain-handling capacity could be expanded and other infrastructure improvements could be made without upward pressure on average costs. In response to these concerns, the DREW Transportation Workgroup determined that marginal costs and revenue of infrastructure improvements should be compared and that costs in excess of marginal revenue (fees and other revenue from handling and transporting grain that would be diverted from the lower Snake River) should be added to the NED costs of dam breaching.

Table 5.9-14. Summary of Estimated Costs of Infrastructure Improvements Needed with Dam Breaching (1998 dollars)

Infrastructure Improvements	Estimated Costs ($ million)	
	Low	High
Mainline Railroad Upgrades	14.0	24.0
Short-line Railroad Upgrades	19.9	23.8
Additional Rail Cars	14.0	36.9
Highway Improvements	84.1	100.7
River Elevator Capacity	58.7	335.4
Country Elevator Improvements	14.0	16.9
Export Terminal Rail Car Storage	2.0	4.1
Total	**206.7**	**541.7**

Source: Appendix I, Economics (Table 3.3-20).

5.9.4.3 Average Annual NED Costs

Average annual transportation-related NED effects are presented for Alternative 4—Dam Breaching, in Table 5.9-15. These values, presented in 1998 dollars, represent the net change from Alternatives 1 through 3, which serve as the base case for this analysis.

Table 5.9-15. Transportation—Average Annual Economic Effects by Discount Rate (1998 Dollars) ($1,000s of Dollars)

Alternative 4	6.875 % Discount Rate	4.75 % Discount Rate	0.0 % Discount Rate
Grain	(22,566)	(22,731)	(23,156)
Non-grain Commodities	(4,624)	(4,710)	(4,904)
Infrastructure	(16,001)	(9,149)	2,996
Total	(43,191)	(36,589)	(25,064)
Adjusted Total[1/]	**(37,813)**	**(33,346)**	**(25,064)**

[1/] The DREW Transportation Workgroup analysis used 2007 as the base year. These are the first set of average total annual values. The adjusted totals discount the same stream of costs back to 2005 to allow comparability with other elements of the study.

Source: Appendix I, Economics (Table ES-5).

5.9.5 Cumulative Effects

Effects on transportation would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching, barges would no longer be able to operate. There would be shift of an estimated 126.6 million bushels of grain to transport by rail or truck. There would also be additional investment in highway and railroad infrastructure to support the increased commodity shipments.

5.9.6 Uncertainties in Potential Transportation Effects

Most of the uncertainties in effects of dam breaching on navigation, railroads, and highways are reflected in the economic analysis summarized in Sections 3.3 and 8.4 and in Table 8-1 of Appendix I, Economics. The incremental, annual cost of dam breaching relative to Alternative 1 ranges from about $28 million to about $48 million (6.875 percent discount rate). These uncertainties include those associated with the capability of the existing transportation system to adjust to changes in transportation modes and routes and uncertainty in the magnitude of financial impacts that may be experienced by producers and shippers of commodities as a result of these changes. Rail and highway systems might also be affected by potential slope failures during and immediately after dam breaching. However, the extent or occurrence of such failures is also uncertain.

5.9.7 Findings of Other Studies

As a result of the intense regional interest in the potential of breaching dams on the lower Snake River, a number of other transportation studies have been conducted or are in the process of being conducted. The results of these studies were not all available for inclusion in this report. However, due to concerns that many of the findings of these other studies are not in agreement with the findings of DREW Transportation Workgroup analysis, these other studies and summaries of findings, if available, are briefly addressed in the following section. The more significant of these completed and ongoing studies are those conducted by the State of Oregon and Port of Portland and the State of Washington.

The State of Oregon and Port of Portland completed a study entitled *Breaching the Lower Snake Dams: Transportation Impacts in Oregon.* Key findings of this study include:

- Up to 9,000 full containers currently shipped through the Port of Portland each year could be diverted to the Puget Sound or other ports.
- Four of the six ocean carriers currently calling in Portland might stop if containers could no longer be shipped on the lower Snake River. Two are considered "likely" to stop calling; two others are considered "vulnerable."
- If fewer ocean carriers serve Portland, shippers who use the Port of Portland to ship export containers may need to ship containers through Puget Sound area ports, with associated increases estimated at $200 per container on average. This would result in a possible loss of export markets, increased congestion and wear on road and rail infrastructure, and increased energy consumption and air emissions.
- Barge companies would lose between $4 million and $11 million in business annually, and their rates to the remaining customers on the Columbia River would likely increase.
- Agricultural land with yields less than 45 bushels per acre may be at risk of being taken out of production due to higher transportation costs. Low yield dryland wheat farm acreage in Wallowa County, Oregon, and Lincoln and Adams counties, Washington is at greatest risk for being removed from production.
- Increased transportation costs could reduce the value of some farmland in eastern Oregon and Washington by an estimated $88 per acre.

The State of Washington (Washington State Legislative Transportation Committee) is in the process of conducting three studies concerning the effects of dam breaching on transportation in Washington State. One of the studies has been completed and the other two are apparently ongoing. A summary of the findings of the completed study and how it differs from the findings of the DREW Transportation Workgroup study is presented below. Summaries of the purpose of the other two studies are also presented below.

- The completed study was conducted by HDR Engineering, referred to as the State of Washington/Port of Benton Hanford Investment Study (January 2000), shows that the practical capacity of the BNSF's Columbia River Gorge and Stevens Pass routes will be reached in 2005 or 2006, given current rail traffic growth rates and the capacity of the Stampede Pass route will be reached in the 2020's. The findings of this study differ significantly from the finding of the transportation impacts analysis conducted by the DREW Transportation Workgroup for the FR/EIS. As noted previously, studies for the FR/EIS found that the rail system could accommodate the projected shift of grain to rail with only minor system improvements if dams were breached in about 2007. Rail system representatives stated that the shift of grain to rail would have an insignificant effect on rail system capacity. If dam breaching is recommended and authorized for implementation, the issue of rail system capacity should be studied in greater detail and the differences between the State's study and studies conducted for the FR/EIS should be resolved.

- A second study being conducted by HDR Engineering for the Washington State Legislative Transportation Committee addresses the impacts of dam breaching on state highways and county and city roadways of Washington. The scope of this study is broader than the study that was completed by HDR in 1999 and used as the basis for estimates of highway system impacts and infrastructure costs that are presented in this section. If dam breaching is authorized for further study and/or implementation, the findings of the ongoing HDR study should be reviewed and incorporated in any further studies by the Corps of the impacts of breaching lower Snake River dams on the highway system in Washington.
- The third study being conducted by the State of Washington is a study funded by the Washington State Department of Transportation that addresses the benefits and impacts of 286,000-pound and 315,000-pound rail cars on light-density rail lines in Washington. Although heavier cars may help address capacity constraints on existing mainlines, most light-density lines do not have the necessary rail infrastructure to carry heavier cars. This study is not relevant to the findings of the DREW transportation analysis, which assumed that grain that would shift to rail with dam breaching would be transported on standard-size rail cars. Data currently available about the short-line railroads shows that significant improvements to railroad beds would be needed to use the larger cars. The volume of grain that would be shifted to rail with dam breaching would not make these improvements economically feasible. Therefore, it is judged that standard cars would continue to be used.

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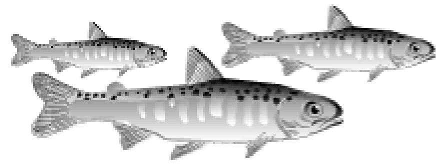


5.10 Electric Power

The four lower Snake River dams are part of an integrated system of hydroelectric facilities located throughout the Columbia River Basin. This system provides a number of products and services, including firm and non-firm energy, peak, and sustained capacity; daily load-following capacity; and other attributes that contribute to the reliability of the regional power system (see Section 4.10, Electric Power). Changing system hydropower operations affects the ability of the regional power system to generate electricity and the cost of generating that electricity. Changing hydropower operations also affects system reliability and capability, transmission, and ancillary services. The potential effects of the alternatives on electric power are summarized in Table 5.10-1.

Changes in the regional power system's ability to provide energy and capacity, and the costs of providing these products, form the core of the power system impact analysis conducted by staff members of the Corps and BPA for this FR/EIS. The Drawdown Regional Economic Workgroup Hydropower Impact Team (DREW HIT), was formed to assist in the analysis and provide a forum for interested parties to provide input. The majority of the information presented in the following sections is drawn from the DREW HIT report entitled *Technical Report on Hydropower Costs and Benefits* (DREW HIT, 1999). A more detailed discussion of the methodology and findings of the portion of the DREW HIT analysis that addresses net economic costs is provided in Appendix I—Economics (Section 3.1).

Table 5.10-1. Summary of Potential Effects of the Alternatives on Electric Power

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Power generation	Power generation would increase as projected by power needs.	Same as Alternative 1.	Same as Alternative 1.	The four lower Snake River hydropower facilities would no longer be operated or produce hydropower, creating the need for replacement power.
Financial impacts to ratepayers	Alternative 1 would not affect existing pricing mechanisms	Same as Alternative 1.	Same as Alternative 1.	Increases in monthly power bills are likely.

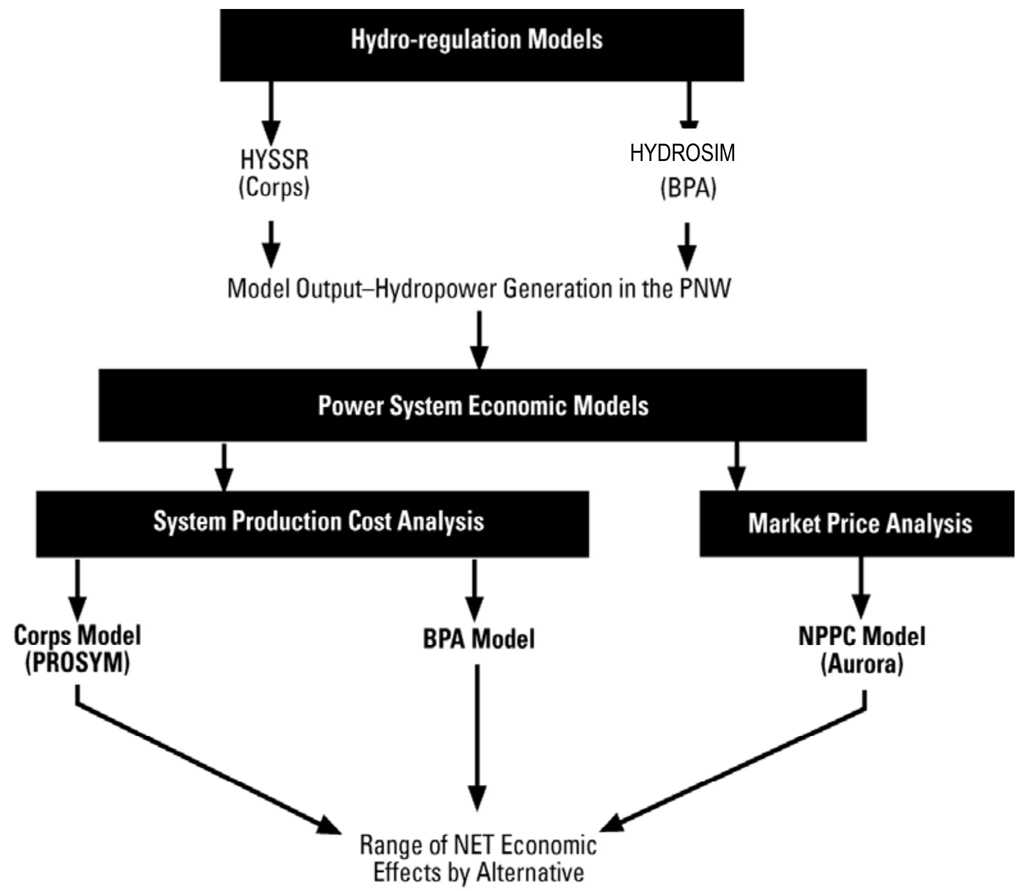
5.10.1 Methodology

The overall goal of the DREW HIT study was to develop an estimate of the net economic effects associated with the changes in hydropower under each of the alternatives. This required a number of steps. The first step involved using system hydroregulation studies to estimate how much hydropower generation would occur under the different alternatives and under different water conditions. This information was then incorporated into three different power system models to estimate how changes in hydropower generation would affect generation from other more costly power resources (Figure 5.10-1). In addition, this analysis investigated the potential financial impacts of these changes on regional ratepayers. The power system modeling tools were also used to help identify the changes in air pollutant emissions associated with the different alternatives. The potential effects of the alternatives on air emissions are addressed in Section 5.3, Air Quality.

The entire electrical industry has been undergoing significant changes from the regulated industry of the past to a partially competitive industry. The Federal Energy Regulatory Commission (FERC) opened wholesale electric power markets to competition by requiring utilities that own, control, or operate transmission lines to offer others the same electricity transmission service that they provide themselves. Open transmission access improves the flexibility to purchase electricity from generation facilities located throughout the Western Systems Coordinating Council (WSCC) area.

5.10.1.1 Hydroregulation Models

Changes in hydropower production were evaluated for this study on a system-wide basis. Two hydro-regulation models—the Corps' Hydro System Seasonal Regulation Program (HYSSR) and BPA's Hydro Simulator Program (HYDROSIM)—were used



Source: Modified from DREW HIT, 1999

Figure 5.10-1. Schematic of the Models Used in the DREW HIT Analysis

to estimate how much hydropower generation would occur under different alternatives and water conditions. These models simulate 50 and 60 historic wateryears and provide estimates of month-by-month hydropower generation in the Pacific Northwest for each of these years.

5.10.1.2 Power System Models

The hydro-regulation modeling results were incorporated into three power system models to estimate the net economic costs associated with each alternative. Three models that have been used in other studies by the Corps, BPA, and the Northwest Power Planning Council (NPPC) were used to assure that the cost estimates were adequately bracketed. The Corps model (PROSYM) and the BPA model evaluate annual net economic effects using a system production cost analysis approach. The NPPC model (Aurora) employs a market price analysis approach. These two approaches are discussed in more detail in Appendix I—Economics (Section 3.1.5).

The net economic costs developed for this study consist of three components: 1) annual net economic effects determined by system production costs or market-clearing prices, 2) transmission reliability costs, and 3) ancillary services.

System Production Costs Analysis

The system production cost analysis identifies net economic effects by comparing the production costs of using different forms of energy production. Changes in hydropower generation result in different levels of operation of more costly thermal generating power plants.

Projected resource additions based on the BPA model results are presented for 2010 and 2018 in Table 5.10-2. New generating units are assumed to be natural gas-fired combined cycle units. System production costs were calculated for each alternative based on this information.

Table 5.10-2. Power Resource Additions by Alternative for Selected Years

Alternative (aMW)	2010			2018		
	PNW	**PSW**	**Total**	**PNW**	**PSW**	**Total**
Existing Conditions	5,390	3,260	8,650	8,720	8,770	17,490
System Improvements	5,380	3,190	8,570	8,710	8,760	17,470
Dam Breaching	6,210	3,260	9,470	9,700	8,750	18,450
Difference from Base Condition (aMW)						
System Improvements	(10)	(70)	(80)	(10)	(10)	(20)
Dam Breaching	820	-	820	980	(20)	960
Difference from Base Condition (MW)						
System Improvements	(10)	(80)	(90)	(10)	(10)	(20)
Dam Breaching	890	-	890	1,070	(20)	1,040

[1/] The system improvements estimates apply to both Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements.

( ) = negative, PNW = Pacific Northwest, PSW = Pacific Southwest, MW = Megawatts, aMW = average Megawatts

Source: DREW HIT, 1999 (Table 25).

Market Price Analysis

The market price analysis approach calculates net economic effects by multiplying projected market prices by the changes in hydropower output from the base condition. Future market prices were estimated using the NPPC Aurora model. This model estimates prices by using hourly demands and individual resource characteristics to determine which generating resources are needed for each area in any given hour.

Summary of Analysis

The three models used for this analysis—Corps (PROSYM), BPA, and NPPC (Aurora)—are similar but vary in scope. The results from the BPA and NPPC models served as the primary estimate of net economic effects for all alternatives and water years. The Corps model was used to confirm results from the other models, test study assumptions, evaluate Alternative 4—Dam Breaching, and to estimate air quality impacts. The net economic effects computed from the three models were very close to one another.

5.10.1.3 Transmission Reliability

The Pacific Northwest electricity transmission grid was originally constructed in combination with the generation system. Since the transmission and generation systems interact electrically, the loss of hydropower generation would affect the transmission system's ability to move bulk power and serve regional loads. Removal of the lower Snake River dams would, therefore, impact the reliability of the transmission system. The DREW HIT analysis developed estimates of the costs associated with maintaining transmission reliability at the current level.

5.10.1.4 Ancillary Services

Ancillary services are the benefits provided by hydropower facilities that are not reflected in the energy and capacity values discussed above. Hydropower has traditionally been acknowledged to have an advantage over most thermal units because of its ability to start quickly, to follow load, to act as a capacitor or inductor to improve system power factors, and in other ways to contribute flexibility to power systems. The value of these ancillary services estimated in the DREW HIT analysis was based on the revenue that BPA receives for marketing these services from the Lower Snake River Project.

5.10.2 The Alternatives and Their Impacts

A range of net economic effects was estimated based on the different power system models and different assumptions of future economic conditions. These effects are presented for Alternatives 2 through 4 in Table 5.10-3. These values, presented in 1998 dollars, represent the net change from Alternative 1—Existing Conditions. A negative value indicates that the alternative has a higher cost or less benefit than Alternative 1—Existing Conditions. Each alternative was analyzed using 2005 as the base year. Average annual costs were calculated based on a 100-year period of analysis at three discount rates–6.875 percent, 4.75 percent, and 0.0 percent. The different discount rates had little effect on the net average annual costs of each alternative. The point estimates discussed below are based on the 6.875 percent discount rate.

Table 5.10-3. Average Annual Economic Effects by Discount Rate (1000s of Dollars)

	6.875 % Discount Rate		4.75 % Discount Rate		0.0 % Discount Rate	
	Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Alternatives 2 and 3						
System Costs	10,000	7,000	10,000	7,000	9,000	7,000
Transmission Reliability Costs	0	0	0	0	0	0
Ancillary Services Costs	0	0	0	0	0	0
Total Costs	**10,000**	**7,000**	**10,000**	**7,000**	**9,000**	**7,000**
Total Cost Point Estimate		**8,500**		**8,500**		**8,000**
Alternative 4						
System Costs	(221,000)	(255,000)	(220,000)	(256,000)	(217,000)	(260,000)
Transmission Reliability Costs	(22,000)	(28,000)	(19,000)	(24,000)	(16,000)	(18,000)
Ancillary Services Costs	(8,000)	(8,000)	(8,000)	(8,000)	(8,000)	(8,000)
Total Costs	**(251,000)**	**(291,000)**	**(247,000)**	**(288,000)**	**(241,000)**	**(286,000)**
Total Cost Point Estimate	**(271,000)**		**(267,500)**		**(263,500)**	

Source: DREW HIT, 1999 (Table 37).

5.10.2.1 Alternative 1—Existing Conditions

This alternative was considered the base condition for the purpose of the DREW HIT analysis. The results of the analysis for the other alternatives are compared with this condition. Projected increases in existing generation capacity under this alternative are presented for 2010 and 2018 in Table 5.10-2.

5.10.2.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

The DREW HIT analysis evaluated Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements as one cumulative alternative. The minor differences in generation that might occur between the two alternatives were not addressed in the DREW HIT analysis.

Based on the DREW HIT analysis, this alternative would result in increases in system hydropower generation. It is not expected that the transmission system would be impacted with this alternative, and the changes in ancillary services are considered to be minimal. The average annual economic effect associated with Alternatives 2 —Maximum Transport of Juvenile Salmon and 3—Major System Improvements would be a $8.5 million cost saving or benefit compared to Alternative 1—Existing Conditions.

5.10.2.3 Alternative 4—Dam Breaching

Under Alternative 4—Dam Breaching, the four lower Snake River hydropower facilities would no longer be operated, near-natural river levels would exist, and no hydropower generation would occur. This would be an unavoidable adverse impact. The analysis of this alternative did not include any hydropower impacts that may occur with changes in irrigation withdrawal from the lower Snake River reservoirs. The point estimate of average annual net economic costs consists of three components: 1) the point estimate of system costs ($238 million), 2) the point estimate of transmission reliability costs ($25 million), and 3) the point estimate of ancillary service costs ($8 million). Using a 6.875 percent discount rate, this results in a point estimate of annual total net economic costs of $271 million (Table 5.10-3). The following section addresses potential financial impacts to ratepayers if dam breaching were to occur. There would be no significant changes in rates under the other three alternatives.

5.10.2.4 Revised Biological Opinions

The DREW HIT used conditions under the 1995 Biological Opinion as the baseline for their economic analysis because the 2000 Biological Opinion had not been issued when the analysis began. Using the 1995 Biological Opinion conditions as the baseline slightly overstates the amount of energy generated by the four lower Snake River dams. Conditions have changed as a result of the 2000 Biological Opinion but not significantly. A comparison of average Snake River project generation between conditions under the 1995 Biological Opinion, the 1998 Biological Opinion, and those under the 2000 Biological Opinion is provided in Table 5.10-4. The comparison of the average annual generation with the 1995 Biological Opinion and the 2000 Biological Opinion, as defined by the HYSSR model, showed that annual generation from the four lower Snake River dams is about 6 percent lower with the 2000 Biological Opinion operation than with the 1995 Biological Opinion operation. The distribution of the changes over the average years is shown in Figure 5.10-2. As shown in this figure, the majority of the generation reduction occurs in the months of April, May, and June. This is the time period when hydropower generation in the Pacific Northwest has the lowest economic value. So, the impact on power benefits from the four lower Snake River dams would be considerably lower than the 6 percent reduction in annual generation with the 2000 Biological Opinion. For this reason, it was judged that the relatively small change was not enough to warrant a re-analysis of the economic impacts associated with reduction in hydropower with dam removal.

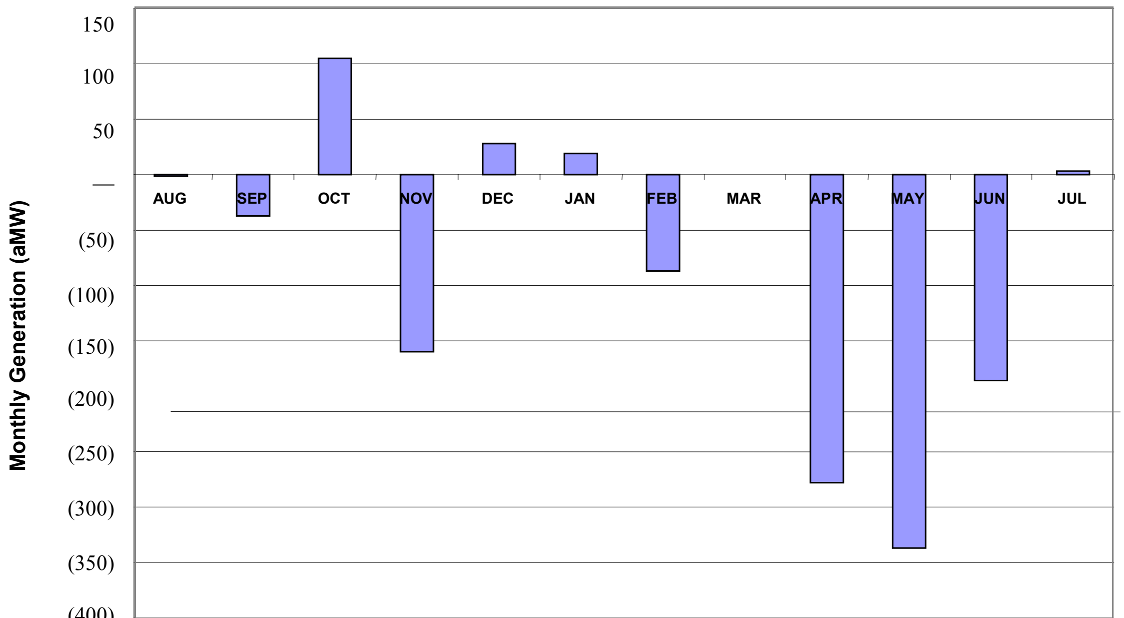
Table 5.10-4. Examination of Lower Snake River Plant Average Generation with 1995, 1998, and 2000 Biological Opinions Based on HYSSR Model Runs

	Generation From Four Snake River Dams (aMW) – Base Condition												
	AUG	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AVE**
1995 Biological Opinion	724	617	616	708	908	1,082	1,314	1,454	1,974	2,386	2,175	1,091	1,254
1998 Biological Opinion	724	709	737	595	964	1,009	1,154	1,424	1,772	2,114	2,083	1,109	1,200
2000 Biological Opinion	722	580	721	548	936	1,101	1,227	1,454	1,696	2,049	1,989	1,094	1,176
Difference: (2000 – 1995)	(1)	(37)	105	(160)	28	19	(87)	–	(278)	(337)	(186)	3	(78)
Difference (% Change)	(0.2%)	(6.0%)	17.0%	(22.6%)	3.1%	1.8%	(6.6%)	0.0%	(14.1%)	(14.1%)	(8.6%)	0.3%	(6.2%)
Difference: (2000 – 1998)	(2)	(129)	(16)	(47)	(28)	92	73	30	(76)	(65)	(94)	(15)	(24)
Difference (% Change)	(0.2%)	(20.9%)	(2.6%)	(6.6%)	(3.1%)	8.5%	5.6%	2.1%	(3.9%)	(2.7%)	(4.3%)	(1.4%)	(1.9%)
Difference: (1998 – 1995)	0	92	121	(113)	56	(73)	(160)	(30)	(202)	(272)	(92)	18	(54)
Difference (% Change)	(0.0%)	13.0%	16.4%	(19.0%)	5.8%	(7.2%)	(13.9%)	(2.1%)	(11.4%)	(12.9%)	(4.4%)	1.6%	(4.5%)

Source: Appendix I, Economics (Table 3.1-24).

5.10.3 Financial Impacts to Ratepayers under Alternative 4—Dam Breaching

It is not possible to say for sure how the costs associated with Alternative 4—Dam Breaching would ultimately be paid. Before restructuring of the electricity industry, a large portion of the costs would have been BPA's responsibility, and BPA would have raised its rates to recover increased costs. In a restructured, competitive wholesale power market, the price that BPA can charge its customers is effectively capped by the market price of electricity. BPA can no longer recover higher costs by raising its rates because utilities that buy power from BPA now have alternate sources of electricity supplied by the wholesale electricity market.



Source: Appendix I, Economics (Figure 3.1-6).

Figure 5.10-2. Difference in Snake River Generation (2000 Biological Opinion – 1995 Biological Opinion)

The following discussion addresses the potential financial impacts of dam breaching to ratepayers based on a number of different cost distribution scenarios. The purpose of this discussion is to illustrate the magnitude of the costs associated with changes in hydropower operation by providing some examples of the effects on consumers under different assumptions. It is not intended to determine where the financial impacts of these costs will be distributed. An illustration of the effect of spreading the cost over all BPA customers, for example, is not meant to imply that this is a likely or even possible scenario.

The following analysis provides examples of the cost to consumers for one year, 2010, using a discount rate of 6.875 percent. Costs would be distributed by load. Four possible load scenarios are addressed in this analysis:

Load 1—The entire Pacific Northwest load, which is projected to be 25,457 aMW or 223,003,320 megawatt hours (MWh) in 2010.

Load 2—Regional consumers who have benefited from Federal hydroelectric power, either through direct purchases from BPA or through a mechanism called the regional exchange. This would exclude the commercial and industrial customers of regional investor-owned utilities. These customers constitute about 30 percent of the total regional load. The remaining load—70 percent—is projected to be 17,820 aMW, or 156,103,200 MWh in 2010.

Loads 3 and 4—BPA customers. Two possibilities are examined here: allocating costs over all BPA sales (Load 3); or allocating costs over only BPA's firm, cost-based sales (Load 4). BPA sales under average water conditions are approximately 10,540 aMW or 92,330,000 MWh per year. However, loss of the lower Snake River facilities would reduce this generation by about 1,250 aMW under average water conditions. With the removal of the lower Snake River dams, annual BPA sales would therefore be about 9,290 aMW or 81,380,000 MWh. BPA firm sales are approximately 8,200 aMW or 71,832,000 MWh. Loss of the lower Snake River facilities would reduce BPA firm sales by about 760 aMW under critical water conditions, so BPA firm sales would be about 7,440 aMW or 65,174,000 MWh.

In addition to increased power costs, there is the question of how the costs of implementing the alternatives would be distributed. This question would ultimately be answered by Congress in the legislation that authorizes the selected alternative. Two possible scenarios are examined here. The first scenario assumes that BPA would repay hydropower's share of the implementation costs, which would be approximately 90 percent of total costs. The second scenario assumes that the nation's taxpayers would pay all the implementation costs. Implementation costs used for this analysis are net of the costs that would occur if Alternative 4—Dam Breaching were not implemented. If Alternative 4—Dam Breaching is not implemented, investments will have to be made over time to maintain and repair the dams.

5.10.3.1 Possible Power Rate Increases

Possible power rate increases based on the various loads, repayment scenarios, and additional power system costs are presented in Table 5.10-5. Possible average wholesale rate increases to power customers could range from 0.67 to 5.86 mills/kWh. It is difficult to determine how these increased wholesale rates would translate into increases in monthly power bills for different customers. Each utility purchases different amounts of BPA's wholesale electricity to serve its residential, commercial, agricultural, and industrial customers. Some Pacific Northwest utilities purchase almost no power from BPA and therefore the rate increases would be very minimal to the customer. Other utilities, however, rely exclusively on purchases from BPA, and the potential rate increases identified in Table 5.10-5 could be passed directly to the customer.

The top portion of Table 5.10-5 shows the scenario that would involve BPA paying 90 percent of the net implementation costs. Under this scenario, BPA's annual implementation cost repayments would be $19.6 million higher under Alternative 4—Dam Breaching than under Alternative 1—Existing Conditions. This figure is based on a 6.875 percent discount rate. The bottom portion of the table shows that if BPA is not required to pay for the dam breaching implementation costs, they would have an annual repayment saving of about $71.3 million at a 6.875 percent discount rate. This is because, under this scenario, the dams would be removed and BPA would have no further costs.

Table 5.10-5. Possible Wholesale Rate Impacts under Alternative 4—Dam Breaching[1/]

	Low	Medium	High
Implementation Costs Allocated to Hydropower (000s dollars)[2/]			
Implementation Costs	19,620	19,620	19,620
System Power Costs	220,000	288,000	362,000
Total Costs	239,620	307,620	381,620
Possible Rate Increase (mills/kWh)			
Load 1	1.07	1.38	1.71
Load 2	1.54	1.97	2.44
Load 3	2.94	3.78	4.69
Load 4	3.68	4.72	5.86
Implementation Costs not Allocated to Hydropower (000s dollars)			
Implementation Costs	(71,280)	(71,280)	(71,280)
System Power Costs	220,000	288,000	362,000
Total Costs	148,720	216,720	290,720
Possible Rate Increase (mills/kWh)			
Load 1	0.67	0.97	1.30
Load 2	0.95	1.39	1.86
Load 3	1.83	2.66	3.57
Load 4	2.28	3.33	4.46

[1/] These costs calculated using a 6.875 percent discount rate are presented net of Alternative 1—Existing Conditions in 1998 dollars.
[2/] These implementation costs were based on low, medium, and high forecasts of fuel prices, demand for electricity, and efficiency of future generating resources.
Source: DREW HIT, 1999 (Table 42).

5.10.3.2 Possible Monthly Bill Increases

Possible average monthly electricity bill increases are shown by sector in Table 5.10-6. These figures are based on 1995 electricity consumption data compiled by the NPPC and assume that wholesale rate increases would pass on to the different consumer sectors. This would not happen in all cases, but increases are presented here for illustrative purposes. This table is based on a 6.875 percent discount rate and assumes that hydropower will repay 90 percent of the implementation costs.

This analysis suggests that the average Pacific Northwest household monthly electricity bill could increase between $1.20 and $6.50 depending on which set of cost distribution and economic forecast assumptions is applied. The monthly bill increase for the average Pacific Northwest commercial establishment could range from $6.70 to $36.30.

The major impact would be to the industrial sector if the assumed cost distributions occur. For example, the average industrial customer (excluding the aluminum companies and other Direct Service Industries) could see monthly electricity bills increase between $302 and $1,645. The aluminum companies in the Pacific

Table 5.10-6. Possible Monthly Bill Increases by Sector under Alternative 4—Dam Breaching

Sector	Consumption (kWh/Month)	Monthly Bill Increase[1/] Low ($/month)	Medium ($/month)	High ($/month)
Load 1				
Residential	1,113	1.2	1.5	1.9
Commercial	6,199	6.7	8.6	10.6
Industrial (non-DS)	280,848	301.8	387.4	480.6
Aluminum Plant	160,600,000	172,567.1	221,538.6	274,831.2
Load 2				
Residential	1,113	1.7	2.2	2.7
Commercial	6,199	9.5	12.2	15.2
Industrial (non-DS)	280,848	431.1	553.4	686.6
Aluminum Plant	160,600,000	246,522.9	316,481.9	392,613.7
Load 3				
Residential	1,113	3.3	4.2	5.2
Commercial	6,199	18.3	23.4	29.1
Industrial (non-DS)	280,848	826.9	1,061.6	1,317.0
Aluminum Plant	160,600,000	472,880.0	607,075.1	753,111.0
Load 4				
Residential	1,113	4.1	5.3	6.5
Commercial	6,199	22.8	29.3	36.3
Industrial (non-DS)	280,848	1,032.6	1,325.6	1,644.5
Aluminum Plant	160,600,000	590,465.1	758,028.8	940,377.6

[1/]These estimates are based on a 6.875 discount rate, and a 90 percent hydropower cost allocation.
Source: DREW HIT, 1999 (Table 44).

Northwest are extremely large consumers of electricity, with an average monthly consumption of 160,600,000 kWh. Any increase in the electricity rate will have a significant impact on their monthly power bills. Depending on the selection of cost distribution and economic condition impacts, the average monthly power bill for aluminum companies could increase between $172,600 and $940,400.

Monthly bill increases for selected business and public buildings are listed in Table 5.10-7. These potential increases are also included in the average totals listed in Table 5.10-6.

5.10.4 Power Replacement With Non-Polluting Resources

The economic analysis of power impacts was based on the assumption that any new replacement generating facilities would be natural gas-fired combined-cycle combustion (CC) turbine plants. Since hydropower generation releases no air emissions, the replacement of the hydropower generation with thermal-based plants will increase air pollution. It was estimated that if the four Snake River dams are breached and replaced with CC plants, the CO_2 emissions for generation of electricity

Table 5.10-7. Possible Monthly Bill Increases for Selected Commercial and Public Buildings under Alternative 4—Dam Breaching

Sector	Consumption (kWh/Month)	Monthly Bill Increase [1/] Low ($/month)	Medium ($/month)	High ($/month)
Load 1				
Grocery Store	120,000	128.9	165.5	205.4
Elementary School	27,000	29.0	37.2	46.2
Hospital	927,000	996.1	1,278.7	1,586.4
Hotel	400,000	429.8	551.8	684.5
Large Office Building	581,000	624.3	801.5	994.3
Load 2				
Grocery Store	120,000	184.2	236.5	293.4
Elementary School	27,000	41.4	53.2	66.0
Hospital	927,000	1,423.0	1,826.8	2,266.2
Hotel	400,000	614.0	788.2	977.9
Large Office Building	581,000	891.8	1,144.9	1,420.4
Load 3				
Grocery Store	120,000	353.3	453.6	562.7
Elementary School	27,000	79.5	102.1	126.6
Hospital	927,000	2,729.5	3,504.1	4,347.0
Hotel	400,000	1,177.8	1,512.0	1,875.7
Large Office Building	581,000	1,710.7	2,196.2	2,724.5
Load 4				
Grocery Store	120,000	441.2	566.4	702.6
Elementary School	27,000	99.3	127.4	158.1
Hospital	927,000	3,408.2	4,375.4	5,428.0
Hotel	400,000	1,470.6	1,888.0	2,342.2
Large Office Building	581,000	2136.1	2742.3	3402.0

[1/] These estimates are based on 1995 consumption data compiled by the NPPC, a 6.875 discount rate, and a 90 percent hydropower cost allocation.
Source: DREW HIT, 1999 (Table 45).

in the WSCC would increase by over 4 million tons per year (see Appendix P, Air Quality and Section 5.3). Other thermal generation resources, renewable resources, or conservation could also be used to replace the hydropower generation lost with dam breaching and these would have different effects on air pollution.

A study was done to determine the cost of replacing the energy from the four lower Snake River dams with enough conservation such that no increase in CO_2 emissions would result (see Section 3.1.6.4, Appendix I, Economics). The first step was to estimate how much conservation would be needed to replace the four lower Snake River dams. Using the PROSYM model, and an average shape for conservation resources, it was determined that removal of the four lower Snake River dams would require the acquisition of 1152 aMW of conservation resources, by year 2010. This amount of conservation would result in no increase in CO_2 emissions upon removal of the dams.

The next step was to determine if there were enough potential conservation resources to meet this need. According to studies performed by the NPPC[1], there are only about 1,000 aMW of conservation available in the PNW by the year 2010. Replacing the lower Snake River dams with this conservation would completely exhaust the currently identified PNW supply. Replacement also requires an assumption that no conservation would be acquired in absence of dam removal. This assumption is debatable. In other words, for the 1,000 aMW of conservation to be available, no conservation would be acquired to help mitigate load growth in the PNW, or for any other reason other than dam removal.

However, assuming this conservation would be available, the next step was to cost out this conservation. According to the NPPC, the cost of this conservation is approximately 24.6 mills/kWh in 1998 dollars. Implementing the necessary conservation measures would cost approximately $250 million (1152 aMW x 8760 hrs x 24.6/mills/kWh x 1000 kWh/MWh). This assumes that an additional 152 aMW of non-polluting resources could be purchased at 24.6 mills/kWh. The system production costs for using CC plants as replacement generation was also $250 million in year 2010 (i.e., the cost of replacing lost Snake River generation with conservation is about the same as with CC plants, provided enough conservation is available at this low cost).

The conservation replacement strategy assumes that currently available conservation is used exclusively to replace the loss of the lower Snake River dams, and would otherwise go undeveloped. This is unlikely, since the most cost-effective conservation probably be utilized before year 2008, which is assumed to be the year of dam breaching. Though other conservation measures may be available to replace those used by 2008, they would be less cost effective and hence the conservation replacement strategy would be more costly.

If, alternatively, the four lower Snake River dams were replaced with a more expensive alternative non-polluting resource, such as renewables like wind or geothermal, additional costs would be incurred. A renewable resource costing 35 mills/kWh, for example, might be approximately $130 million more expensive annually than replacement with new combined-cycle turbines, or conservation.

Because of the uncertainty associated with adequate availability of enough low-cost conservation to replace all of the generation from the Snake River dams, a possible non-polluting option would be a combination of conservation and renewable resources. This combination would be more costly than the CC replacement strategy, to the extent that the renewable resources, at costs of around 35 mill/kWh, would be required to supplement the 24.6 mills/kWh conservation measures. For example, if 152 aMW of renewables and 1,000 aMW of conservation was needed to replace the Snake River generation, this could be done at a cost of about $262 million per year, which is an increase of about $12 million over the CC replacement strategy.

One major difference between the replacement of hydropower generation with CC plants and conservation/renewables is the implementation process. Implementing replacement with CC plants is a market-based strategy that would require minimal

[1] Appendix G, Conservation Cost, Performance and Value, Draft Fourth Northwest Conservation and Electric Power Plan, Northwest Power Planning Council.

implementation effort. An active marketplace now exists to purchase and sell electricity, and if the Snake River dams were breached, the market would have sufficient time to build replacement resources such as CC plants. The conservation/renewables strategy would require government intervention to implement. For conservation resources, implementation could require the government to enforce new building codes, new standards for energy-consuming devices, and direct funding of conservation projects. For renewable energy resources, implementation efforts would probably require direct subsidies to build the renewable projects.

The NPPC recognized in their latest power plan that the amount of conservation that can be implemented in any given year is limited since no one conservation measure will provide large output by itself. Hence, implementation of a widespread conservation/renewable plan would require an active implementation process that must proceed far in advance of the dam breaching. This timing issue, the need for economic incentives, and the need for strong political commitments all contribute to a relatively high degree of uncertainty of implementing a conservation/renewable plan that would completely replace the generation from the lower Snake River dams.

Non-Polluting Alternative Summary

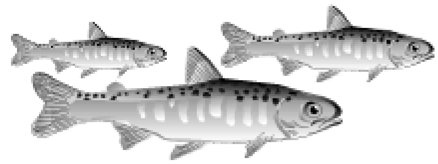
The cursory analysis examined the impact of using non-polluting resources such as conservation and wind to replace the lost hydropower generation if the four lower Snake River dams are breached. Conservation and renewable resources could be used to replace the hydropower generation from the four lower Snake River dams and result in no net change in air pollution from the existing conditions. The costs could be similar to, but higher, than the replacement with natural gas-fired combined-cycle combustion turbine (CC) plants. The implementation of conservation/renewables would require considerable government intervention including subsidies, and implementation long before the dams are breached. The CC plant replacement strategy would require almost no government intervention or subsidies.

5.10.5 Cumulative Effects

Effects of electric power generation resources would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching there would be a need for replacement power plants which would have some adverse effects in other areas.

5.10.6 Uncertainties in Potential Electric Power Effects

Uncertainties in estimates of the effects of dam breaching on electric power costs are driven primarily by uncertainties in forecasts of future gas prices and load estimates. Details of the factors that drive uncertainties in electric power costs are presented in Sections 3.1 and 8.4 and in Table 8-1 of Appendix I, Economics. Estimated incremental annual costs range from about $251 million to about $291 million (6.875 percent discount rate).



5.11 Water Supply

This section discusses the likely short-term and long-term impacts on agriculture, municipal, and industrial water uses associated with the four alternatives. Short-term effects are associated with construction- and demolition-related activities. Long-term effects are those that persist or occur after the dams have been breached and the river has returned to its natural level. In general, most of the discussion is focused on Alternative 4—Dam Breaching because little or no change in existing water use would be expected as the result of the first three alternatives. The information provided in this section is primarily derived from the Economic Analysis of Water Supply Effects (DREW Water Supply Workgroup, 1999). The report associated with this analysis is presented in its entirety as Section 3.4 of Appendix I, Economics. See Table 5.11-1 for a summary of potential effects of the alternatives on water uses.

5.11.1 Agriculture Water Uses

5.11.1.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. Pump stations for agriculture irrigation would continue to withdraw water from the Ice Harbor reservoir and pump the water to individual farm distribution systems. No impacts to agricultural water use are expected under this alternative.

Table 5.11-1. Summary of Potential Effects of the Alternatives on Agricultural, Municipal, and Industrial Water Uses

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Agricultural Water Uses	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Pumping station intakes for irrigation that currently draw from the Ice Harbor reservoir would be above the water level. Pump modifications would be required for irrigation to continue. • Excess silt and sand could damage water supply system components.
Municipal, Industrial, and Other Uses	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Pumping station intakes for M&I wells, privately owned wells, HMU irrigation systems, and cattle watering stations would need to be modified or the water supply would need to be replaced. • Excess silt and sand could damage water supply system components.

5.11.1.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, operation of the four hydropower facilities would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to agricultural water use are expected under this alternative.

5.11.1.3 Alternative 3—Major System Improvements

Under this alternative, operation of the four hydropower facilities would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to agricultural water use are expected under this alternative.

5.11.1.4 Alternative 4—Dam Breaching

Approximately 37,000 acres of irrigated farmland currently rely on pumped water from the Ice Harbor reservoir. Additional farmland is irrigated by private wells. Under Alternative 4—Dam Breaching, the river would return to its natural level and pumping station intakes that are currently in the reservoir would be above the water level. The long-term impacts to agricultural water users resulting from the elimination of the current water supply were assessed in terms of economic costs (DREW Water Supply Workgroup, 1999).

Economic Costs

The Corps evaluated two approaches to determine the economic effects of Alternative 4—Dam Breaching on Ice Harbor irrigators. The first approach—the system modification—estimated the costs to construct a new intake and distribution system that would be reliable at lower water levels. Irrigators would continue to produce crops under this approach. The second approach—farmland value—measured economic effects in terms of the change in farmland value if these lands no longer had access to irrigation water from the lower Snake River. Under this approach, the land currently irrigated would revert back to dryland farming. These two evaluation approaches are discussed in the following sections.

A combination of these two approaches is explored as a sensitivity analysis in Section 3.4.5.1 of Appendix I, Economics. The sensitivity analysis shows what the economic impacts to pump irrigators would potentially be if it is possible to keep the high value crops in production with an alternative water source such as wells.

System Modification

This analysis approach identified and considered three significantly different options for the modification or replacement of river pump stations to maintain current water supply capability under Alternative 4—Dam Breaching (see Appendix D, Natural River Drawdown Engineering for descriptions of all three options). An acceptable modified irrigation system would need to meet the following requirements: 1) the system would be operational prior to breaching of Ice Harbor Dam; 2) the system would function through a full range of river stages without interruption; and 3) the modified system would be able to handle a potentially large quantity of suspended sediment. Under current conditions, pump stations withdraw water from the Ice Harbor reservoir and pump the water uphill several hundred feet to the individual farm distribution systems. Without the pool of water created by Ice Harbor Dam, the pumping station intakes would be completely out of water.

The first option involved modifying each existing pump station by extending pipes and installing additional or bigger pumps based on increases in lift requirements. During review of this concept, the engineering study team identified a number of technical concerns that indicated that this would not be a feasible option (see Appendix D, Natural River Drawdown Engineering).

The second option involved the replacement of river stations with groundwater sources. Based on discussions with Dr. Robert Evans, an irrigation specialist in the County Extension office in Prosser, Washington, this does not appear to be a feasible option. Wells present numerous problems. There would likely be difficulties in receiving approval from the Washington State Department of Ecology (Ecology). These wells would need to be drilled deep and would, as result, have high initial and operating costs. The well water would also require treatment to counter high pH levels, and high sodium content in the well water could lead to soil sealing problems. There is also some concern that this system could not be installed without some interruption in irrigation water deliveries. Interruption of irrigation water deliveries would severely impact permanent crops, such as orchards and vineyards.

After consideration of options 1 and 2, the study team focused its efforts on a third option that they determined would technically work and satisfy the criteria outlined above. This option involves a pressure supply system that includes one large pumping station and distribution system with a sediment basin. The system would provide water via a single river pump station and the water would be delivered to each farm through a main pipeline distribution system. Each farm-level pump would also require modifications in order to connect to the main pipeline distribution system. Because it is anticipated that sediment effects resulting from dam breaching would be significant, a sediment basin/reservoir is included as a component of the one large pump station system. The pump station would be located at a narrow point in the river to reduce problems with river fluctuation and meandering. For additional details on this option, refer to Appendix D, Natural River Drawdown Engineering.

The primary irrigation system would consist of six main components: the pumping plant at the river, the pipe network, connections to existing irrigation systems, secondary pumping plants, a control system, and a sediment control reservoir. Total construction costs for this option were estimated to be $291,481,000 (1998 dollars) (see Table 5.11-2).

Table 5.11-2. Cost of Modifying Ice Harbor Agricultural Pumping Stations, 1998 Dollars

Component	Construction Costs ($)
Mobilization, Demobilization, and Preparation	11,896,148
Earthwork for Structures	5,207,616
Utilities	6,997,734
Access Road	4,849,592
Pipelines	71,865,100
Pumping Plant	9,243,520
Pumping Machinery	52,678,290
Subtotal, Pump Plant System	***162,738,000***
Subtotal, Sediment Reservoir	***128,743,000***
Pump Plant and Reservoir Total	**291,481,000**

Source: DREW Water Supply Workgroup, 1999 (Appendix I, Economics [Table 3.4-5])

The modified agricultural pump system would likely result in increased energy and other operation and maintenance expenses as well. Additional lift of the irrigation water with new pumps or the conversion of existing pumps would result in higher operating costs. Specifically, the greater horsepower would increase the cost of power to the water user. Added equipment could also require greater maintenance expenditures and could increase future replacement costs.

Increased maintenance necessary to treat sediment-related problems, even with a sediment control reservoir in place, is not easily predictable. Replacement of worn parts of pumps, valves, sprinklers, and filters could initially be significant.

Although the extent of increased operation and maintenance (O&M) expenses associated with the modified irrigation system is not fully understood, additional

O&M expenses associated with modifying the existing pump stations are estimated to be $3,573,000 per year (1998 dollars). The estimated modification and O&M costs provide an upper bound measurement of the economic effects to irrigators.

Farmland Value

This analysis based the determination of economic effects to irrigators under Alternative 4—Dam Breaching on a change in farmland values that would occur with elimination of the current water supply. Typical land values for farm properties near Ice Harbor were used. This information was compiled through discussions with farm managers, cooperative extension agents, farmland appraisers, agricultural economics professors, and the use of published enterprise budget sheets for a number of crops. Analysis of this data provides an estimate of typical farmland value and permits the quantification of the economic effect to farmland owners under Alternative 4—Dam Breaching.

Table 5.11-3 summarizes the estimated market value of the primary types of irrigated farmland in the region. In addition, local farm appraisers and agricultural experts have indicated that non-irrigated farmland near the Ice Harbor reservoir is limited to some grazing a short period of the year and would sell for $75 to $150 per acre.

Table 5.11-3. Farmland Value Estimates for Selected Crops

Type of Cropland	Value per Acre ($)
Row Crops	2,500 to 3,500
Vineyards (at maturity)	5,500 to 9,500
Apple Orchards (at maturity)	10,000 to 32,000
Poplars	2,500 to 3,500
Non-irrigated Farmland	75 to 150

Source: DREW Water Supply Workgroup, 1999 (Appendix I, Economics [Table 3.4-6])

Approximately 37,000 acres of irrigated farmland currently rely on pumped water from the Ice Harbor reservoir. Of this amount, it is estimated that more traditional irrigated cropland accounts for 28,400 acres and that the remaining 8,600 acres are poplar plantations. Detailed crop information for about 20,000 of the irrigated acres at Ice Harbor was collected through interviews with farm operators. The crop information in conjunction with the farmland value data described above was used to determine the average per acre value of irrigated farmland in the region. Based on the farmland value approach, the average per acre value of irrigated farmland equals $4,100.

The economic impact to pump irrigators under Alternative 4—Dam Breaching was estimated by applying this average per acre value to the total amount of irrigated crop acreage, adding the value of the poplar tree acreage, and then subtracting the value of non-irrigated cropland (Table 5.11-4). The economic effect of Alternative 4—Dam Breaching measured on the basis of a change in farmland value is equal to $134,240,000.

Table 5.11-4. Economic Impact to Pump Irrigators based on Change in Farmland Values under Alternative 4—Dam Breaching

	Value/Acre ($)	Number of Acres	Total Value ($)
Irrigated Cropland	4,100	28,400	116,440,000
Poplar Trees	2,500	8,600	21,500,000
Total Value of Irrigated Cropland			137,940,000
Non-Irrigated Cropland	100	37,000	3,700,000
Total Change in Value			**134,240,000**

Source: DREW Water Supply Workgroup, 1999 (Appendix I, Economics [Section 3.4.2.4])

Summary

The economic analyses conducted by the DREW Water Supply Workgroup indicate that the cost of modifying the Ice Harbor agricultural pumping stations to provide current water supplies following dam breaching ($291,481,000) would be more than twice the value of the 37,000 acres of farmland that are irrigated ($137,940,000). Given the extensive investment that would be required to maintain existing levels of water supply following drawdown, relative to land values, production would be unlikely to continue on lands that are currently irrigated with water from the Ice Harbor reservoir. A much reduced irrigation system that is designed to continue delivering irrigation water to the estimated 7,750 acres of orchard and vineyard cropland would be more appropriate. Design and cost data for a reduced system are not available. Therefore, the water supply economic analysis used the farmland value method to assess the economic effects of dam breaching (see Appendix I, Economics). In the absence of Congressional funding to modify existing pumps, it seems likely that Ice Harbor irrigators going out of business would be an unavoidable adverse impact.

Sediment Concerns

During and after implementation of Alternative 4—Dam Breaching, it is likely that the silt and sand that has accumulated in the reservoirs behind the four lower Snake River dams would be eroded and entrained by the faster moving river flows. It could take several years for this material to be depleted (see Section 5.4). Excessive quantities of silt and sand could cause damage to pumps, valves, and other components of water supply systems. Intakes would have to be kept clean and clear. Sand particles are heavy enough that most could be kept out of well-designed pumping systems. The silt, however, could remain suspended for long periods of time. The most practical means of handling sand and silt would be to use large settling ponds. No data are available to quantify the expected sediment load in the river, therefore the extent of required settling facilities is unknown at this time.

Water intakes in the Columbia River could also be susceptible to short-term impacts. The majority of the sediments carried downstream during and following dam breaching would be deposited in the upper end of the McNary reservoir. To avoid problems due to potential sedimentation under Alternative 4—Dam Breaching, water intakes in the pool should be located as far above the streambed as practical and should be located in areas having noticeable flow velocities high enough to discourage the deposition of sediment. Locating water intakes in relatively calm water is not advisable where there is a potential for higher rates of sediment deposition (Appendix F, Hydrology/Hydraulics and Sedimentation).

5.11.2 Municipal, Industrial, and Other Uses

5.11.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. No impacts to municipal and industrial (M&I) water users are expected under this alternative.

5.11.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, operation of the four dams would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to M&I water users are expected under Alternative 2—Maximum Transport of Juvenile Salmon.

5.11.2.3 Alternative 3—Major System Improvements

Under this alternative, operation of the four hydropower facilities would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to M&I water users are expected under Alternative 3—Major System Improvements.

5.11.2.4 Alternative 4—Dam Breaching

Municipal and Industrial Water Uses

The M&I pump stations that draw from the lower Snake River are all located on Lower Granite Lake. Uses include municipal water system backup, golf course irrigation, industrial process water for paper production, and concrete aggregate washing. Under Alternative 4—Dam Breaching, the river would return to its natural level and pumping stations would require modifications to maintain current water supplies. The assessment of long-term economic effects on M&I water users is based on the required system modification costs. Modifications required for the M&I pump stations at Lower Granite are summarized in Table 5.11-5.

The total modification costs for these M&I pump stations on the Lower Granite reservoir would range from $11,514,000 to $55,214,000. There is a cost range because the required modification costs for Potlatch Corporation vary significantly depending on whether a water cooling facility would be necessary. The Potlatch Corporation system modifications would be either $10.8 million or $54.5 million of the total.

Privately Owned Wells

Review of Washington Department of Ecology water well reports identified 180 functioning wells within approximately one mile of the lower Snake River. The

Table 5.11-5. Modifications Required for M&I Pump Stations at Lower Granite

Pump Station	Summary of Modifications
Clarkston Golf Course	Would require modifications including construction of a utility building, water intake system, and power supply.
Potlatch Corporation	Would require extensive modifications including the primary plant intake, the plant diffuser, and potentially a water cooling facility.
Atlas Sand & Rock	Would require modifications including construction of a utility building, water intake system, and power supply.
Lewiston Golf Club	Would require modifications including construction of a utility building, water intake system, and power supply.
Two PUD Stations	Have not been used in several years and would not be modified.

Source: DREW Water Supply Workgroup, 1999 (Appendix I, Economics [Section 3.4.3.2])

Corps determined one mile to be the range within which wells could be potentially affected under Alternative 4—Dam Breaching. Based on an analysis conducted by engineers from the Corps, about 40 percent or 71 of these wells are expected to require modification if dam breaching were to occur. Total well modification costs are presented by reservoir in Table 5.11-6. Total costs are approximately $56,447,000. This total includes direct, contingency, project management, and overhead costs.

Table 5.11-6. Well Modification Costs by Pool, 1998 Dollars

Pool	Well Modification Cost ($)
Ice Harbor	18,373,000
Lower Monumental	12,462,000
Little Goose	7,797,000
Lower Granite	17,815,000
Total	**56,447,000**

Source: DREW Water Supply Workgroup, 1999 (Appendix I, Economics [Table 3.4-14])

Water Supply

It should be noted that the estimated well modification costs shown in Table 5.11-6 have been revised since the economic analysis was completed; and the revised well modification costs are equal to $67,042,000. This increase in cost has not been incorporated in the analysis because it does not significantly change the relative size of the water supply economic effects. If it is determined that the dam breaching alternative is the preferred alternative, then additional analysis and refinement would be required. It is estimated that the change in well modification costs would change the conclusions of the water supply analysis by 4 to 5 percent.

The cost estimate was based on a typical cost per well with average increases in pump size and well depth. The estimate does not include additional operation and maintenance expenses associated with the well modifications. As a practical matter, each well would have to be considered individually under dam breaching conditions.

Conditions after dam breaching would have to be observed to determine exactly how deep a well would have to be drilled to produce water at current rates. The Corps recommends that all well modifications be performed after dam breaching has occurred. It is unclear what the water well users would do in the interim.

Habitat Management Units

Ten Habitat Management Units (HMUs) have irrigation systems that are either supplied by surface water intakes in the river or by groundwater wells. Under Alternative 4—Dam Breaching, each pumping station would have to be modified to accommodate the lower and more fluctuating water surface levels. Installation of new piping and increased pump requirements could not be done prior to dam breaching, therefore temporary measures would be implemented for the irrigation period of August 1 to approximately early October. Temporary measures would include use of trailer-mounted pumps and flexible piping. The two water wells would not be modified until after the dams were breached and the groundwater was stabilized.

Cattle Watering

Many of the land acquisition agreements for the lower Snake River reservoirs provide landowners with guaranteed river access for cattle watering. Under Alternative 4—Dam Breaching, it would not be practical to provide access to the river for cattle watering. Environmental concerns about cattle waste in the river and the need to extend fences out into the river make providing river access impractical. To meet a prior legal obligation to provide for cattle watering, a well could be drilled and a pump and water tank installed at each of the watering sites. Since the wells could not be drilled until after the dams were breached, temporary watering facilities would be provided and maintained until the permanent system was complete. Temporary watering would be truck-hauled water to each watering site (see Annex L of Appendix D, Natural River Drawdown Engineering for the Cattle Watering Facilities Monitoring Plan).

5.11.3 Summary of Economic Effects

The economic effects of Alternative 4—Dam Breaching were evaluated for three types of water use: agricultural uses, M&I uses, and private wells. Total direct economic effects were estimated to range from $202.2 million to $245.9 million. Average annual costs were calculated on a 100-year period of analysis at three discount rates—6.875 percent, 4.75 percent, and 0.0 percent (Table 5.11-7). Average annual costs range from $2.2 million using a 0.0 percent discount rate to $15.4 million using a 6.875 percent rate.

For further details regarding the RED sensitivity, refer to Appendix I, Economics, Section 6.3.5. For further details regarding direct impacts and sensitivity refer to Appendix I, Economics, Section 3.4.5.1.

Table 5.11-7. Average Annual Economic Effects by Discount Rate (1,000s of dollars)

Alternative 4—Dam Breaching	6.875 % Discount Rate Min.	6.875 % Discount Rate Max.	4.75 % Discount Rate Min.	4.75 % Discount Rate Max.	0.0 % Discount Rate Min.	0.0 % Discount Rate Max.
Loss of Irrigated Farmland Value		(9,241)		(6,438)		(1,342)
M&I Pump Stations[1/]	(793)	(3,801)	(552)	(2,648)	(115)	(552)
Privately Owned Wells		(3,886)		(2,707)		(565)
Total Costs	**(13,920)**	**(16,928)**	**(9,697)**	**(11,793)**	**(2,022)**	**(2,459)**
Total Cost Point Estimate	**(15,424)**		**(10,745)**		**(2,241)**	

1/ A range of costs is presented for M&I pump stations because the modification costs for the Potlatch Corporation's Lewiston, Idaho facility vary significantly depending on whether a water cooling facility would be necessary.

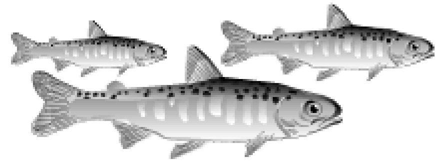
Source: DREW Water Supply Workgroup, 1999 (Appendix I, Economics [Table 3.4-16])

5.11.4 Cumulative Effects

Effects on water supply uses would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching pump modifications would be required for irrigation systems, municipal and industrial water supply intakes, and at some cattle watering stations. Excess silt and sand could damage water supply system components.

5.11.5 Uncertainties in Potential Agriculture, Municipal, and Industrial Water Uses

The water supply analysis evaluated the sensitivity of costs of dam breaching to uncertainties in acreages remaining in production, number of acres potentially affected, and future income. These analyses identified an incremental annual cost of dam breaching that ranged from about $14 million to about $17 million (6.875 percent discount rate) (Appendix I, Economics, Sections 3.4 and 8.4 and Table 8-1).



5.12 Land Ownership and Use

Table 5.12-1 summarizes the potential effects of the alternatives on land ownership and use.

5.12.1 Regional Land Use

Land use in much of the 25 county study area is predominantly agricultural (see Figure 4.11-1) and it is this component of regional land use that would most likely be affected by the proposed alternatives. It is not likely that regional range land, forest land, or urban areas would be significantly affected. As a result, the following discussion focuses on agricultural land use.

5.12.1.1 Alternatives 1 Through 3

Agricultural land would not be affected by the first three alternatives considered under this FR/EIS.

5.12.1.2 Alternative 4—Dam Breaching

Agricultural land use would be affected by changes in transportation and water supply associated with Alternative 4—Dam Breaching. The following sections discuss these changes in turn.

Transportation

Transportation changes associated with the Alternative 4—Dam Breaching, could significantly affect regional farmers. Approximately 5,000 farms are located in 13 of the 25 counties in the lower Snake River study area. These 13 counties, which currently account for approximately 75 percent of total grain movements on the lower

Table 5.12-1. Summary of Potential Effects of the Alternatives on Land Ownership and Use

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Regional Land Use	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Transportation cost increases could reduce or eliminate production on some farm lands. • Reduced access to irrigation water supplies could reduce or eliminate production on some farm lands.
Lower Snake River Corridor	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Project lands would not be needed for commercial navigation or hydropower. • Project lands currently leased to state and local governments and private entities for fish and wildlife management would likely continue to be leased. • Public control of a significant portion of public lands would likely be necessary to protect salmon and their habitat. • Restoration of previously submerged lands would be likely. • A number of real estate actions would be required with respect to lands conveyed for public port and industrial facilities, reserved rights, park and recreation leases, and easements. • Real estate administrative costs are estimated to be $1,189,800.

Snake River, would experience about 75 percent of the total increase in transportation costs associated with dam breaching.

The five counties that ship the largest quantities of grain on the lower Snake River would be the most affected by the increased costs. Latah, Idaho, and Lewis Counties in Idaho, and Whitman County in Washington would incur about 61 percent of the total cost increase. Whitman County, which, alone, accounts for 33 percent of the total grain shipped on the lower Snake River, would incur about 36 percent of the total increased cost. Estimated cost increases per bushel currently shipped on the lower Snake River range from $0.06 per bushel in Wallowa County, Oregon to $0.42

per bushel in Idaho County, Idaho (DREW Social Analysis Workgroup, 1999 [updated 2001]).

A range of potential cost increases per acre are presented by county in Table 5.12-2. These costs represent three scenarios. The first scenario assumes that cost increases would only be distributed across the acres that produce crops that are shipped via the lower Snake River. The second scenario assumes that the costs would be distributed across all the acres that produce wheat and barley in each county. The third scenario distributes costs across all cultivated acres in each county.

Table 5.12-2. Increased Transportation Costs and Total Costs per Acre by County under Alternative 4—Dam Breaching

Subregion/County	Average Impact per Acre for Bushels Shipped on LSR ($)[1/]	Average Impact per Acre of Wheat and Barley Production ($)[2/]	Average Impact per Acre of Harvested Cropland ($)[3/]
Upriver			
Latah, ID	16.17	12.60	6.21
Lewis, ID	15.52	15.02	8.73
Idaho, ID	29.47	28.98	13.55
Nez Perce, ID	19.63	6.09	4.23
Clearwater, ID	27.12	6.98	1.66
Wallowa, OR	3.93	1.62	0.83
Reservoir			
Whitman, WA	14.37	8.26	7.42
Walla Walla, WA	3.60	1.16	1.11
Adams, WA	2.81	1.14	1.02
Columbia, WA	4.85	2.45	2.86
Garfield, WA	10.46	4.25	5.47
Asotin, WA	16.34	7.99	6.96
Downriver			
Franklin, WA	2.24	0.20	0.13

[1/] Average impact per acre for bushels shipped on the lower Snake River = total cost increase per county/total number of bushels from that county shipped on the lower Snake River average yield of bushels per acre.

[2/] Average total impact per acre of total wheat and barley production = total cost increase per county/total number of bushels produced in that county average yield of bushels per acre.

[3/] Average total impact per acre of total harvested cropland = total cost increase per county/total number of harvested acres in that county.

Note: All costs per bushel include transportation, handling, and storage costs.

LSR – lower Snake River

Source: DREW Social Analysis Workgroup, 1999 (updated 2001)

Cost increases per acre under the first scenario range from $2.81 per acre in Adams County, Washington to $29.47 per acre in Idaho County, Idaho. The first scenario represents a worst-case situation that assumes that all of a farmer's production is shipped via the lower Snake River. This is likely the case for those farms located close to the river. The other two scenarios assume that not all of a farmer's production is shipped via the river and that per bushel cost increases would be distributed over a larger number of acres. The effects on individual farms measured on a per acre basis would likely fall within the ranges presented under the three scenarios depending on the percentage of production that is currently transported on the lower Snake River, total acreage planted in wheat and barley, and the availability of transportation alternatives.

Farms in specific counties could see annual impacts as high as $7,120, while other counties could see impacts lower than $1,000 per farm (Table 5.12-3). These increases could result in marginal farms going out of business, at least in the short run. In the long-term it is likely that these increased costs would be capitalized into the value of the land. The value of the land would be reduced and agricultural production would continue. Alternatively, these increased costs could accelerate the existing trend toward consolidation that is evident in all three subregions (see Figures 4.14-6 through 4.14-8).

Table 5.12-3. Average Increased Transportation Cost per Farm by County under Alternative 4—Dam Breaching

Subregion/County	Number of Farms (1992)	Average Transportation Cost per Farm ($)[1/]	Average Total Cost per Farm ($)[2/]
Upriver			
Latah, ID	492	2,085	2,524
Lewis, ID	143	6,022	7,120
Idaho, ID	495	1,971	3,797
Nez Perce, ID	249	2,809	2,807
Clearwater, ID	139	171	289
Wallowa, OR	267	167	167
Reservoir			
Whitman, WA	1,001	5,722	5,947
Walla Walla, WA	594	626	626
Adams, WA	505	785	785
Columbia, WA	157	1,747	1,747
Garfield, WA	163	3,617	3,617
Asotin, WA	66	3,226	3,226
Downriver			
Franklin, WA	732	50	50

[1/] Transportation cost increase per county divided by number of farms per county.
[2/] Transportation, storage, and handling increases per county divided by number of farms per county
Source: DREW Social Analysis Workgroup, 1999 (updated 2001)

As a result of the significant regional interest in the potential for dam breaching, a number of transportation studies have been conducted by other agencies and interested groups. The State of Oregon and Port of Portland completed a study entitled *Breaching the Lower Snake Dams: Transportation Impacts in Oregon.* Key findings of this study with respect to agricultural land use include:

- Agricultural land with yields less than 45 bushels per acre may be at risk of being taken out of production due to higher transportation costs. Low yield dryland wheat farm acreage in Wallowa County, Oregon, and Lincoln and Adams Counties, Washington is at greatest risk for being removed from production.
- Increased transportation costs could reduce the value of some farmland in eastern Oregon and Washington by an estimated $88 per acre.

Water Supply

Approximately 37,000 acres of cropland are currently irrigated from the Ice Harbor reservoir (see Figure 4.11-1). The Corps used two approaches to estimate the economic effects of Alternative 4—Dam Breaching on Ice Harbor irrigators. These approaches—the pump modification approach and the farmland value approach—and the associated projected costs are discussed in Section 5.11.1.4. Both approaches indicate that the cost of modification would be very high and, in the absence of Congressional appropriation, costs to modify the pumps could be prohibitive based on total farm values. Under these circumstances, production would be unlikely to continue on these lands.

5.12.2 Lower Snake River Corridor

5.12.2.1 Alternatives 1 Through 3

Land ownership and use would remain essentially unchanged under the first three alternatives considered in this FR/EIS. The four lower Snake River dams and existing recreation areas and habitat management units (HMUs) would remain in place.

5.12.2.2 Alternative 4—Dam Breaching

Disposition of Lands

Under Alternative 4—Dam Breaching, an estimated 13,771.6 acres of currently inundated land that lie between the ordinary high water line of the original river bed and the normal operating pools would be exposed (Appendix K, Real Estate). The state-owned riverbed, which comprises 19,464 acres, was not acquired by the Federal government. Total acres and acres below normal operating pool are presented by project in Table 5.12-4. The aesthetic effects of this alternative are discussed in Section 5.15.

Table 5.12-4. Project Lands

	Total Acres	Acres Below Normal Operating Pool
Lower Granite	17,668.6	8,448.2
Little Goose	15,684.8	10,825.2
Lower Monumental	14,104.0	4,960.4
Ice Harbor	13,039.5	9,001.8
Total[1/]	**60,496.9**	**33,235.6**

[1/] The acreage of currently inundated land lying between the ordinary high water line of the river bed and the normal operating pools (13,771.6 acres) is calculated by subtracting the area of the state-own riverbed (19,464 acres) from the total acreage below normal operating pool (33,235.6 acres).
Source: Appendix K, Real Estate.

Under Alternative 4—Dam Breaching, project lands would be retained to monitor and maintain the biological effectiveness of dam breaching. Although project lands would no longer be required for commercial navigation or hydropower, a significant portion would arguably be needed to meet other existing or newly authorized purposes. Significant acreage is, for example, leased to state and local governments and private entities for recreation or fish and wildlife management. It is expected that many of these lease holders would choose to continue their operations under the same or modified arrangements. It is also anticipated that public control of a significant portion of public lands would be necessary to protect the environmental and natural benefits to salmon associated with dam breaching. Restoration of previously submerged lands is also likely. It is expected that any reauthorizing legislation would include provisions to meet the above concerns. If any lands were no longer required, they would be reported to the General Services Administration (GSA) for disposal. GSA would screen the lands with other Federal agencies to determine whether there is another Federal requirement for the property. If not, GSA would then dispose of the lands to other eligible public or private entities or individuals.

Real Estate Actions

Lands Conveyed for Public Port and Industrial Purposes

The Secretary of the Army previously conveyed lands in fee to various port districts for operation of port and industrial facilities in connection with the four lower Snake River dams. The legislation that enabled these transfers required that the lands be conveyed at a fair market value and restricted their use to port and industrial purposes only. Dam breaching would in most cases make the use of these lands for these limited purposes impractical. It is, therefore, expected that any legislation implementing dam breaching would release the deed restrictions or otherwise address this potential inequity.

Reserved Rights

In certain instances, landowners reserved certain rights when the Federal government acquired their property. Examples of these reserved rights include cattle watering corridors and water pipelines. If dam breaching were to occur, it would be necessary in some cases to terminate the rights that were reserved in the land acquisition deeds. This is discussed in more detail in Section 5.2 of Appendix K, Real Estate.

Park and Recreation Leases

Leases are granted for recreational and other public uses at each of the four projects. The leases are normally granted for 25 years to a state or political subdivision of a state (i.e., county, city, or port authority) at no cost, with the consideration being the development, operation, and maintenance of the facilities. A letter sent to all Corps park and recreation lease holders in January 1998 advised them of the potential for dam breaching and asked them about the types of impacts they would anticipate, how dam breaching would affect their operations, whether they would continue to operate their facilities, etc. The Corps developed a number of actions based on individual responses to these requests. These are discussed in Section 5.3 of Appendix K, Real Estate and briefly summarized here:

- Amend leases to expand or delete existing lease boundaries to accommodate reduction or expansion of facilities. Expansion could, for example, involve the extension or relocation of a boat launching ramp. An example of a reduction might be closure of a marina or swimming area.

- Generally, leases may be relinquished by the lease holder giving a 1 year notice to the issuing office. If a lease holder elected to relinquish their lease back to the Government, a negotiated termination would be involved.
- If leases were terminated by relinquishment from the lease holder, the Corps would try to solicit a new lease holder to operate the facilities. Due to declining funds for operation and maintenance programs, the Government may close park and recreation facilities if a new lease holder could not be obtained.

Easements

Easements are granted at the four lower Snake River facilities for various purposes including roads, utilities, pipelines, and pumping plants. If dam breaching were to occur, it may be necessary to amend easements to expand the easement boundaries to accommodate relocation or extension of these facilities. Many facilities would not be affected but intakes for pumping plants may need to be extended to near-natural river levels, in which case the easement would be amended. If a facility needed to be relocated, the existing easement would be terminated and a new one issued.

Dam Breaching-Related Actions

If dam breaching were to occur, it may be necessary to negotiate agreements with affected property owners to perform mitigation outside the lower Snake River project lands. It may also be necessary to enter into relocation contracts for the alteration or replacement of affected structures. These issues are discussed further in Sections 5.5 and 5.6 of Appendix K, Real Estate, respectively.

Administrative Costs

Real estate administrative costs that would be incurred under Alternative 4—Dam Breaching are summarized in Table 5.12-5. The cost categories identified in Table 5.12-5 are discussed further in Appendix K, Real Estate, Section 6.

Real Estate Recommendations

If dam breaching were to occur, the Corps' real estate-related recommendations include the following:

- The Corps should retain jurisdiction over land holdings throughout the biological evaluation process. This would avoid the additional time and expense required to reacquire the land and would preclude any incompatible uses of the land during this interim period.

Table 5.12-5. Real Estate Administrative Costs (dollars)

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Total
Cattle Watering Corridors	70,000	170,000	110,000	60,000	410,000
PPR Leases	6,000	12,000	12,000	48,000	78,000
Pump Stations/ Appurtenances[1/]	128,000	0	0	8,000	136,000
Structure Modification/Protection	20,000	35,000	32,000	63,000	150,000
Off-facility Wells	84,000	45,000	45,000	39,000	213,000
Utility Crossings	0	1,000	0	3,500	4,500
Total	**308,000**	**263,000**	**199,000**	**221,500**	**991,500**
Contingency (20%)	61,600	52,600	39,800	44,300	198,300
Total Plus Contingency	**369,600**	**315,600**	**238,800**	**265,800**	**1,189,800**

Notes:
PPR = Public Park and Recreation
[1/]This assumes that Congress would authorize and fund construction of a substitute point of withdrawal and related water pipelines/facilities to serve approximately 8 irrigators whose existing pumping ability would be negatively affected by dam breaching. It is not known at this point whether this authorization or funding would be forthcoming.
Source: Appendix K, Real Estate, Table 7-1

- Authority should be granted (and funds made available) to the Corps to acquire any additional real estate rights that might become necessary for the salmon recovery program and to manage the existing outgranting programs in accordance with sound real estate practice. As the records-holding agency, the Corps is best suited to manage and mitigate impacts to existing grantees and otherwise administer project lands during the evaluation phase.

- The Federal government, subject to Congressional authorization and funding appropriations, and to the extent reasonably possible, should mitigate impacts to holders of existing outgrants and reserved rights by providing substitute rights of way and replacement or relocation of facilities.

- At the request of the port commissions, deed restrictions on lands previously conveyed for public port and industrial purposes should be conditionally released or amended as necessary, because dam breaching may render such uses impractical.

- New authority should be given to the Corps to retain and manage sufficient lands to provide for an ecosystem corridor to ensure the viability of the salmon recovery program. The quantity and use of the lands to be retained for this purpose would be coordinated with regional stakeholders, including NMFS, the U.S. Fish and Wildlife Service, tribes, Washington Department of Fish and Wildlife, and the Idaho Department of Fish and Game.

- If authorized and funded by Congress, replacement water withdrawal facilities and rights-of-way at the Ice Harbor reservoir should be turned over at no cost to an as yet to be determined legal entity for ownership, operation, and maintenance.

- If Congress decides to compensate members of the public as they did for certain damages resulting from the 1992 Lower Granite drawdown test, the compensation, authorization, and appropriations should be enacted prior to the actual dam breaching events. This would allow baseline information to be gathered, claim procedures to be developed and the process to be expedited.

- If funds and resources were made available, a real estate plan and associated gross appraisal would be required. This would be done in conjunction with the detailed design report referenced in Section 3.5.2 of the FR/EIS.

5.12.3 Cumulative Effects

Effects on land ownership and use would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching transportation cost increases could reduce or eliminate production on some farm lands in the region.

5.12.4 Uncertainties in Potential Land Ownership and Use

Uncertainties in regional land use under dam breaching are driven by uncertainties in future transportation and irrigation costs. These factors are addressed in Sections 5.9 and 5.11. Control and management of project lands that would be exposed by dam breaching are uncertain in the long term, but likely would remain with the project at least until restoration was completed.

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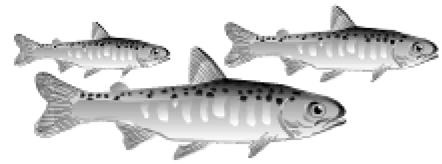


5.13 Recreation and Tourism

This section discusses the potential effects of Alternative 4—Dam Breaching on recreation and tourism. Alternative 1—Existing Conditions through Alternative 3—Major System Improvements would not change existing recreation facilities or use patterns. They would, however, differ in terms of the number of salmon and steelhead that are projected to be available for recreational harvest over the 100-year period of study. Alternative 4—Dam Breaching would have significant effects on recreation and tourism. Breaching the four dams would return the lower Snake River to near-natural conditions. This significant change in river conditions would affect existing developed and dispersed recreation areas, as well as the types of recreation activities that could occur on or along the river. There would also be larger projected increases in the number of salmon and steelhead available for recreation harvest under this alternative than under Alternatives 1 through 3.

The following sections address the effects of the proposed alternatives on existing recreation facilities and sites, dispersed recreation sites, recreation activities, future visitation, and the results of the DREW recreation analysis, which assessed the economic effects of the proposed alternatives.

Table 5.13-1 summarizes the potential effects of the proposed alternatives on recreation.

Table 5.13-1. Summary of Potential Effects of the Alternatives on Recreation

Impact Areas	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Developed Recreation Areas and Dispersed Recreation Sites	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Eleven of the 33 developed recreation areas would be closed and 18 would require extensive modifications. • Fish viewing facilities would no longer be functional. • Many current dispersed sites dependent on current aesthetic features or on water access would no longer be used. • New dispersed sites would develop in the future as the river shoreline stabilized and beaches and views developed.
Effects on Recreational Activities and Visitation	Current usage patterns would generally continue, although the demand for recreation opportunities would increase as the regional population grows.	Possible improvement in fishing-related opportunities and use of facilities if fish population levels increase.	Same as Alternative 2.	• Water-based recreation activities would change from flat-water to river-oriented and there would be an accompanying shift in usage patterns. This shift would take a number of years. • Moving or redesigning existing facilities, building new facilities, and revegetation efforts would allow for quicker recovery of land-based activities. • Fishing activity in the first years following breaching would be lower, but would rebound and be enhanced as salmon recovered and resident species stabilized. There would be a shift in the type of fishing/fish available. • Overall, both recreational fishing and general recreation would be expected to increase within 10 years as the river is restored and if fish respond to natural river conditions.

5.13.1 Recreation Facilities and Sites

Alternatives 1 through 3 would have no effect on existing recreation facilities and sites (see Section 4.13.1.1). Under these alternatives, it is possible that over time, existing facilities and sites could be upgraded and new facilities and sites added if there is sufficient demand and available funding.

Breaching the four lower Snake River dams would significantly affect existing recreation areas and facilities. Most of the existing facilities were developed around the reservoirs. Existing water-based recreation facilities, such as boat ramps, swimming beaches, and moorage facilities, were designed to operate within very specific ranges of water elevations (generally within 5 feet of full pool). If dam breaching were to occur, none of these facilities could continue to be used without modification because river elevations would be lower than they currently are. Some existing recreation facilities such as boat ramps, could be extended to provide access to water. Other features such as parking areas and lawns could be redeveloped closer to the river to provide access. Some facilities however, such as marinas and moorage facilities, would likely not be rebuilt due to the incompatibility of these facilities with a near-natural river. Estimated changes in river elevation that would occur under Alternative 4—Dam Breaching are summarized by reservoir and developed recreation area in Table 5.13-2.

Table 5.13-2. Estimated Changes in River Elevation under Alternative 4—Dam Breaching by Reservoir and Developed Recreation Area

Recreation Area	Current Reservoir Elevation (feet above msl)	Near-Natural River Elevation (feet above msl)[1/]	Difference (feet)
Lower Granite Lake (Lower Granite Reservoir)			
Hells Gate State Park	733-738	725	(8-13)
Chief Looking Glass Park	733-738	725	(8-13)
Clearwater Ramp	733-738	720	(13-18)
Swallows Park	733-738	715	(18-23)
Southway Ramp	733-738	715	(18-23)
Hells Canyon Resort	733-738	705	(28-33)
Greenbelt Ramp	733-738	705	(28-33)
Chief Timothy State Park	733-738	685	(48-53)
Nisqually John Landing	733-738	685	(78-83)
Blyton Landing	733-738	645	(88-93)
Wawawai Co. Park	733-738	635	(98-103)
Wawawai Landing	733-738	635	(98-103)
Offield Landing	733-738	625	(108-113)
Lake Bryan (Little Goose Reservoir)			
Illia Dunes	633-638	615	(18-23)
Boyer Park and Marina	633-638	615	(18-23)
Illia Landing	633-638	615	(18-23)
Willow Landing	633-638	575	(58-63)
Garfield County Ramp	633-638	555	(78-83)
Central Ferry State Park	633-638	545	(88-93)
Little Goose Landing	633-638	525	(108-113)
Lake West (Lower Monumental Reservoir)			
Riparia	537-540	515	(22-25)
Texas Rapids	537-540	505	(32-35)
Lyons Ferry State Park	537-540	475	(62-65)
Lyons Ferry Marina	537-540	475	(62-65)
Ayer Boat Basin	537-540	445	(92-99)
Devil's Bench	537-540	435	(102-105)
Lake Sacajawea (Ice Harbor Reservoir)			
Windust Park	437-440	425	(12-15)
Fishhook Park	437-440	365	(72-75)
Levey Park	437-440	345	(92-95)
Charbonneau Park	437-440	345	(92-95)
North Shore Ramp	437-440	345	(92-95)
Matthews Park	437-440	416	(21-24)

Notes:
msl = mean sea level
1/ Estimated near-natural river elevations are based on the river elevation that existed prior to construction of the four lower Snake River dams.

The Corps estimates that if dam breaching were to occur, 11 of the 33 existing developed recreation areas would be closed and 18 would require extensive modifications if they were to be retained. Eleven recreation areas would be closed because they would no longer be able to provide access to water and there are no other attributes that would be important enough to keep them open for recreationists. The water access facilities that would be affected at these sites include boat ramps,

For further details regarding the RED sensitivity, refer to Appendix I—Economics, Section 6.3.5. For further details regarding direct impacts and sensitivity refer to Appendix I—Economics, Section 3.4.5.1.marinas, moorage facilities, and developed swimming areas. Lake Bryan would be most affected, with four out of six recreation areas closed. Lake West would have three out of six recreation areas closed. Three of the 14 recreation areas at Lower Granite Lake would be closed. Lake Sacajawea would be the least affected with one area out of six closed.

As noted above, 18 of the recreation areas could be modified to offer water access for boats. River access for boats at these 18 recreation areas could be provided by ramps, which would either be extensions of existing ramps or new ramps. None of the marina, boat moorage, boat basin, or dockside service facilities (i.e., marine fuel and dumping facilities) located along the lower Snake River would be able to operate if the four dams were breached. Several boat moorage facilities were located along the lower Snake River in the Lewiston-Clarkston area prior to the construction of Lower Granite Dam (Corps, 1975), which suggests that it might be possible to develop small boat basins for temporary moorage along a near-natural river. This type of development would, however, only be possible if designed to be compatible with salmon recovery plans.

Breaching the four lower Snake River dams would also affect upland recreation facilities. Many of the potentially affected recreation areas have facilities such as picnic shelters, concrete walks, and interpretive signs that are located near the existing reservoirs. Although the activities that occur at these facilities are not water dependant, the proximity of water enhances the recreation experience. Some of these facilities, such as picnic tables, could be moved closer to the river. However, other more permanent facilities such as shade structures and parking areas may not be able to be relocated because of the need to allow natural riparian functions to develop along the newly exposed river shorelines.

The fish viewing facilities at the four dams would no longer be functional under near-natural river conditions. Fish viewing opportunities could occur at hatcheries or outdoor interpretive displays.

The following sections discuss the likely effects of dam breaching on recreation facilities and sites by reservoir.

5.13.1.1 Lower Granite Lake (Lower Granite Reservoir)

Eight of the 13 existing recreation areas on Lower Granite Lake that currently provide boating access could continue to function with site modifications. Three of the remaining five sites (Offield Landing, Blyton Landing, and Nisqually John Landing) would be closed because it would not be possible to access a near-natural lower Snake River from these locations. Water access would no longer be possible from Chief Looking Glass Park, but it is expected that the park would remain open.

Existing marina and/or moorage facilities at Hells Canyon Resort, Greenbelt Ramp and Boat Basin, and Hells Gate State Park would no longer be functional under

Alternative 4—Dam Breaching. It would, however, be possible to extend the boat ramps at these locations. It is not known whether the lease holders of the Hells Canyon Resort would choose to extend their boat ramp and keep other facilities open.

None of the developed swimming beaches that currently exist would be useable under Alternative 4—Dam Breaching because river elevations would be between 8 feet (Hells Gate State Park and Chief Looking Glass Park) and 53 feet (Chief Timothy Park) below existing reservoir levels (see Table 5.13-2). It is unlikely that new developed beaches would be built along the free-flowing river segments due to concerns regarding safety. Swimming, however, would likely occur at informal or dispersed locations, depending on future management restrictions.

Under Alternative 4—Dam Breaching, upland facilities would be higher and further away from the river than they presently are. As dewatered areas stabilize and revegetate, views of the river from these locations may be blocked unless view corridors are maintained.

Under Alternative 4—Dam Breaching, Lower Granite Dam would no longer be able to serve as a bridge connecting Lower Deadman Road, on the south side of the river, with Almota Road on the north. Local recreationists wanting to cross the river would either have to cross at Central Ferry Bridge, about 24 river miles downriver from the dam, or the bridge at Clarkston, which is about 32 river miles upriver.

A brief summary of the likely effects of dam breaching is provided for each developed recreation area in Table 5.13-3. Projected closures and modifications of Corps facilities are contingent on future physical conditions, available funding, and Federal authorization, as well as compatibility with salmon recovery plans.

5.13.1.2 Lake Bryan (Little Goose Reservoir)

Facilities at two (Boyer Park and Central Ferry State Park) of the seven Little Goose recreation areas could continue to provide water access if they were modified. The other five recreation areas (Illia Landing, Willow Landing, Garfield County Ramp, and Little Goose Landing) would be closed under Alternative 4—Dam Breaching. Although the ramps at Boyer Park and Central Ferry State Park could continue to provide access, the marina at Boyer Park would not be replaced nor would the boat basin at Central Ferry State Park. Under Alternative 4—Dam Breaching, there would be no boat moorage facilities available along the section of river that flows through what is currently Lake Bryan.

None of the developed swimming beaches that currently exist would be useable under Alternative 4—Dam Breaching because river elevations would be between 18 and 113 feet below existing reservoir levels. It is likely that dispersed swimming would occur along this stretch of river as natural beaches emerge or are formed. This would, however, depend upon future road access, parking, and sanitation facilities,

Upland recreational facilities at the two recreation areas that would potentially remain open under Alternative 4—Dam Breaching would also be affected. Although the

Table 5.13-3. A Summary of the Likely Effects of Alternative 4—Dam Breaching on Recreation Areas on Lower Granite Lake (Lower Granite Reservoir)

Recreation Area	Physical Effects
Hells Gate State Park	The river would be between 8 and 13 feet below existing pool elevation ranges at this location. The existing six-lane boat ramp, handling docks, marine, marine fuel, marine dump station, and irrigation intakes could no longer be used. The boat ramp would not be extended.
Chief Looking Glass Park	The river would be between 8 and 13 feet below existing pool elevation ranges at this location. The existing boat basin, two-lane boat ramp, and handling dock would not be functional and would be taken out of service.
Clearwater Ramp	The river would be between 13 and 18 feet below current pool elevation ranges at this location. The existing two-lane boat ramp and handling docks would no longer be functional. The boat ramp could, however, be extended.
Swallows Park	The river would be between 18 and 23 feet below existing pool elevation ranges at this location. The existing four-lane boat ramp, handling dock, and swimming area would be unusable and access between the waterside day-use areas would be difficult. The irrigation system would also be affected. Some of these impacts could be mitigated, including the boat ramp, which could be extended to provide river access.
Southway Ramp	The river would be between 18 and 23 feet lower than current pool elevation ranges at this location. The existing two-lane boat ramp and handling dock could, however, be extended.
Hells Canyon Resort	The river would be between 28 and 33 feet below existing pool elevation ranges. The existing marina, two-lane boat ramp, and all facilities would not be usable and irrigation intakes would be affected. The boat ramp could be extended, but it is not known if the lease holders of the resort would choose to extend the ramp or attempt to keep other facilities open.
Greenbelt Ramp	The river would be between 28 and 33 feet below current pool elevations at this location. The existing two-lane boat basin, boat ramp, and handling docks would not be functional. The boat ramp could, however, be modified to provide river access.
Chief Timothy State Park	The river would be between 48 and 53 feet below current pool elevation ranges at this location. The four-lane boat ramp, handling docks, swimming beach and irrigation system would no longer be usable. The boat ramp could, however, be modified to provide river access.
Nisqually John Landing	The river would be between 78 and 83 feet below current pool elevation ranges at this location. The existing one-lane boat ramp and primitive swimming would not be functional and the area would be closed.
Blyton Landing	The river would be between 88 and 93 feet below current pool elevations at this location. This would eliminate use of the existing one-lane boat ramp. The area would be closed.
Wawawai County Park	The river would be between 98 to 103 feet below existing pool elevations at this location. The embayment that provides water access to this park would be dry and irrigation intakes would not work. The park would no longer have access to the river and would be separated from the river by the existing railroad line.
Wawawai Landing	The river would be between 98 and 103 feet below existing pool elevations at this location. The existing boat basin, boat ramp, primitive swimming beach, and Washington State University docks would not be usable. Some mitigation measures could allow limited use of some recreation facilities, including the boat ramp which would be modified.
Offield Landing	The river would be between 108 and 113 feet below existing pool elevations at this location. The existing one-lane boat ramp and handling docks would not function and the area would be closed.

Boyer Park boat ramp could be relocated to provide access, it is not known if the Port of Whitman County would keep Boyer Park open in the absence of boat moorage facilities. If this park were to remain open, irrigation intakes and other facilities would need to be relocated closer to the water to keep the park in operation. Alternative 4—Dam Breaching would have less effect on the upland recreation facilities at Central Ferry State Park because the existing boat ramp and staging area could be relocated.

If dam breaching were to occur, Little Goose Dam would no longer serve as a bridge connecting the north and south sides of the river. Local recreationists wanting to cross the river would either have to cross at Lyons Ferry Bridge, about 11 river miles downriver from the dam, or Central Ferry Bridge, which is about 13 river miles upriver.

A brief summary of the likely effects of dam breaching is provided for each developed recreation area in Table 5.13-4.

Table 5.13-4. A Summary of the Likely Effects of Alternative 4—Dam Breaching on Recreation Areas on Lake Bryan (Little Goose Reservoir)

Recreation Area	Physical Effects
Illia Dunes	The river would be between 18 and 23 feet below existing pool elevations at this location. There are no developed water-oriented facilities at Illia Dunes. The main effect of dam breaching would be to significantly increase the width of the existing beach adjacent to Lake Bryan.
Boyer Park and Marina	The river would be between 18 and 23 feet below current pool elevations at this location. The existing three-lane boat ramp, handling dock, marina, marine dump station, public gas dock, tour boat dock, and swimming beach would not be usable and irrigation intakes could also be affected. Although the marina and related facilities would not be useable, boat ramps could be relocated to allow river access. In addition to losing water-oriented facilities, the dry boat storage facility and the motel could be affected by a decrease in customers. Access to Boyer Park and Marina, located on the north side of the river, would be more difficult for some local recreationists, residing in communities south of the river.
Illia Landing	The river would be between 18 and 23 feet below existing pool elevation ranges at this location. The area would be closed.
Willow Landing	The river would be between 58 and 63 feet below existing pool elevations at this location. The existing two-lane boat ramp would no longer be functional and the area would be closed.
Garfield County Ramp	The river would be between 78 and 83 feet below existing pool elevations at this location. The existing primitive two-lane boat ramp would not be usable and the area would be closed.
Central Ferry State Park	The river would be between 88 and 93 feet below current pool elevations at this location. The existing four-lane boat ramp, handling docks, boat embayment, marine dump, and developed beach area would no longer be usable and the 60-unit campground would be farther from the water than it is currently.
Little Goose Landing	The river would be between 108 and 113 feet below existing pool elevations at this location. The existing one-lane boat ramp and handling dock would not be usable and the area would be closed.

5.13.1.3 Lake Herbert G. West (Lower Monumental Reservoir)

Three (Lyons Ferry Marina, Ayers Boat Basin and Devil's Bench) of the six recreation areas that provide boat access to Lake West would be closed under Alternative 4—Dam Breaching. Texas Rapids and Lyons Ferry State Park could provide access to the river if their ramps were extended. The Lyons Ferry marina is leased to the Port of Columbia and has moorage for 44 boats, a restaurant/grocery store, and other amenities. If Alternative 4—Dam Breaching were implemented, the Port would likely close the facility, which would eliminate all boat moorage and possibly use of the boat ramp. Alternative 4—Dam Breaching would also leave the developed swimming area at Lyons Ferry State Park unusable. It is, however, likely that undeveloped swimming areas would evolve as beaches were formed along the near-natural river.

Under Alternative 4—Dam Breaching, upland facilities would be higher and further away from the river than they presently are. If Lyons Ferry Marina is closed, most, if not all, of the upland facilities such as the campground, restaurant/grocery store, and marina grounds would also likely close. Dam breaching may also negatively affect upland facilities at Lyons Ferry State Park.

If dam breaching were to occur, Lower Monumental Dam would no longer serve as a bridge connecting Lower Monumental Road, on the south side of the river, with Devil's Canyon Road on the north. Recreationists wanting to cross the river would either have to cross at the U.S. Route 12 bridge, about 40 river miles downriver from the dam, or at Lyons Ferry Bridge, which is about 17 river miles upriver.

A brief summary of the likely effects of dam breaching is provided for each developed recreation area in Table 5.13-5.

5.13.1.4 Lake Sacajawea (Ice Harbor Reservoir)

Five of the six recreation areas on Lake Sacajawea that currently provide boating access could continue to function provided their ramps were extended. The sixth area, the North Shore ramp, would be removed to allow the river to bypass Ice Harbor Dam. The two recreation areas that have marina-moorage capabilities (Charbonneau Park and Fishhook Park) would no longer have these capabilities if dam breaching were to occur. None of the developed swimming areas that presently exist would be useable under Alternative 4—Dam Breaching because river elevations would be between 12 feet (Windust Park) and 95 feet (Charbonneau Park and Levey Park) below existing reservoir levels (see Table 5.13-2). It is, however, possible that natural swimming areas would evolve as beaches were formed along the near-natural river.

Under Alternative 4—Dam Breaching, upland recreation facilities would be higher and further away from the river than they presently are. Some existing facilities could be moved or new facilities could be built closer to water. Three of these recreation areas are very popular, particularly with people from the Tri-Cities. As a result, it is likely that efforts would be made to reconfigure the facilities at these locations.

A brief summary of the likely effects of dam breaching is provided for each developed recreation area in Table 5.13-6.

Table 5.13-5. A Summary of the Likely Effects of Alternative 4—Dam Breaching on Recreation Areas on Lake Herbert G. West (Lower Monumental Reservoir)

Recreation Area	Physical Effects
Riparia	Dam breaching would have little effect on this recreation area because the existing boat ramp has silted closed. The primary use of Riparia is for fishing access.
Texas Rapids	The river would be between 32 and 35 feet below the current pool range at this location. The existing two-lane boat ramp and dock would not be usable and the irrigation intake would be affected. The ramp could be relocated.
Lyons Ferry State Park	The river would be between 62 and 65 feet below the existing pool range at this location. The existing two-lane boat ramp, handling dock and swimming beach would not be usable, and the irrigation system in the day-use area and comfort station area could be affected. The boat ramp could be relocated to provide river access.
Lyons Ferry Marina	The river would be between 62 and 65 feet below current operating ranges at this location. The existing marina and boat ramp would not be usable and irrigation intakes would be affected. Much of the campground would overlook a sizable dewatered area. The marina would be closed.
Ayer Boat Basin	The river would be between 92 and 99 feet below the current pool elevation range at this location and the boat tunnel that goes under the railroad to connect the boat basin with Lake West would be dry. The area would be closed.
Devil's Bench	The river would be between 102 and 105 feet below the existing pool range at this location and the existing two-lane boat ramp would not be usable. The area would be closed.

Table 5.13-6. A Summary of the Likely Effects of Alternative 4—Dam Breaching on Recreation Areas on Lake Sacajawea (Ice Harbor Reservoir)

Recreation Area	Physical Effects
Matthews	The river would be between 12 and 15 feet below the existing lake level at the recreation site. The existing boat ramp could be extended to the river.
Windust Park	The river would be between 12 and 15 feet below current pool elevations at this location. The existing one-lane boat ramp and developed swimming beach would no longer be usable. There would also be potential problems with the irrigation intakes, and the day-use area would no longer be adjacent to the water. The boat ramp could be modified to provide access to the river.
Fishhook Park	The river would be between 72 and 75 feet below existing pool elevations at this location. The existing two-lane boat ramp, staging area, handling docks, temporary moorage, and sanitary dump stations would not be functional. Irrigation intakes would not work and there would likely be other irrigation problems. In addition, the day-use area and campground would not have direct water access. The moorage facilities would not be able to be relocated, but the boat ramp could be relocated.
Levey Park	The river would be between 92 and 95 feet below existing pool elevations at the current location. The existing two-lane boat ramp, handling docks, staging area, sanitary dump station and developed beach could no longer be used. Irrigation intakes would also likely be unusable and the day-use area would not be adjacent to water. The boat ramp could be modified to provide river access.
Charbonneau Park	The river would be between 92 and 95 feet below existing pool elevations at this location. The existing marina, marina dump, two-lane boat ramp, and developed beach would not be functional. In addition, existing irrigation intakes would need to be relocated to be functional and some additional work might be required on the irrigation system. The boat ramp could be modified.
North Shore Ramp	The entire area near the dam that contains the ramp and other recreation facilities would be removed as part of the actions implementing the dam breaching alternative.

5.13.2 Dispersed Recreation Sites

Alternatives 1 through 3 would not affect existing dispersed recreation sites. Alternative 4—Dam Breaching would, however likely affect these sites. These potential effects are described in the following paragraphs.

There are numerous undeveloped dispersed recreation sites along the shores of the lower Snake River. Some of these sites are simply pull offs adjacent to a highway that provide water access for anglers. Others are larger areas where people picnic, swim, and participate in other day-use activities. None of these dispersed sites have developed facilities such as restrooms, formal trails, or formal parking.

Near-natural river levels under dam breaching would range from approximately 8 to 100 feet below existing dispersed sites. Dam breaching would alter some of the features, such as beaches, that attract people to these sites and use patterns for many dispersed areas would change. Some sites would simply cease to be used because the features that attracted people would be eliminated. Other sites would be so high above or far away from the river that access would be difficult and possibly dangerous. These sites would likely also be abandoned.

Returning the river to a near natural condition would, however, result in the creation of new dispersed sites. Over a period of several years, the river and silty shoreline would stabilize and natural features, such as beaches, would form. While these features would attract users and new dispersed areas would evolve, it is likely that the use of such sites could be regulated to minimize impacts to fish, wildlife, and cultural resources. Many of the passive activities that presently occur at existing dispersed sites would also occur at these new dispersed sites. If allowed by managing agencies, river recreationists would also likely create dispersed sites at locations such as beaches that could only be accessed by the river.

5.13.3 Recreation Activities

Existing recreation activities and future trends are not expected to change under Alternatives 1 through 3. Recreation activities are, however, expected to change under Alternative 4—Dam Breaching. Some types of recreation activities that require or favor flatwater conditions would no longer be possible, while opportunities for other recreational activities that require, or are more favorable under, natural river conditions would be expanded. The following sections discuss the effects of Alternative 4—Dam Breaching on existing recreational activities, as well as the new recreation activities that would likely be possible along a near-natural lower Snake River.

5.13.3.1 Existing Recreational Activities and Displaced Users

Breaching the four lower Snake River dams would have dramatic effects on regional recreation, reducing the supply of lakes that presently support flatwater recreation by approximately 34,000 acres. Lake or flatwater-oriented recreation activities, including water skiing, sailing, fishing for some warm-water species, and sightseeing in the current type of tour boats that cruise between Portland and Lewiston, would no longer be possible if breaching were to occur. Some activities that occur on lakes, such as fishing, swimming, hiking, camping, and wildlife viewing, could still occur along a near-natural river. Breaching the dams would also expand opportunities for recreation activities, such as drift boating, rafting, kayaking, and jet boating, that require, or are more favorable under, natural or near-natural river conditions.

Visitor distribution in 1998 is presented by activity in Table 4.14-2. A visitor in this context refers to the entry of one person into a recreation area or site to engage in one or more recreation activities. The load factors presented in Table 4.14-2 account for visitors engaging in more than one activity during a visit and, as a result, the percentage of visitors engaging in various activities at each reservoir adds up to more then 100. The percentage of visitors that engaged in activities that would no longer be possible after dam breaching (e.g., boating and water-skiing) ranged from 26 percent at Lake West to 33 percent at Lower Granite Lake. The percentage of existing visitors engaging in activities that would still be possible after dam breaching in some form or another ranged from 123 percent at Lower Granite Lake to 175 percent at Lake Bryan.

Some flatwater recreationists would adapt to the new conditions. These recreationists would either attempt to use the river setting for their existing activities or would substitute other activities. Other recreationists, however, may find a river setting unsuitable to their needs and would either discontinue their flatwater activity or travel to another site. Lakes and reservoirs in the general region that might receive displaced recreationists include Lake Coeur d'Alene, Lake Pend Oreille, Priest Lake, Dworshak Lake (part of the year), and the lower Columbia River reservoirs.

From a historical perspective, it is interesting to note that a survey of mainly local recreationists conducted by Washington State University prior to construction of Lower Granite Dam found that 75 percent of respondents thought that the dam would detract from their recreational enjoyment of the area (Corps, 1975). The primary activities of people at the time were sightseeing (including driving for pleasure), fishing, and hunting. It is not known whether these people eventually accepted and enjoyed reservoir recreation activities or were displaced to other natural or near-natural rivers.

5.13.3.2 New Recreational Activities

As noted in the preceding sections, breaching the four lower Snake River dams would significantly alter the lower Snake River. These changes to the river would affect the types of recreation activity that would be possible. The following section provides a brief description of the likely characteristics and environmental setting of a near-natural lower Snake River and then discusses some of the more popular recreation activities that would likely take place following dam breaching.

Environmental Setting

The following description of the likely characteristics and environmental setting of a near-natural lower Snake River is based on an assessment developed by Corps staff.

River Characteristics

Under Alternative 4—Dam Breaching, the lower Snake River would be diverted in a channel around each of the four concrete dam structures, which would remain in place. River flows would continue to be regulated for various purposes including flood control, hydropower, irrigation, and recreation by a series of dams located upstream, including Dworshak Dam on the Clearwater River and the Hells Canyon Dam Complex above the Hells Canyon stretch of the Snake River. The stretch of the river flowing through Lewiston would continue to be regulated by levees, as would many parts of the river between Lewiston and the confluence of the lower Snake and Columbia Rivers. Levees would be necessary to protect existing transportation systems (i.e., highways, railroads, and bridges).

It is possible to gain insight into likely river conditions following breaching by examining the river conditions that existed prior to construction of the four lower Snake River dams. Mapping prepared in the early 1930s by the United States Engineer Office, Portland, Oregon, provides a comprehensive insight into pre-dam conditions along the lower Snake River (see Appendix S, Snake River Maps). Based on this information, there were 60 individually-named rapids in the 145-mile stretch of the lower Snake River between Asotin, Washington, and its confluence with the Columbia River; 24 major islands were either specifically named or were of significant size. The maximum sounding depth noted was in excess of 70 feet in the vicinity of the Palouse River's confluence with the Snake River.

From inspection of this mapping, an estimated average width for the lower Snake River is about 1,000 feet, with an estimated average depth of 15 feet. Using these dimensions at the mean annual flow of 55,000 cubic feet per second (cfs), average velocity would be about 3.7 feet per second. Assuming an average width of 1,250 feet and average depth of 25 feet for the recorded maximum discharge of 312,000 cfs, an average velocity for this discharge is about 10 feet per second. These assumed average values compare reasonably well with the velocity values of 5 to 9 miles per hour (7 to 13 feet per second) noted at the rapids by the survey party during the 1930s surveys along the lower Snake River.

More detailed information on the likely characteristics of a near-natural lower Snake River based on the 1935 mapping is provided in Appendix A, Anadromous Fish.

Class of Rapids

It qualitatively appears that the lower Snake River's rapids would likely be generally classified as Class II or III using the accepted International Scale of River Difficulty, although some of the longer rapids such as the Palouse Rapids could be in the Class IV range. Flow velocities through the rapids areas were noted on the 1935 mapping as generally being between 5 to 9 miles per hour (7 to 13 feet per second).

Average Gradient

Based on the information provided by the 1935 mapping of the river, elevation change between Asotin Creek and the confluence with the Columbia River at low water elevation would be from 728.2 feet above mean sea level (msl) to 311.9 feet above msl. This results in a difference of 416.3 feet and an average gradient of 2.9

feet per mile. About 76 percent, or 316 feet, of this vertical change would occur through named rapids.

Scenery

Typical scenery along the lower Snake River includes rocky shorelines with intermittent sand beaches and irrigated parks. Agricultural land predominates above high rock cliffs on often rolling hills. Evidence of human development includes Wawawai River Road (a country road) and State Route 193, which follows the north side of Lower Granite Lake. U.S. 12 follows the south side of Lower Granite Lake for approximately 7 miles from Clarkston to Silcott. The river is crossed at six locations, including all four dams, by state or county highways. Two railroad corridors parallel the length of the river. One of these railroads follows the south shore of the river from Ice Harbor Dam to Lyons Ferry (RM 62) where it crosses the river and heads toward Spokane. From this point, the second railroad line follows the north shore up to the Idaho border and beyond.

Climate

The climate of the lower Snake River varies somewhat between Ice Harbor and Lower Granite Dams, but exhibits the same general characteristics. Summers are usually very sunny, hot, and dry, with temperatures usually topping out at 110 degrees Fahrenheit; winters are usually cold. Often there are weeks of fog and 30-degree temperatures along the river corridor. Temperatures in spring and fall range from 50 to 80 degrees Fahrenheit. Annual precipitation ranges from 7 to 9 inches at Ice Harbor Dam to 10 to 14 inches at Lower Granite Dam.

Solitude

The sounds of farming are prominent at some locations along the lower Snake River at certain times, and the sounds of jet boats are common in some areas during the summer. The sounds of trains are also fairly routine along the length of the river. Stretches of the lower Snake River that are difficult to access and have few developed facilities are, however, likely to offer good solitude, which may be measured in terms of the absence of the sights and sounds of civilization, including other recreationists.

Land Ownership

Land ownership along the lower Snake River corridor is not expected to change from the current arrangement. The land adjacent to the water is expected to remain in public ownership. Recreation development may need to be limited in these areas to reduce potential impacts to ESA-listed stocks.

Activities

In order to assess the effects of dam breaching on river-oriented recreation, Corps recreation planners estimated how long it would take for the river and adjacent land to reach conditions that were suitable for river-oriented recreational activities. The expected suitability of various types of river recreation is estimated in percentages in

5-year increments following dam removal. Five years after dam removal, for example, it is estimated that river conditions would be at approximately 50 percent of their optimal suitability for jet boating and jet skiing (Table 5.13-7).

Table 5.13-7. Recreation Suitability Recovery after Dam Removal[1/2/]

Activity	Year 1 (%)	Year 5 (%)	Year 10 (%)	Year 20 (%)
Jet Boating, Jet Skiing	20	50	70	100
Rafting/Kayaking/Canoeing	30	50	80	100
Swimming	20	40	100	100
Picnic/Primitive Camping	80	100	100	100
Developed Camping	60	90	100	100
Hiking and Mountain Biking	80	100	100	100
Hunting	50	80	100	100

1/ The numbers in this table represent an estimate of the percentage of optimal suitability at various years that could be accommodated on the lower Snake River after dam removal.
2/ Future estimates of available anadromous fish angling opportunities are based on numbers of fish projected by PATH and generalized by the DREW Anadromous Fish Workgroup. Resident fishing opportunities are based on a projected one-third reduction in warm water fish habitat following breaching.
Source: Appendix I, Economics (Table 3.2-8).

Reaching optimal suitability for other water-based recreation activities would also be expected to take a number of years. This is due to several factors including the number of years it would take for the river to stabilize, the initial lack of river access facilities, the time it would take for riparian areas to revegetate, and the time it would take for sport fish populations to recover sufficiently for recreational fishing. Land-based activities would recover faster than water-based activities. Although many land-based recreational facilities, such as campgrounds and picnic areas, would no longer be located next to lakes, they could still be used as the dewatered areas of the old reservoirs recover. Moving existing recreation facilities and building new ones, would allow recreationists to participate in land-based activities sooner than water-based activities.

The following discussion addresses how some of the more popular recreational activities would likely recover after dam breaching.

Fishing

Fishing activity during the first years immediately following breaching would likely be low because the populations of most resident fish, such as yellow perch, bullheads, catfish and bluegill, would be reduced after breaching, and steelhead and salmon populations would not have recovered sufficiently to allow recreational fishing. It is estimated that there would be a one third reduction in warm water fish carrying capacity under near-natural river conditions (Corps, 1999f). Two resident fish species that would likely repopulate after dam removal in numbers significant enough to permit recreational fishing would be smallmouth bass and sturgeon. Smallmouth bass fishing in the vicinity of Lower Granite Lake was considered to be high quality prior to construction of Lower Granite Dam (Corps, 1975).

Based on the PATH results, as extended by the DREW Anadromous Fish Workgroup, it is considered likely that both native and hatchery salmon and steelhead populations would eventually recover in sufficient numbers to allow recreational fishing on the lower Snake River. Fishing success after breaching would also likely be enhanced downstream and upstream of the breached lower Snake River dams. The increase in fish populations along with the modification of existing recreational facilities or the construction of new facilities would allow anglers to increase their participation rates. As steelhead, salmon, and to a lesser extent, smallmouth bass and sturgeon populations would increase, so would fishing activity.

Jet Boating and Jet Skiing

Although there is currently some use of jet boats and jet skis along the lower Snake River, it is anticipated that there would be greater use of these watercraft with dam breaching. After one year, conditions would likely allow for approximately 20 percent of the use that would be possible under optimal river conditions. Within 5 years, boat ramps and other boat access facilities would be reestablished and conditions would likely allow for approximately 50 percent of the use that would be possible under optimal river conditions. Conditions would likely allow for 75 and 100 percent of optimal use by years 10 and 20, respectively (Table 5.13-7).

Rafting/Kayaking/Canoeing

By the end of the first year after breaching, river conditions are expected to allow for approximately 30 percent of the rafting/kayaking/canoeing use that would be possible under optimal river conditions. Conditions are expected to allow for 50 and 80 percent of optimal use by years 5 and 10. Optimal river conditions for rafting, kayaking, and canoeing are anticipated to exist by the end of the second decade following breaching (Table 5.13-7).

Swimming

None of the developed swimming beaches that currently exist would be useable under a dam breaching scenario. It is unlikely that new developed beaches would be built along the near-natural river segments due to concerns regarding safety. Swimming would, however, likely occur at informal or dispersed locations, depending on future management restrictions. As the river stabilized, natural beaches similar to those on the Snake River upstream from Lewiston would become established. The Washington State University recreation use survey conducted prior to the construction of Lower Granite Dam found that survey respondents felt that the loss of natural sand beaches would be one of the more significant negative recreation impacts associated with construction of the dam (Corps, 1975).

By the end of the first year after breaching, river and shoreline conditions are expected to allow about 20 percent of the swimming use that would be possible under optimal river conditions. After 5 years, the level would increase to 40 percent and after approximately 10 years, conditions would be suitable to support 100 percent of demand for swimming (Table 5.13-7).

Land-based Activities

Participation levels for land-based recreational activities would recover faster than levels for water-based activities. Activities that can occur at dispersed areas such as picnicking, primitive camping, hiking, hunting, and mountain bike riding would recover faster than activities such as camping at developed facilities. After breaching, old road and railroad beds would re-emerge along the shoreline of the river. It may be possible to restore or convert some of these road and/or railroad beds into trails for hiking, mountain biking, and horseback riding. By the end of the first year after breaching, land and river conditions are expected to allow for approximately 80 percent of the dispersed use that would be possible under optimal river conditions. After 5 years, conditions for these activities are expected to be suitable to meet all demand.

Although many of the developed land-based recreational facilities such as campgrounds and picnic areas would no longer be located next to water, they could still be used. Moving or redesigning existing facilities, building new facilities, and carefully planning revegetation efforts in dewatered areas could encourage recreationists to participate in land-based activities. Although the increased distance that existing recreation sites would be from the water might be considered negatively by many users, it is felt that by year 10, conditions for camping would be optimally suitable (Table 5.13-7).

5.13.4 Future Visitation

Existing visitation patterns and future trends are not expected to change under Alternatives 1 through 3. Visitation is, however, expected to change under Alternative 4—Dam Breaching. As discussed in the preceding section, some types of recreation activities that require or favor flatwater conditions would no longer be possible, while opportunities for other recreational activities that require or prefer natural river conditions would be expanded.

5.13.4.1 Estimated General River Recreation Demand

The DREW Recreation Workgroup surveyed Washington, Idaho, Oregon, western Montana, and California residents to identify the type and number of recreation users that would visit the lower Snake River if the dams were breached. The survey described the new recreation conditions and asked whether the respondent would visit and, if so, how many times a year. Respondents were also asked the distance, travel cost, and travel time to the spot on the river that they would be most likely to visit. The primary survey distribution was approximately as follows:

- 6,000 surveys to residents of the 18 counties located within 150 miles of the lower Snake River. These counties are distributed by state as follows: 10 in Washington, 5 in Idaho, and 3 in Oregon.
- 1,500 surveys to residents of other parts of Idaho, Oregon, and Washington (500 to residents of each state); 500 surveys to residents of Montana; and 1,000 surveys to residents of California.

The most heavily sampled area consists of the 18 counties where the majority of current visitors reside. The second sample area was included because the DREW Recreation Workgroup felt that a near-natural lower Snake River was a potentially significant recreation resource that would likely attract visitors from more distant locations.

A total of 3,245 completed or partially completed surveys were received for an overall response rate of 41.4 percent. Response rates varied by region and ranged from 21.3 percent in California to 46.3 percent in Montana. This is discussed further in Appendix I, Economics, Section 3.2.

The DREW recreation analysis separated people who would visit a near-natural lower Snake River into two groups: anglers and non-anglers or general recreationists. This division reflects the likelihood that anglers would have a different propensity to visit a near-natural lower Snake River than visitors pursuing other recreation activities. The survey allowed respondents to indicate whether they would: (a) definitely visit the lower Snake River if the dams were breached, (b) probably visit, (c) probably not visit, or (d) definitely not visit. The revised DREW recreation analysis provides two estimates of river recreation demand and economic benefits based on these survey results. The first estimate (Middle Estimate 1) applied the percentage of survey respondents who said they would definitely visit to the total population. This assumes no visitation from those who said that they would probably visit and also assumes that the proportion of surveyed households who did not respond to the survey would visit at the same rate as those who did respond. The second estimate (Middle Estimate 2) applied the visitation rates of households who indicated that they would definitely or probably visit to the proportion of total households equivalent to the survey response rate. This approach assumes that survey non-respondents would not visit.

These middle use estimates predict that a large percentage of general, or non-angling, recreation visitation to a near-natural lower Snake River would originate in distant areas, such as Portland, Seattle, and California. This is discussed further in the following section.

5.13.4.2 Comparison of Demand Estimates with Existing Visitation to Other Rivers

A number of reviewers and members of the public commenting on the Draft FR/EIS expressed concerns with the original visitation estimates developed by the DREW Recreation Workgroup. In response to comments from the technical review performed by the Northwest Power Planning Council's Independent Economic Analysis Board (IEAB), the revised DREW recreation analysis focuses on the two middle estimates discussed in this section (see Appendix I, Economics, Section 3.2). In order to provide some perspective on these estimates, the following sections compare the revised visitation estimates with existing visitation data from free-flowing rivers in the region. The first section briefly identifies the rivers selected for comparison. The second section reviews existing visitation to these free-flowing rivers and compares these totals, as well as existing visitation to the lower Snake River reservoirs, with the projected number of visitors to a near-natural lower Snake River. The third and final section compares the origin of visitors to existing free-flowing rivers with the projected origin of visitors to a near-natural lower Snake River.

Rivers Selected for Comparison

A number of rivers were selected for comparison with a near-natural lower Snake River based primarily on comments received from different parties during the course of the lower Snake River feasibility study. Summary data were compiled for the following rivers:

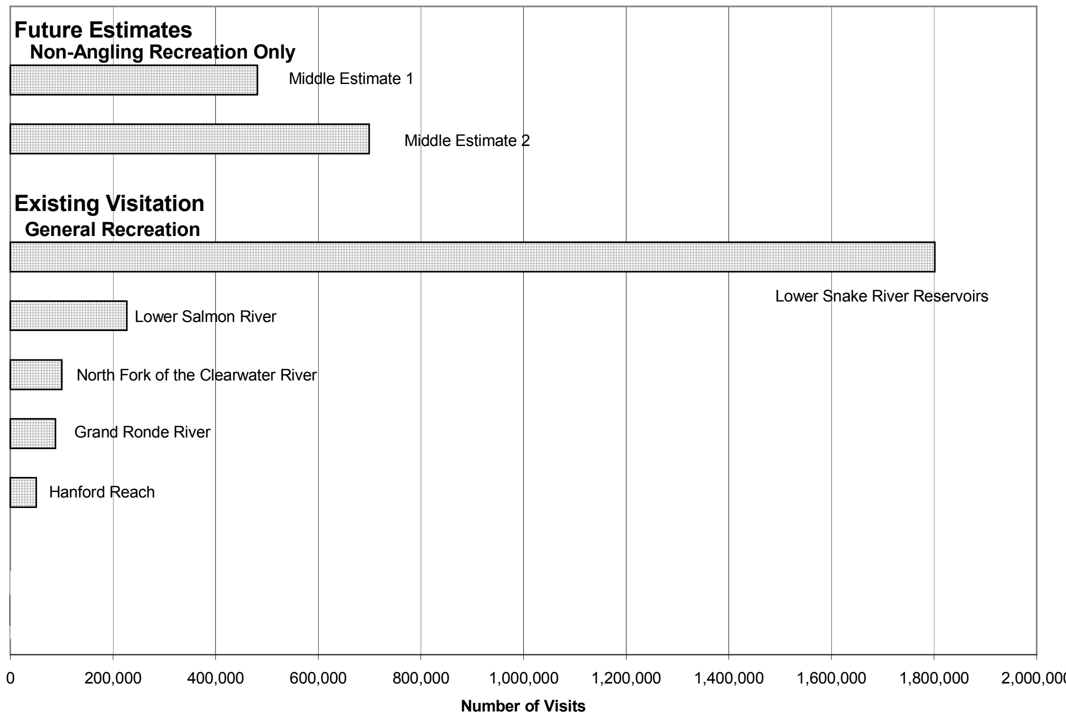
- Hanford Reach of the Columbia River, Washington
- North Fork of the Clearwater River, Idaho
- Lower Salmon River, Idaho
- Lower Deschutes River, Oregon
- Hells Canyon stretch of the Snake River, Idaho, Oregon, and Washington
- Main Salmon River, Idaho
- Middle Fork of the Salmon River, Idaho
- Grand Ronde River, Oregon
- Lochsa River, Idaho.

Review of these existing rivers suggests two general points. First, there is considerable variation among the environmental and social settings of the existing free-flowing rivers selected for comparison, as well as among the range of recreation activities offered by these rivers. Second, it appears that a near-natural lower Snake River would be a fairly unique recreation resource primarily because of its size, accessibility, and the available range of existing recreation facilities and activities.

In general, it appears that a near-natural lower Snake River would offer a very different type of recreation experience to the region's premier whitewater rivers, such as the Main Salmon River, the Middle Fork of the Salmon River, and the Hells Canyon stretch of the Snake River. In addition to whitewater, these rivers also offer a wilderness experience and spectacular scenery. In terms of accessibility, the range of activities offered, and scenery, a near-natural lower Snake River would appear to have more in common with the lower Deschutes River, the Grand Ronde River, or the lower Salmon River. It would, however, be much larger than these rivers, with about 10 times the flow of the lower Deschutes and Grand Ronde Rivers, and about 5 times the flow of the lower Salmon River. The following sections discuss only those rivers where visitation data were readily available.

Number of Visits

Middle Estimates 1 and 2 developed by the DREW recreation analysis estimate that there would be 481,372 and 699,372 annual visitors to a near-natural lower Snake River, respectively. These estimates are compared with the estimated number of annual visitors to existing free-flowing rivers and the lower Snake River reservoirs in Figure 5.13-1. These types of visitation data represent a "head count" of visitors and do not indicate duration of use or length of stay. There is some variation in the existing visitation data presented for different rivers, as well as the accuracy of the existing use estimates provided by different river managers.



Notes:

1/ The Middle Estimate visitation data presented above is based on the number of unique visitor days presented in Appendix I, Economics {Table 3.2-3) multiplied by the appropriate number of trips, or visits, per visitor by geographic location.

2/ The DREW Recreation Workgroup's middle estimate figures presented here are just for non-angling or general recreation. The current use estimates presented for existing free-flowing rivers/unimpounded river stretches and the Lower Snake River reservoirs include both angling and non-angling or general recreation visitors.

Source: Bureau of Land Management (1985; 2000), Ennis (2000), Harris et al. (1989), Hells Canyon National Recreation Area (2000), Loomis (2000), McCoy (2000), and Watson (2000).

Figure 5.13-1. Comparison Between Middle Estimates 1 and 2 and Existing Visitation to Free-flowing Rivers and the Lower Snake River Reservoirs (Number of Visits)

Figure 5.13-1 illustrates that the future non-angling or general recreation demand estimates developed by the DREW Recreation Workgroup are higher than current visitation to existing free-flowing rivers/unimpounded river stretches. Middle Estimate 1 is more than twice as large as the estimated existing visitation to the lower Salmon River, which is the most heavily visited of the rivers selected for comparison (see Foster Wheeler Environmental and Harris, 2001). Middle Estimate 2 is about three times as large. This difference could be explained by the relative size of a near natural lower Snake River, which would be longer (140 miles) than the lower Salmon River (73 miles). It would also have an average mean daily discharge about five times as large as that of the lower Salmon River. Note, however, that Middle Estimates 1 and 2 are only for general or non-angling recreation and benefits associated with projected angling visitation to a near natural lower Snake River comprise over 60 percent of the NED point estimate. The estimate for the lower Salmon River and the other existing rivers/river stretches in Figure 5.13-1 include both angling and non-angling visitation.

Compared to estimated existing visitation to the lower Snake River reservoirs, Middle Estimates 1 and 2 project fewer visitors but predict that the average number of days per trip would be much larger for these visitors. Viewed in terms of recreation days, future visitation projected under Middle Estimates 1 and 2 would be two to three times higher than existing visitation to the lower Snake River reservoirs.

Origin of Visitors

Middle Estimates 1 and 2 predict that visitors from California would account for 30.1 percent and 43.4 percent of total visitation to a near natural lower Snake River, respectively. Middle Estimate 2 is used by the DREW Recreation Workgroup to develop the point estimate presented in the Final FR/EIS. A review of visitation data for existing free-flowing rivers/unimpounded river stretches suggests that it is unlikely that visitors from California would comprise this large a share of total visitation. Visitors from California, for example, comprised 5 percent of nonmotorized boating visitors to the lower Salmon River in 1999 (Garson et al., 2000) and 4 percent of boaters surveyed on the lower Deschutes River in 2000 (Brown, 2001). Visitors from California did, however, account for a larger proportion of nonmotorized boaters visiting the Middle Fork of the Salmon River in 1995 (20 percent of private boaters and 25 percent of commercial boaters) (Hunger, 1996). These proportions are still below those projected under Middle Estimates 1 and 2 and there would be limited similarity between the type of recreation experience offered by the Middle Fork of the Salmon River and a near natural lower Snake River (see Foster Wheeler and Harris, 2001).

The data presented above for other rivers are just for nonmotorized boating, which the DREW recreation analysis estimates would account for just 12 percent of total non-angling recreation days demanded under Middle Estimate 2 (see Appendix I, Economics [Table 3.2-8]). The limited available data also suggests that visitors from California would be unlikely to comprise 30.1 or 43.4 percent of total visitation for other types of recreation activities, such as picnicking/primitive camping or hiking and mountain biking (see Appendix I, Economics [Table 3.2-8]).

Survey data from the main Salmon River, the Middle Fork of the Salmon River, and the lower Salmon River do, however, support the idea that between 30.1 and 43.4 percent of visitation may come from outside the Pacific Northwest. Note, however, that the percentage of visitors from outside the Pacific Northwest varies by river and ranges from somewhere over 50 percent for private boaters on the Middle Fork of the Salmon River to just 9 percent for the lower Deschutes River. Further, these survey data are only for boating. The proportion of total visitation originating outside the region is likely to vary by activity and be lower for non-boating activities.

5.13.5 Economic Effects

The economic values associated with recreation can be separated into direct and indirect economic values and it is important that the reader distinguish between these two types of value. In this FR/EIS, direct and indirect values are addressed as NED and RED values, respectively. This section summarizes the NED recreation values, the recreation-related costs and/or benefits accrued to the nation as a whole as a result of the proposed alternatives. Direct or NED recreation values represent the benefits that the visitor receives from participating in a recreation activity and may be considered an economic measure of the utility that the visitor obtains from the recreation experience. NED recreation benefits are measured in terms of consumer surplus or net willingness-to-pay (WTP), which is the amount that a visitor is willing to pay above the actual costs of the visit. This is distinctly different from indirect or RED recreation values, which measure the effects of actual recreation-related expenditures on local economies. The RED impacts associated with changes in recreation spending are summarized in Section 5.13 of this document and discussed in more detail in Appendix I, Economics, Section 6.

The recreation and tourism analysis conducted by the DREW Recreation Workgroup employed the Travel Cost Method (TCM) to calculate net WTP for existing recreation activities and a hybrid TCM approach known as "contingent behavior" to estimate the value of river recreation under Alternative 4—Dam Breaching. Six recreation-use surveys were conducted as part of this study. Five of these surveys were designed to identify and value current recreation use through surveys of current users. Based on these surveys, existing reservoir use and annual benefits involved 500,172 trips worth $33,254,000 a year. Total existing recreation use identified through these surveys involved 1,147,659 trips worth $82,224,000 a year. Response rates could not be calculated for two of the surveys. Response rates for the other three surveys ranged from 59 to 72 percent.

The DREW Recreation Workgroup also surveyed a much larger sample of Washington, Idaho, Oregon, western Montana, and California residents to identify the type and number of recreation users who would visit the lower Snake River if the dams were breached (see Section 5.13-4 above). Recreation use following dam breaching would be phased in over time as the natural river system recovered from breaching. Use would also be constrained by the capacity of existing facilities such as developed campgrounds, dispersed campgrounds, and boat ramps. The DREW Recreation Workgroup did, however, assume that the number of campgrounds would double within the first decade following dam breaching.

Salmon and steelhead angling demand would be constrained by the projected availability of fish, and only a small fraction of projected angler demand would be met. Estimates of the economic value of angling were developed for three geographic areas—ocean, in-river mainstem, and in-river tributary. The division of in-river harvest into mainstem and tributary is based on the 1998 preliminary PATH results. PATH divided its estimates into mainstem, the area downstream of Lower Granite Dam to the Columbia River estuary, and tributary. (The tributary area encompasses the entire Snake River watershed above Lower Granite Dam, including the Lower Granite reservoir.) The DREW Recreation Workgroup evaluated the NED effects associated with tributary fishing for salmon and steelhead, as well as those associated with fishing for resident fish in the lower Snake River reservoirs. The DREW Anadromous Fish Workgroup evaluated the NED effects associated with ocean and mainstem recreational fishing.

The average annual effects estimated by the DREW Recreation Workgroup are presented for Alternatives 2 through 4 in Table 5.13-8. These values, presented in 1998 dollars and calculated using a 6.875 percent discount rate, represent the net change from Alternative 1—Existing Conditions. Two demand estimates (Middle Estimates 1 and 2) and two estimates of WTP per trip (high and low) are presented for Alternative 4—Dam Breaching. The low estimates presented for Alternative 4—Dam Breaching, are consistent with values in the literature for general recreation, while the high estimates are consistent with literature for river angling. The DREW Recreation Workgroup calculated a point estimate for the most likely value for Alternative 4—Dam Breaching by combining the low NED value for the general recreation Middle Estimate 2 ($59.5 million) with the high NED value for sportsfishing ($45.23 million) and subtracting the existing reservoir recreation value ($31.6 million). This composite results in a point estimate of average annual benefits of $73.13 million, prior to subraction of the costs for additional campsites and associated O&M. Subtracting the average annual campground costs ($2.605 million) results in a point estimate of $70,523 (see Table 5.13-8).

Total recreation effects are further summarized in Table 5.13-9, which also includes the values for ocean and mainstem recreational fishing calculated by the DREW Anadromous Workgroup. As a result, total average net annual NED benefits under Alternative 4—Dam Breaching, calculated using a 6.875 percent discount rate, are slightly higher than the point estimate discussed in the preceding paragraph, $71.26 million compared to $70.52 million. Average annual values are also presented in Table 5.13-9 for the other two discount rates used in this analysis (4.75 and 0.0 percent). The results of this analysis indicate that there would be significant recreation NED benefits associated with breaching the dams. There would also be benefits associated with small projected gains in salmon and steelhead fishing under Alternatives 2 and 3. Using a 6.875 discount rate, this results in a net reduction of $1.87 million in average annual benefits.

Table 5.13-8. Estimated Net Average Annual Recreation Benefits, 1998 Dollars ($1,000s of dollars) (6.875 percent discount rate)[1/]

	Alternative 2	Alternative 3	Alternative 4	
			Low NED	High NED
General Recreation				
Reservoir Recreation	0	0	(31,600)	(31,600)
River Recreation (Middle Estimate 1)			36,900	192,700
River Recreation (Middle Estimate 2)			59,500	310,500
Angling				
Resident & Steelhead	0.006	6	5,201	13,844
Steelhead-Tributaries	1,180	1,228	3,361	30,903
Salmon-Tributaries	29	24	122	481
Total Recreational Fishing	1,215	1,258	8,684	45,228
General Recreation and Angling				
Total Reservoir	1,215	1,258		
Total Middle Estimate 1[2/]			13,984	206,328
Total Middle Estimate2[3/]			36,584	324,128
New Campground Costs[4/]			**(2,605)**	
Total Point Estimate			**70,523**	

Notes:

1/ This table only summarizes the values calculated by the DREW Recreation Workgroup. It does not include the values for ocean and mainstem recreational fishing calculated by the DREW Anadromous Workgroup. The ocean and mainstem values are, however, included in the overall summary presented in Table 5.13-10.

2/ Middle Estimate 1 uses only those respondents that would definitely visit, but then expands this proportion to the total number of households in the survey strata area.

3/ Middle Estimate 2 uses those respondents that would definitely or probably visit, but only applies this to the proportion of households responding to the survey (assumes zero visitation for the proportion of households not returning the survey).

4/ The DREW Recreation Workgroup assumed that the existing number of developed campsites along the Lower Snake River would double within 10 years if dam breaching were to occur. The Corps estimates that average annual costs associated with these campgrounds would be $2,605 using a 6.875 percent discount rate.

Source: Appendix I, Economics (Section 3.2.8.1).

5.13.6 Cumulative Effects

Effects on recreational resources would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching some Snake River recreational facilities would likely be closed and no longer used. Water based recreation activities would change from flat-water to river-oriented and there would be an accompanying shift in usage.

Both recreational fishing and general recreation would be expected to increase within 10 years as the river is restored and if fish respond to near-natural river conditions.

Table 5.13-9. Estimated Total Net Average Annual Recreation Benefits, 1998 dollars ($1,000s of dollars)

	6.875 % Discount Rate	4.75 % Discount Rate	0.0 % Discount Rate
Alternative 2			
General Recreation	0	0	0
Angling			
Ocean	0	0	0
Mainstem	190	197	182
Tributary	1,215	1,185	805
Total	**1,405**	**1,382**	**987**
Alternative 3			
General Recreation	0	0	0
Angling			
Ocean	3	4	6
Mainstem	174	172	130
Tributary	1,259	1,195	673
Total	**1,437**	**1,371**	**809**
Alternative 4			
General Recreation	27,900	31,500	42,100
Campground O&M	(2,605)	(2,249)	(2,443)
Angling			
Ocean	107	134	207
Mainstem	625	824	1,496
Tributary	45,228	49,130	62,213
Total	**71,255**	**79,339**	**103,573**

Notes:
1/ Non-angling recreation and tributary recreational fishing estimates were calculated by the DREW Recreation Workgroup. Ocean and mainstem recreational fishing estimates were calculated by the DREW Anadromous Fish Workgroup. Campground Operation and Maintenance (O&M) costs were calculated by the Corps.
2/ NED benefits are average annual values calculated over a 100-year project life.
3/ NED benefits associated with resident fish in the lower Snake River are included in the tributary estimates developed by the DREW Recreation Workgroup.
Source: Appendix I, Economics (Tables 3.2-3, 3.2-11, 3.2-12, 3.5-13, 3.5-14, and 3.5-15).

5.13.7 Uncertainties in Potential Recreation and Tourism Effects

It has been estimated that dam breaching could result in the potential for a significant increase in recreation use of the unimpounded lower Snake River. Incremental annual economic benefits are estimated to range from about $14 million to about $324 million (Appendix I, Economics [Table 3.2-13]). The uncertainties associated with this analysis are summarized in Sections 3.2.9 and 8.0 of Appendix I, Economics. Major uncertainties that contribute to this broad range of estimated benefits include uncertainty in numbers of salmon and steelhead available for recreational fishing, uncertainty in the number and origin of visitors to a near-natural Lower Snake River, and uncertainty in estimated recreational use values. The estimate of recreational fishing developed by the DREW Recreation Workgroup is based on the preliminary PATH results. The risk and uncertainty associated with these results and their use in the economic evaluations conducted for this study are discussed in Appendix I, Economics, Section 8.3. Additional analyses have been conducted since the DREW process was completed. The results of these analyses suggest that there are few remaining survival improvements that can be achieved from modification of the hydrosystem (i.e., Alternatives 1, 2, and 3). The CRI results indicate that while Alternative 4—Dam Breaching has a slight benefit over the other alternatives, these benefits are inadequate by themselves to prevent extinction of all stocks. Substantial uncertainties remain about whether, and to what degree, any of the alternatives would result in increases in the likelihood of survival and recovery of the listed Snake River stocks. These uncertainties are discussed in Section 5.5.1.7. As a result, it is uncertain that any selected alternative alone could be expected to lead to large potential increases in recreational harvests in the forseeable future.

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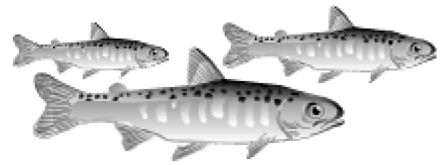


5.14 Social Resources

This section is divided into three parts that correspond with the three main areas of concern addressed in Section 4.14, Social Resources. Section 5.14.1 outlines the impacts to regional employment, income, and population projected under each alternative. This discussion is based on the regional analysis conducted for this study by the DREW Regional Workgroup. Section 5.14.2 addresses communities. This discussion is based on the social analysis conducted for this study by the DREW Social Analysis Workgroup (1999) and the two-phase community-based social impact assessment conducted by a team of social scientists from the University of Idaho (Harris et al., 1999a, 1999b). Section 5.14.3 addresses potential effects to low income and minority populations. A summary of the potential effects of the alternatives on social resources is presented in Table 5.14-1.

5.14.1 Regional Demographics and Employment

Preceding sections of this FR/EIS discuss the effects that the proposed alternatives would have on power, transportation, water supply, and other aspects of the regional and national economy. These sections address the physical aspects of these changes, as well as the costs that would be incurred by producers and, in the case of power, consumers. Increased or reduced spending associated with these changes would also

Table 5.14-1. Summary of the Potential Effects of the Alternatives on Social Resources

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Employment	No change from current and projected future conditions.	Minor job gains associated with implementation spending and avoided costs.	Minor job gains associated with implementation spending and avoided costs.	• Short-term employment gains in the lower Snake River study area would be temporary and vary from year to year, with a maximum projected increase in any one year of approximately 14,871 jobs. • There would be a net long-term loss of 1,372 jobs in the lower Snake River study area. • In the short-term, the Pacific Northwest (including the lower Snake River study area) would experience temporary employment gains that would vary from year to year, with a maximum projected increase in any one year of approximately 14,932 jobs. With job losses included, this total drops to 11,384. • In the long term, the Pacific Northwest (including the lower Snake River study area) would experience a net loss of 2,290 jobs.
Income	No change from current and projected future conditions.	Minor income gains associated with implementation spending and avoided costs.	Minor income gains associated with implementation spending and avoided costs.	• Short-term increases in personal income in the lower Snake River study area would be temporary and vary from year to year, with a maximum projected temporary increase in any one year of approximately $484.8 million. • There would be a net long-term loss of $63.41 million in personal income in the lower Snake River study area. • In the short-term, the Pacific Northwest (including the lower Snake River study area) would experience temporary short-term increases in personal income that would vary from year to year, with a maximum projected increase in any one year of approximately $486.6 million. • In the long term, the Pacific Northwest (including the lower Snake River study area) would experience a net decrease of $252.92 million in personal income.
Population	The lower Snake River study area population is projected to increase by 146,000 or 23.7 percent from 2000 to 2020.	Minor fluctuations in population associated with the employment changes noted above. (Baseline increases under Alternative 1 would occur.)	Minor fluctuations in population associated with the employment changes noted above. (Baseline increases under Alternative 1 would occur.)	• Employment changes could result in a short-term increase in population but a long-term loss. These changes would be larger than under the other alternatives but minor compared to population changes predicted for the region. (Baseline increases under Alternative 1 would occur.)

Table 5.14-1. Summary of the Potential Effects of the Alternatives on Social Resources

Page 2 of 2

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Communities	No change from current and projected future conditions.	• Minor effects but some communities located upriver may be adversely affected by lower probabilities of salmon recovery. • Uncertainty surrounding the future of the dams may negatively affect some communities. • Coastal communities could receive minor economic benefits from increased fish runs.	• Minor effects but some communities located upriver may be adversely affected by lower probabilities of salmon recovery. • Uncertainty surrounding the future of the dams may negatively affect some communities. • Coastal communities could receive minor economic benefits from increased fish runs.	• Upriver communities would likely gain jobs from recreation and tourism associated with a near-natural river and to a lesser extent increased fish runs. Job losses may occur in the forest products sector as a result of the loss of river navigation. • Communities in the reservoir subregion would likely experience a net decrease in employment due to reductions in Corps' employment and increased pressure on family farms. • Downriver communities would lose jobs if farms presently irrigated from Ice Harbor go out of business. These losses would be partially offset by gains in transportation- and power generation-related employment. • Adverse community effects perceived by residents of communities in the lower Snake River region include decreases in population, tax revenues, businesses, property values, agricultural base, declining schools, as well as increased traffic congestion and business failure. • Other lower Snake River region communities with more tourist-oriented economies perceived benefits. • Coastal communities would receive economic benefits from increased fish runs. • Residents of southern Idaho communities perceived impacts ranging from somewhat beneficial to very adverse. Beneficial effects were associated with increased fish runs. Negative effects included increased transportation and utility costs.
Low Income and/or Minority Populations	No change.	No change.	No change.	• Increased salmon would benefit the tribes as would the exposure of approximately 14,000 acres of presently inundated lands. • Hispanic workers employed on farms irrigated from Ice Harbor Reservoir would lose their jobs if these farms go out of business.

affect the regional economy. Inflows or outflows to or from the local economy cause business activity to change by a multiple of the original change. An influx of funds, for example, is spent and re-spent in the local economy as expanding sectors hire labor and buy business inputs and services from local suppliers. This process is known as the multiplier effect. The more locally-produced goods and services purchased, the larger the multiplier effect. A reduction in spending also has indirect and induced effects. Closure of a business in a particular community, for example, has impacts on other firms located in that community. Loss of a business results in less local spending of workers' wages and salaries, and less local spending for business inputs and services, therefore, making the total impact to the economy larger than the initial change.

The regional economic analysis developed for this study addresses the regional economic impacts of changes in spending projected by various DREW workgroups. These impacts, evaluated in terms of jobs and income, were estimated using input-output models, which model the interactions among different sectors of the economy. These models estimate the effects of changes in one sector on the rest of the regional economy. Eight input-output models were constructed to address potential regional effects associated with the alternatives. Models were developed for Washington, Oregon, Idaho, and Montana, the upriver, downriver, and reservoir subregions, and the lower Snake River study area, which consists of the three subregions (see Table 4.14-1 and Figure 4.14-1). The subregion models were developed to examine cases, such as a reduction in irrigated agriculture on the Ice Harbor reservoir, where impacts are relatively localized. Evaluating localized changes using a statewide model would tend to overestimate the impact. States are less dependent on imports than smaller regions and, therefore, tend to have larger multiplier effects. The state models are used to evaluate impacts, such as increases in electric rates, that occur at a larger scale. State input-output models were also used by the DREW Anadromous Fish Workgroup to assess the regional impacts of changes in anadromous fish harvest.

The impacts to regional employment and income summarized in the following sections are presented as net changes from existing conditions. The DREW Regional Workgroup projected changes to employment and income over a 100-year study period. Job totals include both full- and part-time employment. One limitation of this type of regional impact analysis is that it presents a picture of the economy at a single point in time. This picture is based on historical ratios between different sectors of the economy rather than a dynamic structure of changing relationships. It has been suggested that this type of analysis tends to overstate actual impacts because it assumes that all possible adjustments to disturbance are instantaneous and permanent, and that individual responses to disturbances are limited. Individuals who lose their job, for example, are assumed to stay unemployed. In reality, people and businesses adjust over time, as they consider and try alternative occupations, technologies, and locations (IEAB, 1999).

The economy of the lower Snake River study area and the Pacific Northwest as a whole has changed since 1969. Employment increased in all sectors between 1969 and 1998. There were, however, changes in the relative importance of various sectors. Employment in the farm, manufacturing, and government sectors decreased as a share of total employment over this period, while the services and retail sectors saw the largest absolute and relative increases. Non-labor sources of income (income received from dividends, interest, and rent, and transfer payments) have increased as a share of total regional income (see Section 4.14.1, Regional Demographics and Employment).

Employment is projected to increase significantly over the next 20 or so years in the states of Washington, Idaho, and Oregon. Projected increases range from 33.6 percent in Washington to 67.3 percent in Idaho, with a projected increase for all three states of 1,199,655 jobs. The Washington Office of Financial Management (1999), for example, projects that Washington State's economy will become increasingly diversified with the majority of projected employment growth occurring in retail and service industries. These projected increases and the evolving structure of the Pacific Northwest economy form a backdrop against which changes in employment projected for the proposed alternatives should be considered.

Although resource-based industries, such as logging and farming, will likely decline as a share of total employment, they will remain important parts of the region's economic base, especially in small communities where they may be the dominant source of employment (see Figure 4.14-4). While projected job changes may represent a small percentage of existing and projected employment, the loss of these jobs would be very significant for the individuals concerned and the communities where job losses may be concentrated. Potential impacts to communities are discussed in Section 5.14.2, Communities.

The regional analysis is discussed in detail in the DREW Regional Analysis report (DREW Regional Analysis Workgroup, 1999) and Appendix I, Economics, Section 6.

5.14.1.1 Employment

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is the baseline for this analysis. Employment associated with this alternative is summarized in Section 4.14.1, Regional Demographics and Employment. Total full- and part-time employment in the 25-county lower Snake River study area was 332,557 in 1998. Combined employment for the states of Washington, Idaho, and Oregon was 6,187,107.

Alternative 2—Maximum Transport of Juvenile Salmon

Employment change under this alternative would be relatively minor and limited to jobs associated with implementation and avoided costs. Short-term employment associated with implementing this alternative from 2001 to 2004 is projected to range from a loss of 110 jobs to a gain of 69 jobs compared to Alternative 1—Existing Conditions. Reductions in long-term implementation expenditures are expected to result in a net loss of 81 jobs from 2001 to 2026. Changes in the Corps' operating expenditures (avoided costs) would result in a net annual loss of 83 jobs from 2001 to 2026 than Alternative 1—Existing Conditions.

Alternative 3—Major System Improvements

Employment change under this alternative would also be relatively minor and limited to jobs associated with implementation and avoided costs. Short-term employment associated with implementing this alternative from 2001 to 2006 is projected to range from a net gain of 15 jobs to a gain of 813 jobs compared to Alternative 1—Existing Conditions. Increases in long-term implementation expenditures are expected to result in net annual gains of 230 jobs from 2001 to 2026 and 32 jobs from 2027 to 2100. Changes in the Corps' operating expenditures (avoided costs) would result in net annual gains of 44 jobs from 2001 to 2026 and 25 jobs from 2027 to 2100.

Alternative 4—Dam Breaching

Impacts at the Subregion Level

Employment effects associated with this alternative can be divided into short- and long-term effects. Short-term effects, mainly associated with construction activities, would be temporary. Table 5.14-2 presents point estimates of the maximum number of annual temporary jobs that would be generated in the lower Snake River study area by resource area. Major construction projects would include replacement power facilities (5,572 jobs) and transportation-related construction (9,826 jobs). The total change presented in Table 5.14-2 is the sum of the maximum annual temporary increase in employment for each resource area. These increases would not, however, occur in the same year. The maximum temporary employment increase in any 1 year would be 14,871 jobs (Figure 5.14-1). These impacts caused by changes in spending include indirect and induced jobs. Therefore, jobs gained and lost are distributed throughout the regional economy and not only concentrated in the sector where the initial change in spending occurs. These effects are discussed in detail in Appendix I, Economics (Section 6).

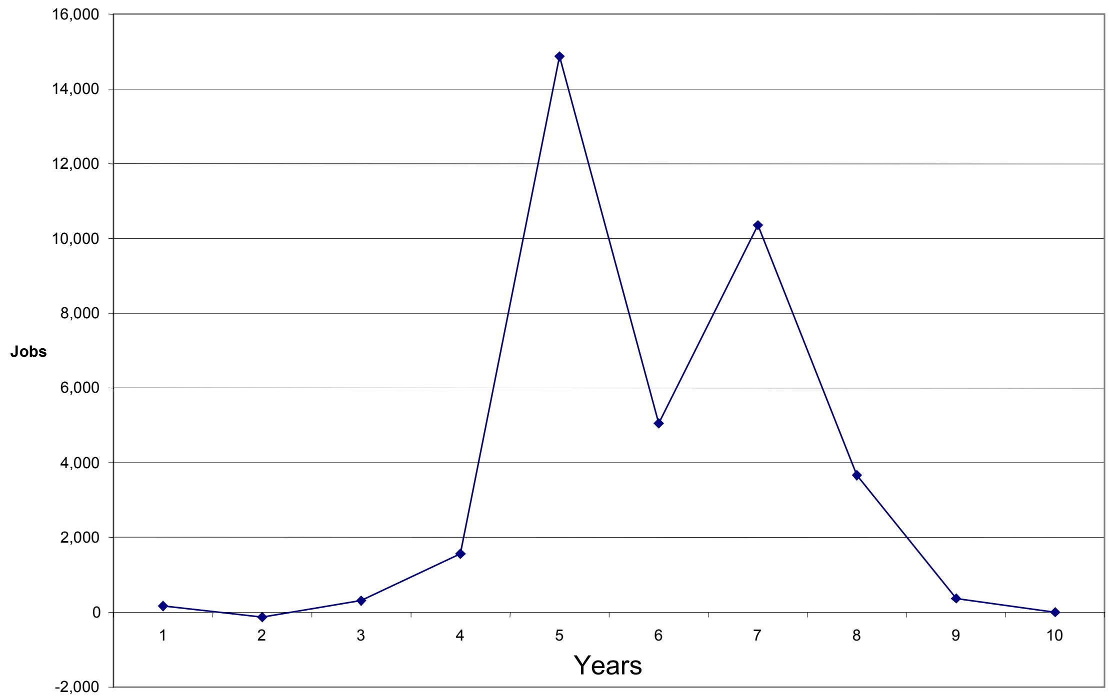
Average point estimates are presented for long-term annual changes in employment in Table 5.14-3. These point estimates suggest that in the long term, employment in the lower Snake River study area would experience a net decrease of 1,372 jobs, which represents less than 1 percent of jobs in the 25-county lower Snake River study area. The area would gain 1,842 jobs with an average income of $24,033 ($44.3 million in personal income/1,842 jobs) (Tables 5.13-3 and 5.14-6). These jobs would mainly result from expenditures associated with replacement power facility operation, recreation, and implementation activities. The lower Snake River study area would, however, lose 3,214 jobs with an average personal income of $32,523 ($104.5 million in personal income/3,214 jobs). The lost jobs would be mainly associated with farmland irrigated from the Ice Harbor reservoir, Corps' operations, and changes in grain transportation. The average annual income in the lower Snake River study area in 1995 was $32,088.

The regional economic analysis prepared for this study developed estimates of employment change for each year of the 100-year study period. High, medium, and low estimates were developed for each year. Point estimates of short- and long-term employment changes, presented in Tables 5.14-2 and 5.14-3, are primarily based on mid-point numbers or "most likely" estimates provided by the DREW workgroups. Averages are shown when effects vary by year over a number of years. Figure 5.14-2 combines short- and long-term employment effects and shows projected net annual employment change for the lower Snake River study area from 2001 to 2051. This figure shows a short-term increase in construction-related employment followed by a long-term net decrease in employment.

Table 5.14-2. Short-term Subregion Employment Effects under Alternative 4—Dam Breaching (Jobs)[1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]
Electric Power				
Power Plant Construction[3/]	0	0	5,572	**5,572**
Transmission Line Construction	0	0	2,080	**2,080**
Recreation				
Campground Construction	0	174	0	**174**
Transportation				
Rail Construction[4/]				**872**
Road Construction[4/]				**1,972**
Transportation Facilities Construction[4/]				**6,982**
Water Supply				
Well Modification	0	916	259	**1,175**
Pump Modification	844	0	0	**844**
Implementation				
Implementation	230	460	460	**1,150**
Total Change[5/6/]	**1,074**	**1,550**	**8,371**	**20,821**
Total Existing Annual Employment (1995)	75,081	68,334	175,325	**318,740**
Change as % of Existing Employment	1.43	2.27	4.77	**6.53**

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.
2/ The lower Snake River study area is comprised of the upriver, reservoir, and downriver subregions.
3/ The DREW HIT assumed that a total of six replacement power plants would be built. The exact locations of these plants are unknown but DREW HIT assumed that three would be located in the downriver subregion, with the other three most likely located in the Puget Sound region. Construction of each power plant is estimated to generate 2,786 short-term jobs. The estimates shown in this table are the maximum number of these jobs that would be generated in any one year—5,572 in the downriver subregion, where two plants would be constructed simultaneously.
4/ These effects would occur in the lower Snake River study area but it is not known how they would be distributed among the subregions.
5/ The upriver, reservoir, and downriver subtotals do not sum to the total lower Snake River study area figure because some of the projected study area impacts were not distributed by subregion.
6/ These totals are the sum of the maximum annual short-term job gains for each resource area. With the exception of the implementation cost category, the jobs identified in this table would only last one or two years. The construction activities generating this projected employment would all have to take place in the same year for an annual gain of 20,821 jobs. This is not the case (see Figure 5.14-1). The maximum temporary employment increase in any one year would be 14,871 jobs.
Source: Appendix I, Economics (Table 6-34).



Source: Appendix I, Economics (Figure 6-1).

Figure 5.14-1. Net Annual Short-term Employment Change in the Lower Snake River Study Area (2001 to 2010) under Alternative 4—Dam Breaching

The employment estimates developed throughout the RED analysis include both full-time and part-time employment. The average conversion factor from full-time and part-time employment totals to full-time equivalents (FTE) is 0.88. This ratio is for the entire United States and not specific to any given state or region. Projected job losses and gains in the lower Snake River study area should be multiplied by 0.88 to obtain an indication of the number of full-time jobs these totals represent.

Impacts at the State Level (Excluding Effects Modeled for the Subregions)

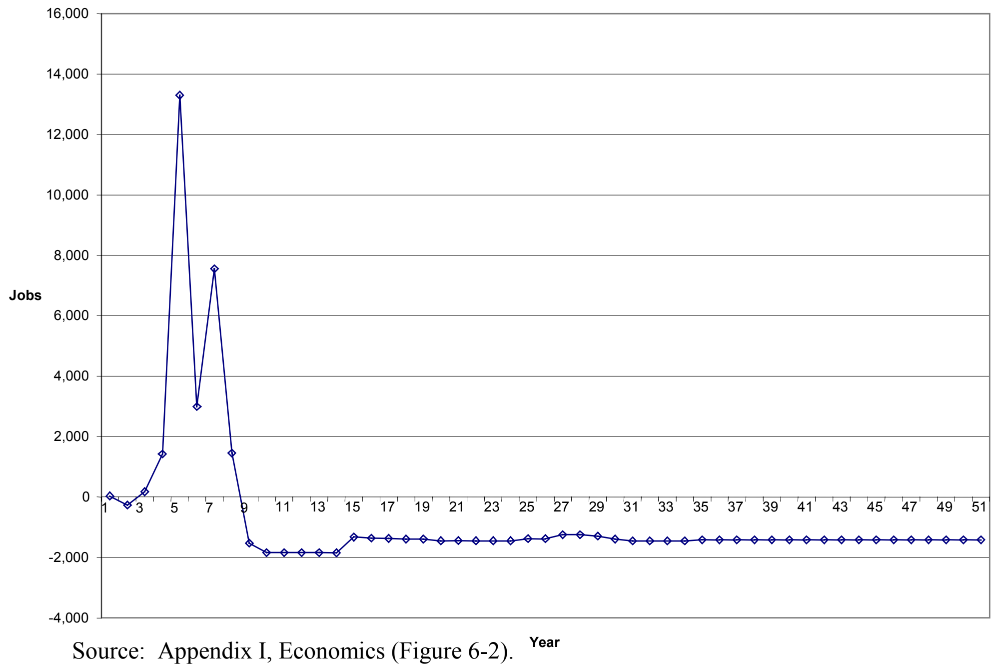
Several impact categories occur either throughout the Pacific Northwest or in an area of a state outside the lower Snake River study area. In addition, impacts associated with changes in commercial and ocean recreational fishing occur in the Pacific Northwest states, Alaska, and British Columbia, Canada. Construction activities resulting directly and indirectly from dam breaching would generate 2,849 temporary jobs in Pacific Northwest areas outside the subregions. This total represents the maximum change that could occur in one year. The majority of these jobs would result from the construction of replacement power facilities in the Puget Sound region of Washington (Table 5.14-4). In the long term, Pacific Northwest areas outside the

Table 5.14-3. Long-term Subregion Employment Impacts under Alternative 4—Dam Breaching (Jobs)[1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]
Increases in Long-term Employment				
Electric Power				
O&M Spending on Replacement Power Plants and New Transmission Lines	0	0	884	**884**
Recreation				
Increased Spending[3/]	0	503	0	**503**
Increased Angler Spending	239	162	0	**401**
O&M Spending on New Campgrounds	0	26	0	**26**
Implementation				
Implementation	6	11	11	**28**
Total Increase	**245**	**702**	**895**	**1,842**
Decreases in Long-term Employment				
Water Supply				
Reduction in Irrigated Lands	0	(1,105)	(474)	**(1579)**
Avoided Costs				
Avoided Costs (Reductions in Corps' Spending)	(283)	(566)	(566)	**(1,415)**
Transportation				
Loss of Barge Transportation (Grain)[4/]	(221)	(407)	491	**(137)**
Reduced Cruise Ship Operations	(83)	0	0	**(83)**
Total Decrease	**(587)**	**(2,078)**	**(549)**	**(3,214)**
Net Long-term Employment Change	**(342)**	**(1,376)**	**346**	**(1,372)**
1995 Employment	75,081	68,334	175,325	**318,740**
Net Change as a % of 1995 Employment	(0.46)	(2.01)	0.20	**(0.43)**

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.
2/ The lower Snake River study area is comprised of the upriver, reservoir, and downriver subregions.
3/ Estimates of the negative effects of electric rate increases are not available for the subregions and are excluded from this table. Rate increase effects are shown by state in Table 5.14-4.
4/ These figures are summarize the effects associated with a loss of grain farm income due to increased transport cost, loss of grain-transportation-related barge revenue, increased grain transportation-related railroad revenue, and changes in truck transportation.
Source: Appendix I, Economics (Table 6-35).

subregions would experience a net loss of 918 jobs. Approximately 2,382 jobs would be lost as a result of the projected increases in electricity bills. These losses would, however, be partially offset by 1,464 new jobs, which would result from operations and maintenance (O&M) spending on new power facilities, increased transportation spending by grain farms, and commercial and ocean recreational fishing (Table 5.14-4).



Source: Appendix I, Economics (Figure 6-2).

Figure 5.14-2. Net Annual Employment Change in the Lower Snake River Study Area (2001-2051) under Alternative 4—Dam Breaching

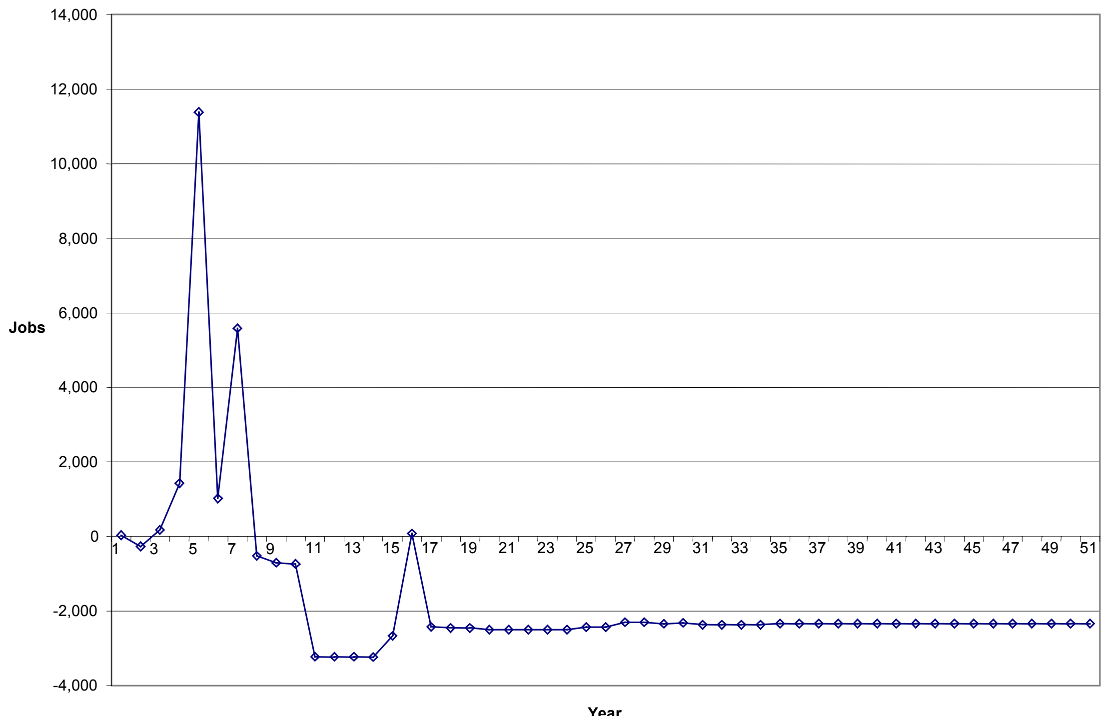
Table 5.14-4. Annual State-level Employment Impacts for Alternative 4—Dam Breaching Excluding those Impacts Modeled for the Subregions (Jobs)[1/2/]

	Washington	Oregon	Idaho	Montana	Total
Short-Term Impacts[3/]					
Power Plant Construction	2,786	0	0	0	2,786
Tidewater Rail Car Storage Construction	0	63	0	0	63
Total	**2,786**	**63**	**0**	**0**	**2,849**
Long-Term Impacts[4/]					
Increased Electricity Bills[5/]	(1,136)	(810)	(366)	(70)	(2,382)
O&M Spending on new Power Plants	876	0	0	0	876
Loss of Barge Transportation (Grain)	224	210	(24)	0	410
Commercial Fishing[6/]					171
Ocean Recreational Fishing[6/]					7
Total	**(36)**	**(600)**	**(390)**	**(70)**	**(918)**

1/ These impacts are not the state totals. Rather they are effects that occur throughout a state (increased electricity bills) or in areas of a state outside the subregions (the remaining categories).
2/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.
3/ Short-term impacts would be temporary. Power plant construction would occur over three one-year periods. Tidewater rail car storage construction would last for just one year.
4/ Long-term impacts would be permanent.
5/ These estimates exclude the impacts that would be associated with plant closures or business failures caused by increased electric bills.
6/ These projected increases would occur in Washington, Oregon, Idaho, Alaska, and British Columbia.
Source: Appendix I, Economics (Table 6-39).

Total Regional Impacts

Total short- and long-term regional impacts are the sum of the above subregion and state-level (excluding subregion) totals. In the short term, the Pacific Northwest as a whole would experience a maximum annual net increase of 23,670 short-term jobs. The construction activities generating this employment would all have to take place in the same year for an annual gain of 23,670 jobs. This is not the case and the maximum temporary employment increase in any one year would be approximately 14,932 jobs. With job losses included, this total drops to 11,384 (see Figure 5.14-3). In the long term, the Pacific Northwest as a whole would experience a net loss of 2,290 jobs. These effects would be permanent. Net annual regional employment change is presented for the years 2001 through 2051 in Figure 5.14-3.



Source: Appendix I, Economics (Figure 6-4).

Figure 5.14-3. Net Annual Total Regional Employment Change (2001 to 2051)

5.14.1.2 Income

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is the baseline for this analysis. Total personal income in the 25-county lower Snake River study area was $12,676.9 million in 1998. Subregion totals ranged from $2,629.5 million in the upriver subregion to $7,316.8 million in the downriver subregion.

Alternative 2—Maximum Transport of Juvenile Salmon

Changes in personal income under this alternative would be associated with implementation and avoided costs. The projections discussed below are net of

Alternative 1—Existing Conditions. Short-term changes in income associated with implementing this alternative from 2001 to 2004 are projected to range from a net loss of $3.02 million to a net loss of $0.78 million. Reductions in long-term implementation expenditures are expected to result in a net loss of $5.15 million in annual personal income from 2001 to 2026. Changes in the Corps' operating expenditures (avoided costs) would result in a net loss of $2.36 million from 2001 to 2026.

Alternative 3—Major System Improvements

Changes in personal income under this alternative would also be associated with implementation and avoided costs. The projections discussed below are net of Alternative 1—Existing Conditions. Changes in income associated with implementing this alternative from 2001 to 2010 are projected to range from a net annual loss of $1.33 million to a net annual gain of $22.29 million. Increases in long-term implementation expenditures are expected to result in net gains of $14.70 million in annual personal income from 2001 to 2026 and $2.07 million from 2027 to 2100. Changes in the Corps' operating expenditures (avoided costs) would result in a gain of $1.26 million in personal income over Alternative 1—Existing Conditions, from 2001 to 2026 and $0.73 million from 2027 to 2100.

Alternative 4—Dam Breaching

Impacts at the Subregion Level

Changes in personal income mirror the changes in jobs discussed in the preceding section. Short-term effects, mainly associated with construction activities, would be temporary and, with the exception of implementation-related effects, last one or two years. Long-term effects would be permanent. Changes in personal income would be distributed throughout the regional economy and not just concentrated in the sector where the initial change in spending occurs.

Construction activities resulting directly and indirectly from breaching the four lower Snake River dams would result in a temporary increase in personal income in the lower Snake River study area. Table 5.14-5 presents point estimates of the maximum temporary increase in personal income that would be generated by resource area. Major construction projects would include replacement power facilities and transportation-related construction. The total change presented in Table 5.14-5 is the sum of the maximum annual temporary increase in business transactions for each resource area. The construction activities generating these projected increases would all have to take place in the same year for a maximum annual temporary increase of $678.81 million in personal income. This is not the case and the maximum temporary increase in personal income projected for any one year would be about $484.8 million.

Average point estimates are presented for long-term annual changes in personal income by subregion in Table 5.14-6. These point estimates suggest that in the long run, total personal income in the lower Snake River study area would experience a net decrease of $63.41 million, which represents less than 1 percent of personal income in the lower Snake River study area (Table 5.14-6). Expenditures associated with

Table 5.14-5. Short-term Subregion Personal Income Impacts under Alternative 4—Dam Breaching (1998 dollars) ($ million per year) [1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]
Electric Power				
Power Plant Construction[3/]	0	0	209.6	**209.6**
Transmission Line Construction	0	0	78.3	**78.3**
Recreation				
Campground Construction	0	6.18	0	**6.18**
Transportation				
Rail Construction[4/]				**27.9**
Road Construction[4/]				**63.1**
Transportation Facilities Construction[4/]				**202**
Water Supply				
Well Modification	0	29.5	8.3	**37.8**
Pump Modification	22.4	0	0	**22.4**
Implementation				
Implementation	6.31	12.61	12.61	**31.53**
Total Change[5/ 6/]	**28.71**	**48.29**	**308.81**	**678.81**
1998 Total Personal Income	2,630	2,731	7,317	**12,677**
Net Change as a % of 1998 Income	1.09	1.77	4.22	**5.35**

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.
2/ The lower Snake River study area is comprised of the upriver, reservoir, and downriver subregions.
3/ The DREW HIT assumed that a total of six replacement power plants would be built. The exact locations of these plants are unknown but the DREW HIT assumed that three would be located in the downriver subregion, with the other three most likely located in the Puget Sound region. Construction of each power plant is estimated to generate $104.8 million in personal income. The estimate shown in this table is for the maximum amount that would be generated in any one year—$209.6 million in the downriver subregion, where two plants would be constructed simultaneously.
4/ These impacts would occur in the lower Snake River study area but it is not known how they would be distributed among the subregions.
5/ The upriver, reservoir, and downriver subtotals do not sum to the total lower Snake River study area figure because some of the projected study area impacts were not distributed by subregion.
6/ These totals are the sum of the maximum annual gains in personal income for each resource area. With the exception of the implementation cost category, the increases in personal income identified in this table would only last one or two years. The construction activities generating these projected gains would all have to take place in the same year for an annual gain of $678.81 million. This is not the case. The maximum short-term annual increase in personal income is projected to be about $484.8 million.
Source: Appendix I, Economics (Table 6-36).

replacement power facility operation, recreation, and implementation activities would increase total annual personal income by $44.27 million. The lower Snake River study area would, however, also see an annual decrease in personal income of $107.68 million. This decrease would be mainly associated with a reduction in irrigated lands, avoided costs, and changes in grain transportation.

Table 5.14-6. Long-term Subregion Personal Income Impacts under Alternative 4—Dam Breaching (1998 dollars) ($ million)[1/]

	Upriver	Reservoir	Downriver	Total Lower Snake River Study Area[2/]
Increases in Long-term Personal Income				
Electric Power				
O&M Spending on Replacement Power Plants and New Transmission Lines[3/]	0	0	23.60	**23.60**
Recreation				
Increased Non-angler Spending	0	10.72	0	**10.72**
Increased Angler Spending	4.48	3.93	0	**8.41**
O&M Spending on New Campgrounds	0	0.77	0	**0.77**
Implementation				
Implementation	0.15	0.31	0.31	**0.77**
Total Increase	**4.63**	**15.73**	**23.91**	**44.27**
Decreases in Long-Term Personal Income				
Water Supply				
Reduction in Irrigated Lands	0	(43.30)	(18.55)	**(61.85)**
Avoided Costs				
Avoided Costs (Reductions in Corps' Spending)	(8.09)	(16.18)	(16.18)	**(40.45)**
Transportation				
Loss of Barge Transportation (Grain)	(4.99)	(9.66)	11.57	**(3.08)**
Reduced Cruise Ship Operations	(2.30)	0	0	**(2.30)**
Total Decrease	**(15.38)**	**(69.14)**	**(23.16)**	**(107.68)**
Net Long-Term Change in Personal Income	**(10.75)**	**(53.41)**	**0.75**	**(63.41)**
1998 Total Personal Income	2,630	2,731	7,317	**12,677**
Net Change as a % of 1998 Income	(0.41)	(1.96)	0.01	**(0.50)**

1/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.
2/ The lower Snake River study area is comprised of the upriver, reservoir, and downriver subregions.
3/ Estimates of the negative effects of electric rate increases are not available for the subregions and are excluded from this table. Rate increase effects are shown by state in Table 5-14-7.
Source: Appendix I, Economics (Table 6.37).

Impacts at the State Level (Excluding Effects Modeled for the Subregions)

Several impact categories occur either throughout the Pacific Northwest or in an area of a state outside the lower Snake River study area. In addition, impacts associated with changes in commercial and ocean recreational fishing occur in the Pacific Northwest states, Alaska, and British Columbia, Canada. Construction activities resulting directly and indirectly from dam breaching would generate $106.64 million in personal income in Pacific Northwest areas outside the subregions. This total represents the maximum change that could occur in one year. The majority of these jobs would result from the construction of replacement power facilities in the Puget Sound region of Washington (Table 5.14-7). In the long term, Pacific Northwest areas outside the subregions would experience a net loss of $189.51 million in personal income. Approximately $232.07 million in personal income would be lost as a result of projected increases in electricity bills. This loss would, however, be partially offset by a gain of $42.56 million in personal income, which would result from O&M spending on new power facilities, increased transportation spending by grain farms, and commercial and ocean recreational fishing (Table 5.14-7).

Table 5.14-7. Annual State-level Personal Income Impacts for Alternative 4—Dam Breaching Excluding those Impacts Modeled for the Subregions (1998 dollars) ($ million)[1/2/]

	Washington	Oregon	Idaho	Montana	Total
Short-term Impacts[3/]					
Power Plant Construction	104.80	0	0	0	**104.80**
Tidewater Rail Car Storage Construction	0	1.84	0	0	**1.84**
Total	104.80	1.84	0	0	**106.64**
Long-term Impacts[4/]					
Increased Electricity Bills[5/]	(119.82)	(73.22)	(32.83)	(6.20)	**(232.07)**
O&M Spending on new Power Plants	23.58	0	0	0	**23.58**
Loss of Barge Transportation (Grain)	5.61	7.34	(0.45)	(0.02)	**12.48**
Commercial Fishing[6/]					**6.25**
Ocean Recreational Fishing[6/]					**0.25**
Total	**(90.63)**	**(65.88)**	**(33.28)**	**(6.22)**	**(189.51)**

1/ These impacts are not the state totals. Rather they are effects that occur throughout a state (increased electricity bills) or in areas of a state outside the subregions (the remaining categories).
2/ Midpoints are shown when only lower and upper bounds were available from other DREW workgroups. Averages are shown when the effects vary by year over a number of years.
3/ Short-term impacts would be temporary. Power plant construction would occur over three one-year periods. Tidewater rail car storage construction would last for just one year.
4/ Long-term impacts would be permanent.
5/ These estimates exclude the effects that would be associated with plant closures or business failures caused by increased electric bills.
6/ These projected increases would occur in Washington, Oregon, Idaho, Alaska, and British Columbia.
Source: Appendix I, Economics (Table 6-40).

Total Regional Impacts

Total short- and long-term regional impacts are the sum of the above subregion and state-level (excluding subregion) totals. In the short term, the Pacific Northwest as a whole would experience a maximum annual net increase of $785.4 million in personal income. The construction activities generating this income would all have to take place in the same year for an annual gain of $785.4 million. This is not the case and the maximum projected increase for any one year would be about $486.6 million. In the long term, the Pacific Northwest as a whole would experience a net decrease of $252.9 million in personal income. These effects would be permanent.

5.14.1.3 Population

It is difficult to predict with any degree of certainty the effect that individual actions, such as the alternatives proposed under this FR/EIS, would have on regional population. For this analysis, changes in regional employment associated with each alternative are used to identify potential trends in population. These trends are compared with the existing population projections identified in Table 5-14-8.

Population is projected to grow in all three subregions. Population in the downriver subregion, for example, is expected to increase by 85,000 or 24.3 percent between 2000 and 2020. Large increases are also projected for each state over this period. The population of Idaho, for example, is expected to increase by 414,000 people or 32 percent (Table 5.14-8).

Table 5.14-8. Population Projections 2000 to 2020 (in thousands)

				2000-2020	
	2000	**2010**	**2020**	**Absolute Change**	**Percent Change**
Downriver	350	392	435	85	24.3
Reservoir	139	156	171	32	23.0
Upriver	128	142	157	29	22.7
Total LSR Study Area	**617**	**690**	**763**	**146**	**23.7**
Oregon	3,421	3,857	4,326	905	26.5
Washington	5,894	6,693	7,610	1,716	29.1
Idaho	1,294	1,493	1,708	414	32.0
Total State	**10,609**	**12,043**	**13,644**	**3,035**	**28.6**

Note: LSR = Lower Snake River

Source: Projections for 2010 and 2020 are from the State of Washington, Office of Financial Management (1999); State of Oregon, Office of Economic Analysis (1997); Idaho Power (1999); data for 2000 are from Table 4.14-7.

The following sections discuss potential population changes associated with each alternative.

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is the base case condition for this analysis. Representative population projections are presented in Table 5.14-8.

Alternative 2—Maximum Transport of Juvenile Salmon

The average household size for the states of Washington, Oregon, and Idaho was 2.59 persons in 1990. The relatively minor fluctuations in employment associated with this alternative could affect the regional population. These effects would, however, be minor compared to the population projections presented in Table 5.14-8.

Alternative 3—Major System Improvements

The relatively minor fluctuations in employment associated with this alternative could also affect the regional population. These effects, like those associated with Alternative 2—Maximum Transport of Juvenile Salmon, would be minor compared to the population projections presented in Table 5.14-8.

Alternative 4—Dam Breaching

Net employment changes associated with dam breaching are presented in Tables 5.14-2, 5.14-3, and 5.14-4. Under this alternative, the maximum annual gain in short-term employment in the lower Snake River study area would be 14,871 jobs (Figure 5.14-1). If all of these workers were hired from outside the region and decided to relocate with their families, this would represent a population increase of 38,516 or about 6 percent of the 25-county study area population in 2000. Given the size of the available labor force in the region and the temporary nature of much of this employment, it is unlikely that potential population increases would approach this level.

Long-term employment in the lower Snake River study area would decrease. It is possible that people who would have filled these positions in the lower Snake River study area either relocate or do not move to the region in the first place. If this were the case with all 1,372 jobs, there would be a reduction in population of 3,554 people or about 0.6 percent of the area's 2000 population. Net job loss throughout the Pacific Northwest would be 2,290. It is unlikely that these projected reductions would cause significant fluctuations in the population of the Pacific Northwest. The combined population of Washington, Oregon, and Idaho—10.6 million in 2000—is projected to grow by about 3 million between 2000 and 2020 (Table 5.14-8).

5.14.2 Communities

This section discusses the potential effects of the proposed alternatives on communities located in areas that could be potentially affected by the proposed alternatives. The following sections focus on communities located in three potentially affected geographic areas: the 25-county lower Snake River study area, the Washington and Oregon coastal region, and southern Idaho. Section 5.14.2.1 focuses on the lower Snake River study area and draws upon the DREW social analysis (DREW Social Analysis Workgroup, 1999) and the Phase I community-based SIA prepared for this FR/EIS (Harris et al., 1999a). These two studies assessed the effects of the proposed alternatives on 9 and 18 focus communities, respectively. Section 5.14.2.2 addresses communities in the coastal region that could be affected by changes in anadromous fish runs. This discussion focuses on two focus communities and is drawn from an economic impact analysis prepared for NMFS (The Research Group, 2000). Section 5.14.2.3 briefly considers communities in southern Idaho that could be potentially affected by changes in grain transportation and, in some cases, anadromous fish runs. Summary information is provided for nine focus communities that were addressed in the Phase II community-based SIA prepared for this FR/EIS (Harris et al., 1999b).

5.14.2.1 Lower Snake River Study Area

The DREW social analysis (DREW Social Analysis Workgroup, 1999) and the Phase I community-based social impact assessment (SIA) (Harris et al., 1999a) provide two different but complementary approaches to community impact assessment. The DREW Social Analysis developed estimates of potential impacts to nine focus communities using information provided by the other DREW workgroups, NMFS, secondary data analysis, key informant interviews, and existing studies. Potential impacts were estimated in terms of percentage change from existing conditions for a range of social indicators (Table 5.14-9).

The UI community-based SIA involved asking community residents to estimate the likely effects of the proposed alternatives on their communities 20 years into the future. The interactive community forum process provided a rich source of information and insights into key issues, concerns, and perceptions of impacts.

Forums were conducted in 18 communities in the lower Snake River study area, including the nine examined in the DREW Social Analysis. Information gathered during these forums included each community's perceptions of its history, an assessment of its current situation, and a projection of potential social impacts under each proposed alternative. The current assessment developed by each community is summarized in Table 4.14-10, grouped according to the type of community. In general, community residents perceived the impacts of the proposed alternatives, particularly Alternative 4—Dam Breaching, to be larger than those identified by the DREW Social Analysis Workgroup. Projected future impacts are summarized by community type and community in Table 5.14-10.

Both the DREW Social Analysis and the UI community-based SIA found that changes in the physical, biological, and human environment would have both adverse and beneficial effects on communities throughout the study area. Projected effects would create both winners and losers within the region, the subregion, and individual communities. Economic and social losses for one community or group may present opportunities for gains by another community or group.

Community Social Impacts

The DREW Social Analysis examined nine focus communities—Clarkston, Colfax, Kennewick, Pasco, and Pomeroy in Washington; Lewiston, Orofino, and Riggins in Idaho; and Umatilla in Oregon (Figure 4.14-1). These communities were selected to capture a range of positive and negative impacts across different types of communities located throughout the region. Specific estimates of potential impacts by Alternative 4—Dam Breaching to each community are summarized in Table 5.14-9. These nine focus communities are divided evenly over the three subregions. The following discussion addresses potential impacts that are likely to be common to other communities located in their respective subregions.

Alternative 1—Existing Conditions

Alternative 1—Existing Conditions is considered the base case for this analysis.

Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Alternatives 2 and 3 would have little effect on the existing social and economic environment for the majority of the communities located in the lower Snake River region. Some communities, particularly those located upriver (e.g., Lewiston, Orofino, and Riggins), could be adversely affected by lower probabilities of salmon recovery. Uncertainty about the future of the four lower Snake River dams may also have negative social effects on some communities.

Table 5.14-9. Significance of Changes in the Physical, Biological, and Socioeconomic Environment Page1 of 4

Alternative	Indicators/Impact Measure	Evaluation Criteria	Clarkston	Colfax	Kennewick	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
	Power										
4	Residential Rate Increases	Residential Rate Increase > 5 percent			X			X			
4		Residential Rate Increase < 5 percent	X	X		X	X		X	X	X
4	Rate Employment Impacts	Decrease in Employment > 1 percent									
4		Decrease in Employment< 1 percent	X	X	X	X	X	X	X	X	X
4	Power Provider Rate Risk	Public Owned Utility			X			X		X	
4		Investor Owned Utility	X	X		X	X		X		X
4	Fixed Income Ratepayers	Poverty Rate >10 percent of all families	X		X			X		X	X
4		Poverty Rate < 10 percent of all families		X		X	X		X		
4	New Power Plant Operation	Increase in Employment > 1 percent									
4		Increase in Employment < 1 percent			X			X			X
4	ST: New Plant Construction	Increase in Regional Employment > 5			X			X			X
4		Increase in Regional Employment < [illegible]									
4		Within 50 miles of Potential Plant Siting			X			X			X
	Recreation										
4	Non-fishing River Recreation	Increase in Employment > 1 percent									
4		Increase in Employment < 1 percent	X	X	X	X		X	X		
4		Short-term Displacement	X	X	X	X		X	X		
4		Short-term Crowding			X			X			X
4	Anadromous Fishing Recreation	Increase in Employment > 1 percent								X	
4		Increase in Employment < 1 percent	X	X	X	X	X	X			
4		Short-term Displacement	X			X	X	X			
4		Short-term Crowding					X	X			
4		Increased Local Fishing Opportunities	X	X	X	X	X	X	X	X	X
4	Site Access	Decrease in Site Access > 25 percent	X	X		X			X		
4		Decrease in Site Access < 25 percent			X		X	X		X	X

Notes: 1. ST = short-term employment associated with construction.
2. Uncertainty related to employment percentages is a result of uncertainties faced by other DREW workgroups, dynamics of local economies, and methodology for allocating regional impacts to local geographic areas.

Source: Appendix I, Economics (Table 7-1).

Table 5.14-9. Significance of Changes in the Physical, Biological, and Socioeconomic Environment

Alternative	Indicators/Impact Measure	Evaluation Criteria	Clarkston	Colfax	Kennewick	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
4	Site Services	Decrease in Site Services > 25 percent	X	X		X			X		
4		Decrease in Site Services < 25 percent			X		X	X		X	X
4	Elderly Recreationists	Over 65 years > 20 percent	X	X					X		
4		Over 65 years < 20 percent			X	X	X	X		X	X
4	New Campground Construction	Increase in Employment > 1 percent									
4		Increase in Employment < 1 percent	X	X					X		
4	Campground Operation & Maintenance	Increase in Employment > 1 percent									
4		Increase in Employment < 1 percent	X	X					X		
	Transportation										
4	Loss of Barge Transportation (Grain)	Increase in Employment > 1 percent			X			X			
4		Increase in Employment < 1 percent	X	X		X	X		X		
4	Farm Spending Related Employment	Decrease in Employment > 1 percent		X							
4		Decrease in Employment < 1 percent	X			X	X		X	X	
4	Dryland Farm Income	Decrease in Total County Farm Income		X					X	X	
4		Decrease in Total County Farm Income	X			X	X	X			
4	ST: Road, Rail and Infrastructure	Increase in Employment > 1 percent	X	X	X	X	X	X	X		
4		Increase in Employment < 1 percent									
4	Grain Transportation Costs	Increase in Avg. Cost > 15 cents per	X	X		X	X		X	X	
4		Increase in Avg. Cost < 15 cents per						X			
4	Farm Consolidation (Dryland)	Risk of Increased rate of Farm	X	X		X	X		X	X	
4	Transportation Costs (other shippers)	Increase in Transportation Cost	X	X		X	X		X	X	
4	Transportation Capacity Uncertainty	Increase in Transportation Uncertainty	X	X	X	X	X	X	X	X	
4	Highway Congestion	Increase in Traffic Volume > 2 percent						X	X		
4		Increase in Traffic Volume < 2 percent	X	X	X	X					
4		Decrease in Traffic Volume					X			X	

Notes: 1. ST=short-term employment associated with construction.
2. Uncertainty related to employment percentages is a result of uncertainties faced by other DREW workgroups, dynamics of local economies, and methodology for allocating regional impacts to local geographic areas.

Source: Appendix I, Economics (Table 7-1).

Table 5.14-9. Significance of Changes in the Physical, Biological, and Socioeconomic Environment

Alternative	Indicators/Impact Measure	Evaluation Criteria	Clarkston	Colfax	Kennewick	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
4	Highway Safety	Increase in Highway Safety					X			X	
4		Decrease in Highway Safety	X	X	X	X		X	X		
	Water Supply										
4	Dislocated Agricultural Workers	Decrease in Employment > 1 percent			X			X			
4		Decrease in Employment < 1 percent									X
4	Farm Income	Decrease in Total County Farm Income > 10						X			
4		Decrease in Total County Farm Income < 10									
4	ST: Pump/Well Modifications	Increase in Employment > 1 percent				X	X				
4		Increase in Employment < 1 percent	X	X	X			X	X		
4		Increased Costs for Well Irrigators/users	X			X		X	X		
	Effects on Food Processors	Decrease in Local Produce			X			X			X
	Implementation/Avoided Costs										
4	Implementation Employment	Increase in Employment > 0.1 percent									
4		Increase in Employment > 0.1 percent	X	X	X	X	X	X	X		
4	ST: Implementation Employment	Increase in Employment > 1 percent	X	X			X		X		
4		Increase in Employment < 1 percent			X	X		X			X
3		Increase in Employment < 1 percent	X	X	X	X	X	X	X		
4	Outside Workers	Increase in Outside Workers >10 percent	X						X		
4		Increase in Outside Workers < 10 percent		X	X	X		X			
4	Human Movement Patterns	Loss of Project Bridges within 50 miles		X	X			X	X		
4	Operations Employment	Decrease in Employment > 1 percent									
4		Decrease in Employment < 1 percent	X	X	X	X		X	X		X
3		Increase in Employment > 0.1 percent									
3		Increase in Employment < 0.1 percent	X		X	X		X	X		X
	Anadromous Fish Recovery										
3 and 4	ST: Social Cohesion	Increased Social Cohesion		X	X			X	X	X	X

Notes: 1. ST=short-term employment associated with construction.

2. Uncertainty related to employment percentages is a result of uncertainties faced by other DREW workgroups, dynamics of local economies, and methodology for allocating regional impacts to local geographic areas.

Source: Appendix I, Economics (Table 7-1).

Table 5.14-9. Significance of Changes in the Physical, Biological, and Socioeconomic Environment

Alternative	Indicators/Impact Measure	Evaluation Criteria	Clarkston	Colfax	Kennewick	Lewiston	Orofino	Pasco	Pomeroy	Riggins	Umatilla
3 and 4		Decreased Social Cohesion	X			X	X				
4	Recovery Uncertainty/Risk	Lower Uncertainty of Salmon	X	X	X	X	X	X	X	X	X
3		Higher Uncertainty of Salmon	X	X	X	X	X	X	X	X	X
3	Business Uncertainty/Risk	Lower Economic Uncertainty/Risk	X	X	X	X	X	X	X	X	X
4		Higher Economic Uncertainty/Risk	X	X	X	X	X	X	X	X	X
3	Extinction Risk/Existence Value	Higher Extinction Risk	X	X	X	X	X	X	X	X	X
4		Lower Extinction Risk	X	X	X	X	X	X	X	X	X
	Other Social Effects										
4	Population Impacts	Decrease in Population > 5 percent						X			
4		Decrease in Population < 5 percent		X	X				X		
4		Increase in Population > 5 percent									
4		Increase in Population < 5 percent	X			X	X			X	X
4	Total Long-term Employment	Employment Losses > 5 percent							X		X
4		Employment Losses < 5 percent	X	X	X	X	X	X			
4		Increase Net Employment > 1 percent									
4		Increase Net Employment < 1 percent				X				X	
4		Decrease Net Employment > 1			X			X			X
4		Decrease Net Employment < 1	X	X			X		X		
4	Total Short-term Employment	Increase in Employment > 5 percent	X	X		X			X		
4		Increase in Employment < 5 percent			X		X	X			X
4	Aesthetics	ST Exposed Shoreline	X	X	X	X	X	X	X		
4		LT Revegetated Shoreline	X	X	X	X	X	X	X		

Notes: 1. ST=short-term employment associated with construction.
2. Uncertainty related to employment percentages is a result of uncertainties faced by other DREW workgroups, dynamics of local economies, and methodology for allocating regional impacts to local geographic areas.

Table 5.14-10. Perceptions of Change by Community and Community Type

Community Dimension	Typical Community Case	Alt. 1 Median Rating[1/]	Alt. 3 Median Rating[1/]	Alt. 1 to 3 Rating Justifications	Alt. 4 Median Rating	Alt. 4 Rating Justifications
Trade Center Community Type						
People	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.5 4.0 2.0 2.0	1.0 3.0 1.5 2.0	• No highly replicated justifications	-3.5 -4.0 -4.0 -5.0	• Decreasing population • High public assistance • Ethnic diversity is low • Lack of industry and job opportunities • Decreased school enrollment • Less people own their own homes • Loss and/or change in recreation opportunities
Jobs & Wealth	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.5 4.0 2.5 1.5	1.5 4.0 1.5 1.5	• Increased utility rates	-3.5 -5.0 -4.5 -5.0	• Declining economy • Decrease in income/wages • Decreased job opportunities • Increased cost of doing business
Place	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.5 3.5 2.0 1.0	1.5 3.0 1.5 1.5	• Current trends continue	-2.5 -4.0 -4.5 -5.0	• Increased traffic congestion • Inadequate social services • Loss of community • Lack of transportation facilities • Loss and/or decrease in farming • Increased business vacancies and struggling business
Vision & Vitality	Lewiston, ID Clarkston, WA Kennewick, WA Pasco, WA	1.0 3.0 2.0 2.0	1.5 3.0 1.5 2.0	• Current trends continue • Good community vitality	-2.0 -4.5 -4.5 -5.0	• Pessimistic vision • Reduced/limited budgets • Decreasing vitality • Diminishing and/or decline in leadership capacity
Highly Productive Dryland Agriculture Community Type						
People	Colfax, WA Genesee, ID Pomeroy, WA	1.0 2.0 -1.0	0 2.0 -1.0	• Current trends continue	-4.0 2.5 -5.0	• Decreased population • Families become less stable • Decreased school enrollment
Jobs & Wealth	Colfax, WA Genesee, ID Pomeroy, WA	-1.0 2.0 2.0	0 1.0 1.0	• Current trends continue • Increased utility rates • Short-term jobs created	-4.0 -3.5 -4.0	• Increased utility rates • High transportation costs • Decreased job opportunities • Decreased agricultural jobs • Decreased income/wages • Increased unemployment • Increased cost of doing business • Decreased tax base • Decreased property values • Jobs and wealth change regardless of alternatives

Table 5.14-10. Perceptions of Change by Community and Community Type

Community Dimension	Typical Community Case	Alt. 1 Median Rating[1/]	Alt. 3 Median Rating[1/]	Alt. 1 to 3 Rating Justifications	Alt. 4 Median Rating	Alt. 4 Rating Justifications
Place	Colfax, WA Genesee, ID Pomeroy, WA	0 2.0 1.0	0 2.0 1.0	• Current trends continue	-4.0 -3.0 -3.5	• Inadequate infrastructure • Inadequate social services • Increased cost of living • Lack of transportation facilities • High traffic congestion • Increased business vacancies • Less pride and sense of place in the community • Inadequate public areas • Decreased number of farms and farm families • Inadequate air and water quality
Vision & Vitality	Colfax, WA Genesee, ID Pomeroy, WA	0 2.0 1.0	0 1.0 0	• Current trends continue	-3.0 -3.0 -3.5	• Pessimistic vision • Lost tax revenue • Reduced budgets
Productive Dryland Agriculture Community Type						
People	Kahlotus, WA Washtucna, WA	2.5 2.0	1.5 2.0	• No highly replicated justifications	-5.0 -4.0	• No highly replicated justifications
Jobs & Wealth	Kahlotus, WA Washtucna, WA	2.0 1.0	2.0 1.5	• Increased jobs	-5.0 -4.0	• Decreased job opportunities • Increased utility rates • Decreased tax base • Poor roads from increased trucking
Place	Kahlotus, WA Washtucna, WA	1.5 1.0 1.0	2.0 1.5 1.5	• Current trends continue	-5.0 -4.0 -4.0	• Lack of transport facilities • Decreased recreation and tourism opportunities • Negative impacts from increased trucking
Vision & Vitality	Kahlotus, WA Washtucna, WA	1.0 1.0	2.0 1.5	• No highly replicated justifications	-5.0 -3.0	• Leadership decline
Multiple Natural Resource Use Community Type						
People	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 2.0 -2.0 1.0	-1.0 1.0 -2.0 0	• Current trends continue	0 -3.0 1.0 -3.0	• Current trends continue
Jobs & Wealth	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 2.0 -1.5 1.5	0	• No highly replicated justifications	-2.0 -4.0 1.0 -2.0	• Increased cost of living
Place	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 2.0 -2.0 1.0	-1.0 2.0 -2.0 0	• Current trends continue	0 -4.0 0 -2.0	• Increased transportation (economic, air & water quality, etc.)
Vision & Vitality	Enterprise, OR Orofino, ID Riggins, ID Weippe, ID	-1.0 1.0 0 0	-1.0 1.5 0 0	• Current trends continue	-1.0 -3.0 1.5 -3.0	• Current trends continue

Community Dimension	Typical Community Case	Alt. 1 Median Rating[1/]	Alt. 3 Median Rating[1/]	Alt. 1 to 3 Rating Justifications	Alt. 4 Median Rating	Alt. 4 Rating Justifications
Snake River Irrigated Agriculture Community Type						
People	Prescott, WA	1.0	1.0	• Current trends continue	-4.0	• Decreased population • Families become less stable • People change for the worse • Lack of industry and job opportunities
Jobs & Wealth	Prescott, WA	1.0	1.0	• Current trends continue	-4.0	• Decreased job opportunities • Jobs decrease due to the ripple effect from agricultural losses • Increased utility rates • Business down/loss of business • Decreased property values
Place	Prescott, WA	1.0	1.0	• Current trends continue	-4.0	• Public areas/appearance worsens • Increased vacancies & businesses struggle • Traffic congestion • Ruin of community • Infrastructure in bad shape
Vision & Vitality	Prescott, WA	1.0	1.0	• Current trends continue	-5.0	• Diminished civic organization capacity • Insufficient tax base • Inadequate fiscal resources • Limited quality social activities
Columbia River Agriculture Community Type						
People	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	1.5 2.0 4.0 3.0	1.5 2.0 3.0 2.5	• Current trends continue	-3.0 -5.0 -0.5 -4.5	• Unstable economy
Jobs & Wealth	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	1.0 2.0 4.0 3.0	1.0 2.0 4.0 3.0	• No highly replicated justifications	-3.0 -5.0 -0.5 -5.0	• Increased utility rates • Shrinking agriculture base • Job losses from agricultural decline
Place	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	1.0 2.0 4.0 3.0	1.0 2.0 2.0 2.5	• Current trends continue	-3.0 -5.0 -2.0 -5.0	• Inadequate infrastructure • Increased traffic congestion • Decreased farming • Loss of opportunities for parks and open spaces and recreation and tourism • Decreased air and water quality • Higher taxes • Community will be ruined
Vision & Vitality	Adams, OR Burbank, WA Stanfield, OR Umatilla, OR	2.0 2.0 4.0 2.5	2.0 1.0 4.0 2.5	• No highly replicated justifications	-3.5 -5.0 0 -5.0	• Decline in civic capacity

[1/] Participants were asked to forecast the likely effects of each alternative on their community and rate changes across four community dimensions—people, jobs and wealth, place, and vision and vitality—for 2020. These ratings ranged from –5 ("adversely affected" by the alternative) to +5 ("beneficially affected" by the alternative) relative to existing conditions. This table presents the median rating assigned to each dimension by community.

Source: Harris et al. (1992).

Alternative 4—Dam Breaching

Breaching the four lower Snake River dams would change the physical and economic environment of the lower Snake River study area. Communities in the upriver region (e.g., Lewiston, Orofino, and Riggins) would likely experience net employment gains as a result of expected increases in recreation and tourism associated with near-natural river, and to a lesser extent increased fish runs. The extent of the effects upon Lewiston and Orofino are, however, uncertain because the possible effects that the loss of river navigation could have upon the forest products industry have not been completely analyzed. Detailed industry studies would be needed to fully evaluate the extent of these effects. In the absence of these studies, potential impacts associated with the wood products industry are assessed qualitatively in Appendix I, Economics, Section 6. The effects of increased transportation costs to farmers would be most significant for communities located in the upriver subregion. Communities in Latah, Nez Perce, Idaho, and Lewis Counties in Idaho would experience the largest increases in transportation costs.

Communities located in the reservoir subregion (e.g., Pomeroy, Colfax, and Clarkston) would likely experience a net decrease in employment due to reductions in Corps' employment and increased pressure on family farms caused by increased transportation, storage, and handling costs for agricultural products. This added pressure to an already depressed agricultural sector may lead to an increased rate of farm consolidation for those farms with a high debt to equity ratio.

Communities located in the downriver subregion (e.g., Pasco, Kennewick, and Umatilla) would likely experience employment loss if farms currently irrigated from the Ice Harbor reservoir go out of business. These losses could be partially offset by expected increases in transportation- and power generation-related employment.

Overall adverse community impacts associated with Alternative 4—Dam Breaching identified by the DREW Social Analysis Workgroup include the following:

- Decreased net farm income and increased financial pressure on dryland farmers throughout the region, particularly those farms located in close proximity to the lower Snake River
- Risk of increased consolidation of family farms and a decrease in rural farm population
- Decreased county property tax base in 20 regional counties from decreased farm land value and potential loss of irrigated lands
- Dislocated full-time and seasonal workers from Ice Harbor irrigated agricultural lands and a loss of a source of local school revenue for communities in close proximity to the reservoir
- Realignment of communities' economic base and changed potential for future growth

Many of the community-level impacts would be caused by the loss of irrigated agriculture from the Ice Harbor reservoir and increased grain transportation costs. Irrigated agriculture-related impacts could be minimized or partially eliminated by mitigation spending to modify existing irrigation pumps. Expanding rail capacity in the region or directly subsidizing affected farms would minimize potential impacts to those farms affected by increased transportation costs.

Communities would likely adjust to these changes. New individuals and businesses seeking new opportunities may replace those that have been displaced. Displaced human and capital resources may be employed in their next best use within the community. This type of adjustment does, however, take time and would vary by community. Community size has been identified as a critical factor affecting a community's ability to adapt to change, with smaller, less diverse communities tending to respond less favorably. The nine focus communities briefly addressed here are discussed in more detail in the DREW Social Analysis report (DREW Social Analysis Workgroup, 1999) and Appendix I, Economics, Section 7.

Community Perceptions

The community-based SIA conducted by the UI Team consisted of two phases. The first phase addressed 18 communities in the lower Snake River study area, including the nine examined by the DREW Social Analysis Workgroup. The second phase involved nine community forums conducted upriver of the lower Snake River study area in southern Idaho. The first phase is addressed in the following text. The second phase is addressed in Section 5.14.2.3.

The following information is drawn from the UI team's discussion of the environmental effects of each alternative by community type (Harris et al., 1999a). This analysis did not address Alternative 2—Maximum Transport of Juvenile Salmon, but the impacts associated with this alternative are likely to be similar to those perceived for Alternative 3—Major System Improvements for most communities.

Each community forum consisted of a set of interactive, structured group activities. Forum participants were assigned to facilitated tables and asked to assess the current or base case condition of their community in terms of four key dimensions: people, jobs and wealth, place, and vision and vitality. Information was then presented on the projected biological, economic, and physical changes associated with three major alternatives: existing conditions, major system improvements, and dam breaching. Community members were asked to forecast the likely effects of these actions on their community and rate changes across the four established community dimensions for 2020. Participants were asked to provide written justification for these ratings, which ranged from –5 ("adversely affected" by the alternative) to +5 ("beneficially affected") relative to existing conditions.

Perceptions of change in the four key dimensions of community are summarized for each alternative by community and community type in Table 5.14-10 and discussed in the following paragraphs. The six community types discussed below are described in Table 4.14-9.

Trade Center Community Type

Residents of Lewiston, Clarkston, and the Tri-Cities of Kennewick, Pasco, and Richland perceived rivers—particularly rivers with dams—as central to their community's character and way-of-life. The ports of Lewiston and Clarkston are viewed by residents as important facilitators of economic growth, with barging and shipping on the lower Snake River perceived as key factors in each community's economic development (although reportedly half of the shipping through the Port of Lewiston, for example, is by truck and rail). Recreational and scenic amenities associated with the existing reservoir system are also seen as important to the character of the area. The economy of the Tri-Cities differs from those of the other two towns because at present it is not directly related to the use of the river. Residents do, however, make use of existing upriver recreation facilities.

Forum participants in each of the four communities forecast an improvement in their economies across all four community dimensions by 2020 for Alternative 1—Existing Conditions (Table 5.14-8). Little change from this pattern was forecast for Alternative 3—Major System Improvements. Significantly, adverse effects were, however, forecast under Alternative 4—Dam Breaching. These adverse effects included declining population, schools, and economic and civic vitality, as well as increased traffic congestion, business failure, and general pessimism.

In general, the results suggested less consensus among forum participants and a wider range of variability in perceived likely impacts for Lewiston than for Clarkston and the Tri-Cities. Ratings of perceived impacts under dam breaching were more negative in the Tri-Cities than they were in Lewiston. Residents of the Tri-Cities would mainly experience a loss in irrigated agriculture and upriver recreation opportunities. Under a dam breaching scenario, the Tri-Cities would likely experience greater positive economic effects than the Lewiston valley, with Pasco, in particular, becoming a transportation hub for commodity shipments formerly transported on the lower Snake River.

Highly Productive Dryland Agriculture Community Type

Residents of the traditionally stable, wealthier, but now-changing farming, bedroom, and government-based communities of the Highly Productive Dryland Agriculture Community Type perceived Alternative 1—Existing Conditions to mainly be an improvement across all four community dimensions (see Table 5.14-10). Conditions under Alternative 3—Major System Improvements were generally perceived about the same or more beneficial for most dimensions in most of the towns. People generally saw current trends continuing. Relatively minor changes perceived under Alternative 3 were increased utility rates and the short-term jobs that would result from efforts to modify the existing hydrosystem to recover salmon stocks.

Significantly, adverse effects were perceived under Alternative 4—Dam Breaching. These effects included declining population, families, and schools; increased costs of business and living; decreased incomes and jobs; fewer businesses and decreased property values; a shrinking tax base; reduced tax revenues (resulting in reduced public sector budgets and services); and the loss of farm families and community pride and vitality. In addition, residents from these towns currently use the river for flatwater recreation activities.

If dam breaching were to occur, the increased costs of transportation for farmers in the lower Snake River study area would be one of the major social impacts. Genesee, Idaho, for example, a community already in transition, would likely experience some of the greatest increases in transportation costs.

Productive Dryland Agriculture Community Type

These agriculture towns of eastern Washington have a significant relationship with the Snake River. An important aspect of this relationship is the transportation of agricultural products via the river at comparatively low costs. These towns are located in relatively close proximity to the ports on the Columbia River. Increases in the costs of transporting commodities via the Columbia River System would therefore be less for these types of community than for the Highly Productive Dryland Agriculture Community Type.

Both Kahlotus and Washtucna saw some improvement in 2020 for the four community dimensions under Alternative 1—Existing Conditions (Table 5.14-10). The sense of community vision and vitality is strong for these communities, but their economies, which continue to be agriculturally dependent, are perceived to remain poor despite being beneficially affected. Both communities see themselves being beneficially affected by the Alternative 3—Major System Improvements, with benefits similar to those under Alternative 1—Existing Conditions.

Significantly, adverse effects were perceived under Alternative 4—Dam Breaching. Justifications given by both communities were a perception of decreased job opportunities, increased utility rates, decreased tax base, poor roads and highways from increased trucking, as well as factors such as leadership decline and lack of recreation and tourism opportunities. Other adverse factors such as a decrease in Corps employment in Kahlotus may have also negatively influenced group ratings.

Multiple Natural Resource Use Community Type

The towns included under this community type are located upriver from the lower Snake River. As a result, their primary relationship with the lower Snake River pertains to the potential effects of the proposed alternatives upon the local fisheries in the Clearwater, Salmon, and Grand Ronde Rivers.

Active and involved residents of some towns, like Orofino and Weippe, shared the philosophies and concerns of farmers downriver from them with respect to Alternative 4—Dam Breaching (Table 5.14-8). In other communities such as Riggins and Enterprise, which have a tourism economy that is somewhat dependent on natural amenities, residents perceived that their community would decline or stay the same under Alternative 1—Existing Conditions. Riggins participants perceived all four community dimensions would improve under Alternative 4—Dam Breaching.

The Multiple Natural Resource Use Community Type perceived Alternative 4—Dam Breaching more positively than any of the other community types. The analysis of the impact rating justifications suggests that this is because these communities see themselves less directly connected to the commodity transportation issues of the lower Snake River and more influenced by salmon recovery. Salmon recovery would add to their nature-based tourism product mix, provide more fishing opportunities, as well as enhancing their sense of place.

Snake River Irrigated Agriculture Community Type

The forum participants at Prescott saw Alternative 1—Existing Conditions and Alternative 3—Major System Improvements as equally beneficial across all four community dimensions. Alternative 4—Dam Breaching was, in turn, perceived as having negative effects across all four dimensions (Table 5.14-10).

Columbia River Agriculture Community Type

None of the communities in the Columbia River Agriculture Community Type have a direct relationship with the lower Snake River, but residents use it for recreation purposes as well as indirectly for the transportation of commodities through ports on the Columbia River. Their perceptions of the effects of the Alternative 4—Dam Breaching appeared to be influenced by a general mistrust of the Federal government and fear of a "domino effect" (i.e., "if it [dam breaching] happens on the lower Snake River, it won't be long before it happens on the Columbia River").

All communities rated Alternative 1—Existing Conditions and Alternative 3—Major System Improvements positively across all four community dimensions. All the communities, with the exception of Stanfield, generally saw themselves being adversely affected by Alternative 4—Dam Breaching. Adverse effects perceived by these communities include an increase in utility rates, a shrinking agricultural base, job losses from an agricultural decline, increased traffic congestion, higher taxes, loss of parks and open spaces, and decreased air and water quality.

5.14.2.2 Coastal Region

Detailed community forums of the type conducted in the lower Snake River study area and southern Idaho by the University of Idaho (Harris et al., 1999a; 1999b) were not conducted in the coastal area. Two local communities were, however, selected to demonstrate the effects of the four proposed alternatives on coastal communities (The Research Group, 2000). The communities are the Astoria area in Clatsop County, Oregon and the Westport area in Grays Harbor County, Washington. Changes in anadromous fish runs would affect the commercial and recreation fishing sectors in these communities. Estimates of the number of fish available for harvest under each alternative were developed by the DREW Anadromous Fish Workgroup based on the preliminary PATH analysis. Harvests were allocated to user groups and geographic areas based on existing agreements and historical harvest distributions. The results of this analysis are summarized for Project Year 25 in Table 5.14-11. Project Year 25 is used because harvest equilibrium would have been reached by then. The following sections address the potential economic effects of each alternative.

Alternative 1—Existing Conditions

This alternative is considered the base case for this analysis.

Table 5.14-11. Economic Impacts of the Proposed Alternatives for Astoria and Westport (Project Year 25)

	Astoria			Westport		
Alternative	Personal Income ($1,000s)	Business Transactions ($1,000s)	Employment	Personal Income ($1,000s)	Business Transactions ($1,000s)	Employment
1	1,132.3	2,171.0	42	30.6	52.3	1
2	1,270.9	2,436.8	47	30.6	52.3	1
3	1,234.7	2,367.4	46	36.8	62.9	1
4	2,482.7	4,760.3	92	255.7	436.9	8
Net Change						
2	138.5	265.8	5	0	0	0
3	102.4	196.3	4	6.2	10.7	0
4	1,350.3	2,589.3	50	225.1	384.6	7

Note:
Personal income and business transaction costs are presented in 1998 dollars.
Source: Compiled from The Research Group, 2000 (Tables VI.3a and VI.4a).

Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements

Alternatives 2 and 3 would have small positive effects on the economies of the Astoria and Westport areas. These alternatives would generate less than $1 million and $10,000 in personal income in the Astoria and Westport areas, respectively. About five jobs would be generated in the Astoria area under each alternative. There would be no jobs generated in the Westport area under either alternative.

Alternative 4—Dam Breaching

Alternative 4—Dam Breaching is projected to generate an additional $1.4 million in personal income, $2.6 million in business transactions, and 50 additional jobs in the Astoria area in Project Year 25, about 1.3 times the current economic contribution made by commercial and recreational salmon fishing (Table 5.14-11). About 58 percent of this increase would result from commercial fishing, with the remaining 42 percent resulting from inriver recreational fishing. Dam breaching would generate an additional $0.2 million in personal income, $0.4 million in business transactions, and seven jobs in the Westport area in Project Year 25, about 10 percent of the current economic contribution made by commercial and recreational salmon fishing. This additional economic contribution would be a significant boost to the Astoria area economy and a minor increase to the Westport area's economy.

5.14.2.3 Southern Idaho

Nine community forums were conducted in southern Idaho. Three community types were identified: The Trade Center Community (Boise and Twin Falls), the Multiple Natural Resource Use Community (Ashton, Cascade, and Salmon), and the Middle Snake River Irrigated Agricultural Community (Firth, Hagerman, Homedale, and Rupert). The following sections summarize the findings for each community type. These findings are discussed in more detail in the Phase II Community-Based SIA (Harris et al., 1999b).

Trade Center Community Type

Forum participants in the Trade Center Communities of Boise and Twin Falls in Phase II perceived positive impacts associated with the implementation of Alternative 4—Dam Breaching. Given the indirect nature of the relationship of these communities to the lower Snake River, their comparatively high capacity to respond to change, and the comparatively minimal degree and kind of impacts they would experience from the implementation of Alternative 4—Dam Breaching, risks associated with this alternative would be minimal for communities of this type compared to other community types.

Multiple Natural Resource Use Community Type

Forum participants in the Multiple Natural Resource Use communities perceived a range of potential impacts associated with the implementation of Alternative 4—Dam Breaching. These potential impacts ranged from somewhat beneficial to very adverse. Salmon, Idaho, although distant from the immediate lower Snake River study area, could be beneficially affected by increased salmon runs. As suggested by their identified impacts and the travel and tourism nature of their local economy, participants perceived some benefits from increased salmon runs and adverse impacts associated with declining salmon and steelhead runs under other alternatives. Similar results were found for Cascade, Idaho. Communities of the Multiple Natural-Resource Use Community Type tend to be relatively resilient and economically diverse, which indicates that they, too, would be less at-risk to changes resulting from the proposed alternatives. It should, however, be noted, that the residents of this type of town perceived that their community character—a key element in the viability and diversity of their economy—would be significantly adversely affected by Alternatives 1 through 3.

The perceptions of forum participants in Ashton in southeastern Idaho differed from those of participants in Salmon and Cascade. Participants in Ashton perceived adverse impacts associated with the implementation of Alternative 4—Dam Breaching, such as increased transportation and utility costs and possible effects on the traditional forest industry of the area.

Given these communities' varied perceptions of the risks associated with Alternative 4—Dam Breaching, the mix of beneficial and adverse impacts, and their active, ongoing efforts to adapt and respond to socioeconomic changes, these types of communities should be able to respond to changes associated with this alternative. Given their distance from lower Snake River ports, negative impacts associated with changes in transportation are likely to be less significant for these communities than for agriculture-based communities located to the north. These Middle Snake River Irrigated Agriculture Communities vary in their level of resiliency and economic diversity. Hagerman and Rupert are most at-risk in terms of community capacity, while Firth has been found to be more resilient but also has a less diverse economic base than even other farm communities. In contrast, Homedale has a broader, more sound economic base.

Middle Snake River Irrigated Agriculture Community Type

Participants in the forums held in Middle Snake River Irrigated Agriculture Communities (Firth, Hagerman, Homedale, and Rupert) perceived substantial negative impacts associated with the implementation of Alternative 4—Dam Breaching.

5.14.3 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires each Federal agency to make the achievement of environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low income populations. The Order further stipulates that the agencies conduct their programs and activities in a manner that does not have the effect of excluding persons from participation in, denying persons the benefits of, or subjecting persons to discrimination because of their race, color, or national origin.

The following discussion is divided into two main sections. The first section discusses the potential for minority and low income populations to be disproportionately affected by the proposed alternatives. The second section provides information on the participants in the 18 community forums held in the lower Snake River study area (see Section 5.13.2.1).

5.14.3.1 Effects on Minority and Low Income Populations

The proposed alternatives, particularly Alternative 4—Dam Breaching, could potentially affect the region, local communities, and regional and local populations in a number of ways. These potential effects are discussed with regard to regional employment and income and local communities in Sections 5.13.1 and 5.13.2.

Potential effects to Native American tribal members are discussed in Section 5.7. Section 5.7 summarizes the results of an environmental justice analysis conducted for this project on behalf of the Columbia River Inter Tribal Fisheries Commission (CRITFC) (Meyer Resources, 1999). The full text of Meyer Resources report, referred to in this document as the Tribal Circumstances report, is available on the Corps website. This section also addresses the potentially affected Hispanic population and assesses whether this population may experience disproportionately high and adverse effects as a result of one or more of the proposed alternative. Potential effects upon low income groups are also assessed.

Alternatives 1 through 3

Implementation of Alternatives 1, 2, or 3 would have no short-term effect upon the current circumstances of low income and/or minority populations. These alternatives could, however, result in long-term beneficial changes to existing conditions if salmon runs were to increase over time.

Another view is expressed in the Tribal Circumstances report. This report provides the perspective of the four CRITFC tribes—the Nez Perce, Yakama, Umatilla, and Warm Springs—and also addresses the perspective of the Shoshone-Bannock tribes (the “study tribes”). The Corps believes that the findings of this report may also be broadly representative of the Colville and the Wanapum because this tribe and band share similar cultures and interest in the health/availability of aquatic resources and habitats as the five study tribes. The Tribal Circumstances report concluded that Alternatives 1 and 2 would do “little or nothing” to correct the cumulative inequities that the tribes have suffered from construction and operation of the four lower Snake River dams. The assessment presented in the Tribal Circumstances report did not address Alternative 3—Major System Improvements, but the impacts associated with this alternative are likely to be similar to those for Alternative 2—Maximum Transport of Juvenile Salmon. The findings of this assessment are summarized for Alternatives 1 and 2 in Table 5.14-12.

Alternative 4—Dam Breaching

Dam breaching could potentially affect the five Native American tribes discussed in the Tribal Circumstances reports, as well as the Colville and Wanapum. This alternative could also affect Hispanic farm workers employed on the farms currently irrigated by water from the Ice Harbor reservoir (see Section 5.10). The potential effects of the proposed alternatives on these groups are discussed in the following sections. In addition, Alternative 4—Dam Breaching would have effects on electric power and air quality. The potential for these effects to disproportionately affect low income and/or minority populations is also discussed below.

Native American Indians

The Tribal Circumstances report concluded that Alternative 4—Dam Breaching would represent a significant step toward redressing the environmental injustice that the tribes have suffered from construction and operation of the four lower Snake River dams. The findings of the environmental justice assessment presented in the Tribal Circumstances report are summarized for Alternative 4—Dam Breaching in Table 5.14-13. The effects of this alternative on the tribes are discussed in more detail in Section 5.7.

The assessment presented in the Tribal Circumstances report concludes that there would be adverse environmental justice effects associated with alternatives that maintain the dams and that only Alternative 4—Dam Breaching would have a positive effect from an environmental perspective. The Corps concludes that any alternative that increases salmon runs would benefit the tribes in the ways summarized in Table 5.14-13.

Farm Workers

Alternative 4—Dam Breaching could negatively affect farm operations located throughout eastern Washington, in the upriver subregion, and as far as North Dakota. Grain shipments dominate downriver commodity movements on the lower Snake River and farm operations and farm workers could be potentially affected by potential increases in transportation costs. The regional employment effects of increased transportation costs are summarized in Table 5.14-3 and discussed further in

Table 5.14-12. Summary of Tribal Environmental Justice Effects Associated with Alternatives 1 and 2[1/]

Factor	Relative Effects on the Study Tribes
Income Level/Health Care Access	• Tribal families are impoverished and unemployed at 3 to 4 times the levels of Washington/Oregon/Idaho residents as a whole (Table 4.8-2). Wintertime tribal unemployment can reach 80 percent. • Tribal members are dying at rates that range from 20 percent to 130 percent higher than non-Indian residents. • Recent analyses describe tribal health and health care access as "poor." • Implementation of Alternatives 1 or 2 would have no substantial effect in remedying these adverse conditions—and if recovery estimates are too optimistic, could make them worse.
Life Support Resources	• Extensive information presented in the Tribal Circumstances and Perspectives report places salmon at the center of the study tribes' cultural, spiritual, and material world. This report argues that salmon guaranteed to the tribes by treaty have almost entirely been lost. Tribal spokespersons and health experts cited throughout the report have identified the devastating effect these losses have had on tribal culture, health, and material wellbeing. • Beatty et al. (1999) indicate that the lower Snake River dams have contributed substantially to destruction of these life-support resources. • Selection of Alternatives 1 or 2 would not significantly change these cumulative conditions—and the pain, suffering and premature deaths of tribal peoples would continue over future decades.
Economic Base	• The cumulative effects of dam construction have transferred potential wealth produced in the river basin from the salmon on which the tribes depend to electricity production, irrigation of agriculture, water transport services and waste disposal, these latter primarily benefiting non-Indians. These transfers have been a significant contributor to gross poverty, income and health disparities between the tribes and non-Indian neighbors. • Selection of Alternatives 1 or 2 (and likely Alternative 3) would continue these conditions and disparities.
Inconsistent Standards	• Historically, agencies asserted confidence that they could manage uncertainty concerning adverse impacts on salmon during construction of the dams that facilitated wealth transfers from the tribes to non-Indians. Some of the same agencies now claim to be risk adverse, when considering more substantial remedial actions that would recover salmon and result in some measure of rebalancing of wealth to improve the circumstances of tribal peoples.

[1/] This analysis did not address Alternative 3—Major System Improvements, but the impacts associated with this alternative are likely to be similar to those for Alternative 2—Maximum Transport of Juvenile Salmon.

Source: Meyer Resources, 1999 (Table 56).

Appendix I, Economics, Section 6.3.4.4. This analysis, based on the findings of the DREW Transportation Workgroup, assumes that no acreage would go out of production and farm employment would remain unchanged. Employment effects would be caused by decreases in farm income caused by increased transportation costs.

Table 5.14-13. Summary of Tribal Environmental Justice Effects Associated with Alternative 4—Dam Breaching

Factor	Relative Effects on the Study Tribes
Income Level/ Health Care Access	• Alternative 4 would not be sufficient to fully restore tribal harvests to the levels obtained before the lower Snake River dams were built. Alternative 4 is the only option that would substantially improve opportunities for tribal fishing—adding 1.6 million pounds to tribal harvests within 30 years. Tribal spokespersons and experts cited in the Tribal Circumstances and Perspectives report inform us that as salmon recovery occurs, tribal health would improve, tribal incomes would increase, and the cultures of the five study tribes would be strengthened. • Cumulatively, as salmon recovery progressed, Alternative 4 could be expected to significantly reduce the differences between tribal and non-Indian material wellbeing (see Table 4.8-2).
Life Support Resources	• Despite severe damage to most stocks, salmon and water remain the central elements of tribal cultural, spiritual and material survival. Today, beset by a narrow on-reservation resource base, and still coping with racial prejudice and limited opportunity off-reservation, the tribes continue to first look to the salmon as they seek to build a more secure future. • Selection of Alternative 4 would significantly reverse a 144-year post-Treaty cumulative trend that, to date, has resulted in endangerment of the salmon, and consequently, endangerment of tribal peoples—while people as a whole in the region have prospered.
Economic Base	• Selection of Alternative 4 would provide significant restoration for salmon. The tribes have harvested and processed salmon from pre-contact times, and possess an economic comparative advantage respecting such activities. Alternative 4 would allow significantly more tribal harvesting and processing; would facilitate extended distribution of salmon as food through extended families and to elders; and would expand the fundamental economic base for tribal wellbeing. • The positive economic effects discussed here would be expected, over time, to significantly reduce the differentials in poverty and unemployment levels between tribal members and their non-Indian neighbors.
Inconsistent Standards	• Selection of Alternative 4 would reverse more than a century of cumulative regional takings of the Treaty-protected resources of the tribes—and provide a step toward more equitable sharing of potential wealth from the Columbia/Snake River Basin between tribal and non-tribal peoples.

Source: Meyer Resources, 1999 (Table 56).

Alternative 4—Dam Breaching could directly affect workers employed on the farms currently irrigated by water from the Ice Harbor reservoir (see Section 5.10, Agricultural, Municipal, and Industrial Water Uses). Twelve farm operations account for 32,618 of the approximately 37,000 acres irrigated from the Ice Harbor reservoir. A total of 2,973 employees—812 full-time and 2,161 seasonal and part-time—worked at these farms during 1997 (Table 5.14-14). It is not clear whether all of the identified seasonal workers are employed annually or just for special projects such as planting trees, harvesting, and pruning. In addition, these employment numbers apply to the entire acreage of each surveyed farm and not just the portion irrigated from the Ice Harbor reservoir. Approximate Ice Harbor irrigation-related employment numbers are presented in Table 5.14-14.

Table 5.14-14. Employment and Acreage on Farms Irrigated by Water from the Ice Harbor Reservoir

County	Total Farm Acreage	Total Employment			% of Acres Irrigated from Ice Harbor[1/]	Estimated Irrigation-Related Employment		
		Full-time	Part-time	Seasonal Part-time		Full-time	Part-time	Seasonal Part-time
Walla Walla	34,900	156	89	822	79.5	124	71	653
Franklin	7,117	656	0	1,250	67.7	444	0	846
Total	**42,017**	**812**	**89**	**2,072**	**77.5**	**629**	**69**	**1,606**

1/ On-site wells irrigate the majority of the remaining acres.
Source: DREW Water Supply Workgroup, 1997/1998 (Farm Survey).

The DREW Water Supply Workgroup used two approaches—the pump modification approach and the farmland value approach—to estimate the economic effects of Alternative 4—Dam Breaching on Ice Harbor irrigators. Their analysis indicated that the cost of modifying the Ice Harbor agricultural pumping stations would be more than twice the value of the 37,000 acres irrigated from Ice Harbor (see Section 5.10, Agricultural, Municipal, and Industrial Water Uses). In the absence of Congressional appropriation, costs to modify the pumps could be prohibitive based on total farm values.

Unemployment compensation data for January 2000 suggest that about 81 percent of Washington farmworkers employed in the production of crops are Hispanic (Washington State Employment Security, 2000). These figures are only for those farm workers who filed unemployment claims. According to the Washington State Employment Security (2000) report, the proportion of workers that are Hispanic is probably higher than indicated by the claims data. Contacts made with the Yakima and Olympia Washington State Employment Security offices also indicated that the majority of farm workers in the potentially affected area were Hispanic. Direct contact with one of the larger potentially affected farms also suggested that this is the case. The Labor Services Manager of this farm estimated that people of Hispanic origin may account for as much as 90 percent of the full-time, part-time, and seasonal labor force employed at their farm and other surrounding farms.

Based on this data, a total of 1,866 to 2,074 workers of Hispanic origin could be affected by dam breaching (Table 5.14-15). This represents 2.2 to 2.4 percent of the study area population that were identified as Hispanic or Latino in 2000 (Table 5.14-16). At a county level, this represents from 7.9 to 8.8 percent of the total 1990 Hispanic population in Walla Walla County in 2000 and from 4.5 to 5.0 percent of the total Hispanic population in Franklin County.

Based on this information, it appears that if these farms were to go out of business, persons of Hispanic origin would be disproportionately affected.

Table 5.14-15. Estimated Hispanic Labor Force on Farms Irrigated from the Ice Harbor Reservoir

	Full-time	Part-time	Seasonal Part-time	Total Employment
Walla Walla County	124	71	653	848
81 Percent Hispanic	100	58	529	687
90 Percent Hispanic	112	64	588	763
Franklin County	444	0	846	1,290
81 Percent Hispanic	360	0	685	1,045
90 Percent Hispanic	400	0	762	1,161
Total	**629**	**69**	**1,606**	**2,304**
81 Percent Hispanic	**509**	**56**	**1,301**	**1,866**
90 Percent Hispanic	**566**	**62**	**1,445**	**2,074**

Table 5.14-16. Potentially Affected Hispanic/Latino Labor Force as a Percent of Hispanic/Latino Population by Geographic Area

	2000 Hispanic/Latino Population[1/]	Potentially Affected Full- and Part-Time Hispanic/Latino Employment		Potentially Affected Employment as a Percent of 2000 Population	
		81 Percent[2/]	90 Percent	81 Percent	90 Percent
Walla Walla County	8,654	687	763	7.9	8.8
Franklin County	23,032	1,045	1,161	4.5	5.0
LSR Study Area	85,113	1,866	2,074	2.2	2.4

Notes:

LSR = Lower Snake River

1/ Source: U.S. Census Bureau, 2000

2/ These estimates are based on the assumption that either 81 or 90 percent of the total potentially affected labor force is Hispanic/Latino. Both estimates are included to provide a range of possible impacts.

Low Income and/or Minority Populations

Alternative 4—Dam Breaching would affect electric power and air quality, as described in the preceding sections of this FR/EIS. The social impacts of these potential effects are discussed in the DREW Social Analysis Workgroup's report, which is available on the Corps website.

Potential effects associated with the changes in power production would result from increases in electricity rates and the siting of new energy facilities. The effects of increased electrical rates were estimated to be relatively minor at the household level. Although rates may increase from 2.0 to 9.5 percent and increase the general cost of living, household electricity rates in the region would still be well below the national average residential rate. Residential households may also face an increase in the general cost of living as producers pass on power-related increases in the cost of doing business onto consumers. However, these effects were also estimated to be relatively minor (DREW Social Analysis Workgroup, 1999).

The regional distribution of power cost increases is presently unknown, as discussed in Section 5.9. Under one scenario modeled by the DREW Hydropower Impact Team (HIT), increased power costs would be distributed equally throughout the Pacific Northwest. Under another scenario, only BPA customers would pay for power production cost increases. Low income households could be more negatively affected under either scenario as equal increases in power rates would comprise a larger share of their income, as would potential increases in the cost of living. However, as stated in the preceding paragraph, at the time of this analysis, the effects of these increases were expected to be relatively minor, suggesting that low income households would not be severely affected.

The revised DREW HIT analysis present two power replacement scenarios. The first assumes that the lost power generation would be replaced by the construction and operation of up to six new combined-cycle, natural gas-fired power plants. The second scenario assumes that the lost power would be replaced by a combination of conservation and renewable energy resources (see Section 5.9). It is not possible to evaluate the potential environmental justice impacts associated with these replacement power facilities because it is unknown at this time exactly where they would be located. Potential effects would, however, be evaluated in accordance with applicable siting regulations, as part of the necessary environmental permitting process for each facility.

As discussed in Section 5.3, Air Quality, Alternative 4—Dam Breaching would affect regional air quality through an increase in vehicle emissions from increased truck transportation, air emissions from replacement power generating facilities, and fugitive dust emissions from exposed sediments. The air quality analysis does not present detailed information on local level changes in particulate matter so it is not possible to assess the potential for these increased emissions to disproportionately affect low income and/or minority populations.

5.14.3.2 Community Forum Participants

The sampling technique employed by the UI Team to select the focus communities that were assessed in the community based SIA was specifically designed to obtain a diversity of community types that were representative of the broad range of communities present in the region. Nine of the 28 communities that were included in the Phase I and Phase II assessments were considered low income and/or minority communities.

The UI Team employed various methods to encourage low income and minority groups to attend the community forums in each of the 28 communities included in the community based-SIA. These methods included placing advertisements with Hispanic newspapers and radio stations and making numerous phone calls in each town, including direct contacts with Hispanic community leaders. Spanish speakers were available at each of the forums to conduct the meeting in Spanish, if necessary. The meeting at Prescott was actually conducted in Spanish. Despite these efforts, the participation by Hispanic community members was low with the majority of participants being Caucasian. In general, participants in the community forums covered a wide range of occupations, with farmers and retirees comprising the most heavily represented occupations, about 16 and 11 percent of total forum participants, respectively. The average age of participants was 53. Twenty-two percent of the participants were women, 78 percent were men.

5.14.4 Cumulative Effects

Effects on social resources would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching there would be a long-term loss of an estimated 1,372 jobs in the lower Snake River study area. In the short-term the Pacific Northwest would experience a maximum annual gain of an estimated 23,670 temporary jobs. In the long-term, the Pacific Northwest would experience a new loss of an estimated 2,290 jobs.

5.14.5 Uncertainty

The social resources section is divided into three parts: regional demographics and employment, communities, and environmental justice. Potential sources of uncertainty associated with each of these areas are addressed in the following sections.

5.14.5.1 Regional Demographics and Employment

The section that addresses regional employment, income, and population is based on the regional analysis conducted for this study by the DREW Regional Workgroup. The economic impact analysis technique used to measure the effects of the proposed alternatives is input-output analysis with synthesized coefficients. Synthesized coefficients are generally believed to be less accurate than survey-based coefficients because they are based on national averages rather than region-specific surveys. These models are, however, widely used to assess potential project effects and models using synthesized coefficients are generally within plus or minus ten percent of survey-based models (DREW Regional Analysis Workgroup, 1999).

The input-output model is driven by estimates of exogenous changes in sales to final demand (i.e., changes in exports, government spending, or investment). Some degree of uncertainty exists in most of these estimates, which were developed by other DREW workgroups. Uncertainty surrounds the estimates used to assess the regional effects of increases in electricity costs, for example, because it is not known at this time who would be responsible for paying these costs (see Section 5.10.3.1). Another example of this type of uncertainty is the effect that breaching the lower Snake River dams would have on agricultural lands presently irrigated from Ice Harbor Reservoir. Two possible scenarios are examined in the regional analysis with the mid-point between the two used to provide an estimate of potential employment effects. Another source of uncertainty surrounds those areas where insufficient information was available to assess potential changes in sales to final demand. These areas include changes to tribal economies and the effects of dam breaching on industries other than agriculture that use the lower Snake River to transport goods. These issues are discussed further in Appendix I, Economics, Section 8.4.2.

5.14.5.2 Communities

Uncertainty also exists in the section that addresses the potential effects of the proposed alternatives on communities. Concerns with the DREW social analysis, which is one source of information used to assess these effects, are discussed in Appendix I, Economics, Section 8.4.2. Potential sources of uncertainty include concerns with the appropriateness of four assumptions used to assess the social effects of the potential alternatives. These include concerns about the allocation of sub-regional employment impacts to local communities, the use of social indicators, such as fishing licenses, poverty rates, and recreation sites to assess broader issues, the use of county-level farm data, and the assumption that job gains are positive and job losses are negative. Existing issues affecting the agricultural sector add some uncertainty to the projected effects of dam breaching on agriculture-related employment and communities.

The community-based SIA conducted by the UI Team is another source of information used in this section to assess potential effects at the community level. The UI team used a theoretical sampling process to select the communities that were included in this assessment. These communities were selected to cover the range of different types of community in the two study areas based on a series of predetermined criteria (see Harris et al., 1999a; 1999b). The ratings summarized for each community in this section are not representative of the total population of the communities studied. Rather, they present the diversity of perceived effects and associated justifications from citizens who are actively involved in their communities or interested in the salmon recovery issue. Care should be taken with the use of numerical ratings to indicate actual magnitude of effects. The scores are specific to each community and their current situation. These scores do not provide ratio-level measurement (i.e., 2 is not twice as bad as 1), but interval-level data about the perceived direction and magnitude of the projected impacts. Technical information on some of the potential effects of the proposed alternatives was not available at the time of the forums. This may have affected the responses provided by some forum participants.

5.14.5.3 Environmental Justice

Uncertainties associated with the potential effects of the proposed alternatives upon tribal communities are discussed in Appendix I, Economics, Section 8.4.3, as well as Section 5.8.4 of this document. Uncertainty surrounding the likelihood of salmon survival and recovery is the main source of uncertainty affecting this analysis. Uncertainties associated with the potential effects of the proposed alternatives upon Hispanic farm workers are primarily related to the effect that dam breaching would have upon farms that presently irrigate from Ice Harbor reservoir. As noted above, two possible scenarios are used to evaluate the potential effects of dam breaching on irrigated agriculture-related employment. Uncertainties also exist with respect to the distribution of projected electricity cost increases, the possible location of potential replacement power facilities, and the geographic distribution of potential air quality effects.

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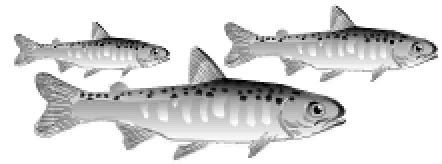


5.15 Aesthetics

Reservoir operations can have significant aesthetic impacts on adjacent lands. These impacts result from a number of factors, including increased shoreline visibility and contrast, erosion, changes in recreational facilities, changes in water characteristics, and production of dust and odors. Decreases in aesthetic quality can affect recreational use and have social and economic consequences for visitors and residents.

This section discusses the likely short-term and long-term aesthetic effects associated with the four alternatives. Short-term effects are associated with drawdown activities and newly exposed sediments. Long-term effects are those that occur after systems have stabilized. In general, most of the discussion is focused on Alternative 4—Dam Breaching because little or no change in aesthetics would be expected as a result of the first three alternatives. See Table 5.15-1 for a summary of potential effects on aesthetics.

5.15.1 Aesthetic Impact Issues

Generally, changes in the aesthetic qualities of reservoirs and river reaches can be attributed to changes in specific physical factors. These factors, discussed below, occur with reservoir drafting (the release of water from storage areas) and could occur under dam breaching conditions.

Table 5.15-1. Summary of the Potential Effects of the Alternatives on Aesthetics

Impact Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Physical Factors	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• The river and shoreline appearance would be dramatically changed with the lake-like reservoirs replaced by a near-natural river. • Water would flow at higher velocity, increasing turbidity, which could decrease water clarity and change its color. • In the short term, the river shoreline with the exposed reservoir bottom would be visually unappealing, but after about 5 years, the shoreline would start to acquire an appealing, natural look. Quality vegetation would take 10 to 25 years to reach a visually appealing, natural look. • Increased noise in the short term from deconstruction activities and in the long term from increased rail and truck traffic due to loss of barging.
Effects on Viewers	No change from current conditions.	Same as Alternative 1.	Same as Alternative 1.	• Initial increase in viewers interested in deconstruction. • Short-term decrease in viewers due to reduction in attractiveness and because attractions of interest would no longer be functioning. • Long-term stabilization or increase in viewers due to near-natural riverine character. • Presence of remaining dam structures, abandoned grain elevators, irrigation systems, and recreational facilities could be unappealing to viewers.

5.15.1.1 Shoreline Contrast

Shoreline contrast is an important visual element when there is substantial shoreline exposed due to lower reservoir levels and contrast between shoreline and adjacent uplands. The aesthetic impact of reservoir drawdown depends on the amount of shoreline exposed, the color and textural contrast between shoreline and adjacent uplands, and the number of people viewing the affected shorelines. If there is an opportunity for large numbers of people to view an exposed area, then there is a high potential for visual impact.

5.15.1.2 Erosion

Fluctuating reservoir levels can cause erosion and landslides along reservoir shores. Scarring from erosion and landslides intensifies shoreline contrast and makes landscapes unattractive. Erosion is generally less of an aesthetic concern on free-flowing river reaches, where dynamic natural processes are expected.

5.15.1.3 Seep Lakes and Embayments

Reservoir drawdown could make seep lakes and embayments susceptible to possible drying and loss of flushing action.

5.15.1.4 Water Characteristics

Changes in reservoir levels can affect the physical and visual characteristics of water in several ways. When water levels in reservoirs are lowered, the remaining water flows at a higher velocity and picks up additional sediment, which in turn leads to increased turbidity. Erosion of reservoir sediments exposed by drafting has the same effect. Increases in turbidity can decrease water clarity and change its color.

The quantity of water in a river can affect its aesthetic quality. Different viewers have different perceptions about the relationship between quantity of river flow and the aesthetic quality of the river environment. Flows similar to historic flows would be acceptable to many viewers.

5.15.1.5 Waterside Facilities

Reservoir drafting can expose waterside facilities such as beaches, swimming areas, boat ramps, docks, and marinas, leaving them unusable (impacts to recreation facilities are discussed in Section 5.13, Recreation). These abandoned and non-functional facilities can be unsightly and detract from the look and feel of a near-natural (i.e., free-flowing) river environment. Some recreation facilities depend on irrigation for park landscaping. Operating reservoirs at elevations below irrigation intakes could reduce or eliminate the ability to irrigate lawns and plantings. The aesthetic quality of these facilities would be diminished by withered or dead landscaping.

5.15.1.6 Dust and Odors

Reservoir drawdown exposes shorelines and lake bottoms to the effects of wind. Fine sediments dry out and are carried off by the wind, which can be a nuisance to nearby residents and recreationists. Odors can be created in areas where organic material is exposed as the result of drafting. Any dust or odor would only last 1 or 2 years following dam breaching.

5.15.2 The Alternatives and Their Impacts

5.15.2.1 Alternative 1—Existing Conditions

Under Alternative 1—Existing Conditions, the four hydropower facilities on the lower Snake River would continue to operate as originally designed. No impacts to aesthetics are expected under this alternative.

5.15.2.2 Alternative 2—Maximum Transport of Juvenile Salmon

Under this alternative, operation of the four dams would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to aesthetics are expected under this alternative.

5.15.2.3 Alternative 3—Major System Improvements

Under this alternative, operation of the four dams would continue as it would under Alternative 1—Existing Conditions. Therefore, no impacts to aesthetics are expected under this alternative.

5.15.2.4 Alternative 4—Dam Breaching

Under this alternative, the four dams would be breached and the lower Snake River would assume a near-natural flow and character. Aesthetic impacts could result from the physical factors discussed previously. Most of these impacts would be short-term and would subside after the river and shorelines stabilize. Figure 5.15-1 is a photograph of the existing Lower Granite Dam. It is representative of the first three alternatives (i.e., existing conditions). Figure 5.15-2 is a photograph that shows the site condition during construction of Lower Granite Dam that may be similar to the condition following implementation of Alternative 4—Dam Breaching.

Physical Factors

A total of approximately 13,772 acres of reservoir bottom would be exposed following the return of the 140-mile river stretch to a near-natural condition. Surface areas of current reservoirs and acres of exposed reservoir bottom under typical river flow conditions following dam breaching are presented in Table 5.2-2.

Implementation of Alternative 4—Dam Breaching would dramatically change the appearance of the river and its shoreline. Average surface water levels could drop from between 94 feet below minimum operating pool (MOP) at Ice Harbor to 110 feet below MOP at Lower Granite. These are, however, maximum values. The drop at the upper reservoirs could also be as little as 10 feet. The lake-like appearance of each reservoir would be replaced by a view of near-natural water which would be riverine in character.

Following drawdown, the river's shoreline would be void of vegetation. Much of the existing shoreline riparian vegetation would be lost and subsequently converted to upland habitat. A Reservoir Revegetation Plan would be implemented to accelerate the development of native vegetation and control soil erosion due to wind and rain (see Annex K of Appendix D, Natural River Drawdown Engineering). The approximately 13,772 acres of exposed reservoir bottom would be bare substrate, mainly silt and sand. In the short term (1 to 5 years), this area would be visually unappealing. In the long term (greater than 5 years), the shoreline would start to acquire a natural look. Quality vegetation would take 10 to 25 years to reach a visually appealing, natural look. Historical acreages of riparian habitat along the lower Snake River suggest that breaching of the dams could result in a long-term increase in riparian vegetation along the river.

Another aesthetic effect of Alternative 4—Dam Breaching would be increased noise. In the short-term, construction-related activities would be heard by people in the vicinity of each dam. Noise would be generated by concrete drilling and blasting equipment, vehicles used to haul materials, and other sources. The use of helicopters to implement the Reservoir Revegetation Plan would also contribute to short-term noise. In the long term, additional noise would be generated by trucks and trains whose number of trips would increase to replace barge transportation.

There would also be additional noise associated with the near-natural river than with the current reservoir system. There would, however, no longer be noise associated with operation of the four lower Snake River hydroelectric generating facilities.

Effects on Viewers

Initially, the demolition of the four dams could attract visitors who would be interested in viewing the scene; but, in general and over the longer term, viewer numbers would be considerably less than under current conditions (Corps and NMFS, 1994). Fewer visitors would be drawn specifically to the dams because navigation locks, fish facilities, and other attractions of interest would no longer be functioning.

The main visual impact would be replacement of the current lake views with views of vegetated uplands, riparian areas, and occasional glimpses of the river. Viewers from several specific areas would be more affected by visual changes than others. For example, those Clarkston and Lewiston residents whose homes overlook the river would be exposed daily to views of the drawdown until the exposed areas have revegetated. Highway travelers along U.S. 12 and other routes that follow or overlook the river would see mudflats and shoreline contrast due to dam breaching until the exposed areas were revegetated. Finally, those recreationists who visit areas near the river would see the affected lakebed areas. This group includes picnickers and trail users at Swallows Park and along the Lewiston Levee Greenbelt.

Loss of the current reservoirs may be regarded as an unavoidable adverse aesthetic impact by certain groups of viewers. For others, the long-term aesthetic impacts of Alternative 4—Dam Breaching could be positive. Over a period of several years, the river and shoreline would stabilize and become more aesthetically appealing because of features such as vegetation and beaches. Many viewers would appreciate the near-natural character of the river and its return to near-historic conditions. However, the remaining structures at the four dam sites (e.g., powerhouses, navigation locks) and disturbed work areas (e.g., disposal sites) would be clearly visible along some river reaches.

5.15.3 Cumulative Effects

Effects on aesthetic resources would be essentially the same for Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements. Under Alternative 4—Dam Breaching the exposed reservoir bottom would be visually unappealing at first, but then later, after about 5 years, would start to acquire an appealing natural look. These changes would increase the amount of visually appealing vegetated river bottom lands in the region.

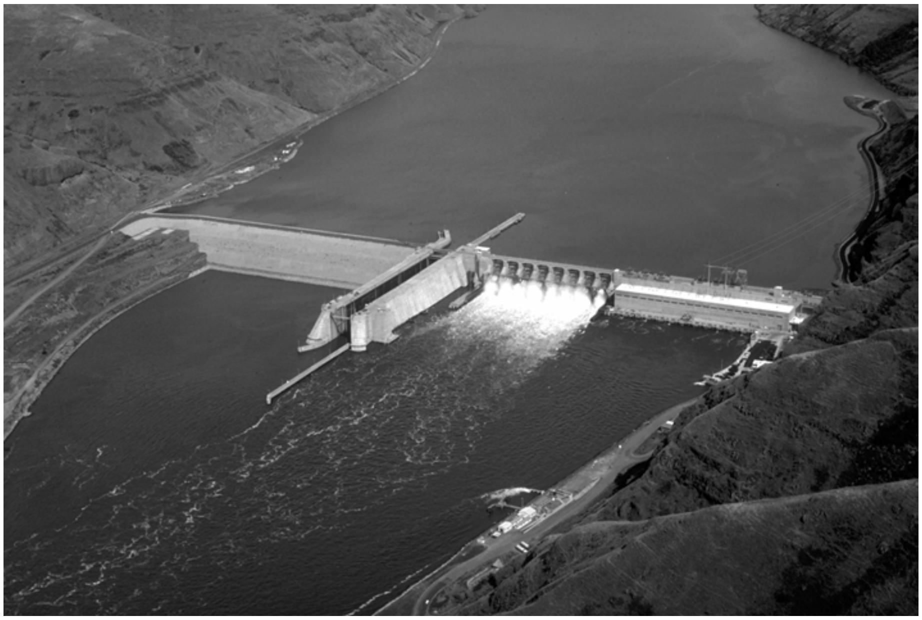
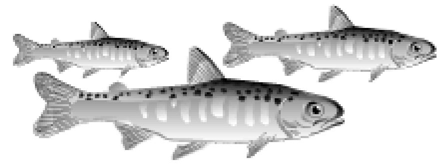


Figure 5.15-1. Current Photograph of the Lower Granite Dam Representative of the First Three Alternatives

Figure 5.15-2. Site Condition During Construction of Lower Granite Dam That May Be Similar to the Breached Condition



5.16 Economic Overview

Actions taken to improve fish passage and survival along the lower Snake River could have economic and social effects on local communities, the Snake River region, the Pacific Northwest, and the nation, as a whole. The economic effects of actions related to the lower Snake River have been analyzed by numerous entities throughout the region. To reduce conflicting analyses and pool resources for a more efficient effort, the Corps convened DREW to develop a combined economic analysis. Members of DREW included representatives of various Federal and regional agencies, tribal representatives, and other interested parties.

DREW conducted the necessary technical analyses to assess the potential economic and social effects of the four alternatives. Within DREW, smaller workgroups oversaw and provided technical support for each area for analysis. Areas of analysis included power, water supply, recreation, transportation, and tribal circumstances. The results of these analyses are summarized, as appropriate, by resource area in Sections 5.2 through 5.15.

The structure of the economic and social analysis developed for this FR/EIS is based on the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* developed by the U.S. Water Resources Council (WRC) (WRC, 1983). These guidelines recommend that the valuation and display of the effects of proposed alternatives be organized into four accounts:

- The national economic development (NED) account, which displays changes in the economic value of the national output of goods and services
- The environmental quality (EQ) account, which displays nonmonetary effects on significant natural and cultural resources
- The regional economic development (RED) account, which addresses changes in the distribution of regional economic activity

- The other social effects (OSE) account, which addresses potential effects from relevant perspectives that are not reflected in the other three accounts.

The NED account is the only account required under the WRC guidelines. This account, as well as the RED account and elements of the EQ and OSE accounts, are addressed in Appendix I, Economics. NED costs and benefits are summarized in Sections 5.8 through 5.13 of this FR/EIS, as appropriate. The RED analysis and the results of the DREW social analysis (OSE) are summarized in Section 5.14 and tribal circumstances are discussed in Section 5.8.

This section presents an overview of the overall findings of the NED analysis. The findings of the passive use value analysis developed for this study by the DREW recreation workgroup are also briefly summarized here. Passive use values are not included in the NED analysis. These findings represent cumulative effects to the economy.

5.16.1 National Economic Development

5.16.1.1 Overview and Results

The NED account addresses the net effects of a proposed action upon the nation. NED analysis is concerned only with economic efficiency at the national level. Economic gains achieved by one region at the expense of another region are not measured as NED benefits. Regional impacts are addressed under the RED account and summarized in Section 5.14. NED costs and benefits are expressed in dollars. The NED analysis conducted for this study addresses power, recreation, transportation, water supply, commercial fishing, tribal circumstances, flood control, and implementation/avoided costs.

There are no dollar benefits or costs presented for tribal circumstances or flood control. NED benefits associated with increased tribal harvest are included in the commercial fishing totals. Ceremonial and subsistence harvests are assigned a food value in the commercial fishing totals. They are not assigned an additional intrinsic dollar value.

The total NED costs and benefits identified in this analysis are presented in Tables 5.16-1, 5.16-2, and 5.16-3. These costs, presenting net of Alternative 1—Existing Conditions, were calculated for a 100-year period of analysis extending from 2005 to 2104. The values presented in these tables were discounted and converted into 1998 dollars. Tables 5.16-1, 5.16-2, and 5.16-3 show total NED costs and benefits discounted using 6.875, 4.75, and 0.0 percent discount rates, respectively.

NED costs are as follows:

- Implementation costs, including all project-related construction and acquisition costs; interest during construction; and operation, maintenance, repair, replacement, and rehabilitation costs. Implementation costs also include water acquisition from BOR, mitigation costs for fish and wildlife programs, and cultural resources protection (Alternatives 3 and 4);
- Cost increases associated with the shift from hydropower to more expensive forms of replacement power (Alternative 4—Dam Breaching);

Table 5.16-1. Summary—Average Net Annual Economic Effects, 1998 Dollars ($1,000s of dollars) (6.875% Discount Rate)

	Alternative 2	Alternative 3	Alternative 4
Costs			
Implementation Costs	-	(22,880)	(48,790)
Power	-	-	(271,000)
Transportation	-	-	(37,813)
Water Supply	-	-	(15,424)
Avoided Costs	-	(10)	-
Total Costs	**-**	**(22,890)**	**(373,027)**
Benefits			
Avoided Costs	-	-	33,570
Recreation	1,405	1,437	71,255
Commercial Fishing	160	158	1,486
Implementation Costs	3,460	-	-
Power	8,500	8,500	-
Total Benefits	**13,525**	**10,095**	**106,311**
Net Benefits	**13,525**	**(12,795)**	**(266,716)**

Notes:

1. These costs and benefits, calculated for a 100-year period of study extending from 2005 to 2104, are discounted using a 6.875 percent discount rate and converted to 1998 dollars.
2. Costs and benefits are presented for Alternatives 2 through 4 net of the base case (Alternative 1—Existing Conditions).
3. A positive monetary value indicates that the alternative being evaluated has a lower cost or greater benefit than Alternative 1—Existing Conditions. A negative monetary value indicates that the evaluated alternative has a higher cost or lower benefit than Alternative 1—Existing Conditions. Positive monetary values, therefore, represent benefits, while negative values represent costs.

Source: Appendix I, Economics (Table ES-11).

- Transportation cost increases associated with the shift of barge-transported commodities to more costly truck and rail systems (Alternative 4—Dam Breaching);
- Construction/O&M costs for irrigation and water supply systems (Alternative 4—Dam Breaching);
- Costs incurred under Alternative 3—Major System Improvements that would not be incurred under Alternative 1—Existing Conditions, or under Alternatives 2 and 4.

NED benefits are as follows:

- Costs incurred under Alternative 1—Existing Conditions that would be avoided under Alternative 4—Dam Breaching. These include operations, maintenance, repair, and replacement costs, as well as the costs associated with the rehabilitation of existing infrastructure;
- Recreation benefits from increased fish runs and the shift to a near-natural river;
- Commercial fishing benefits from increased fish runs;
- Implementation costs for fish-related improvements that would not be incurred under Alternative 2—Maximum Transport of Juvenile Salmon; and
- Power benefits from increases in system hydropower generation (Alternatives 2 and 3).

Table 5.16-2. Summary—Average Net Annual Economic Effects, 1998 Dollars ($1,000s of dollars) (4.75% Discount Rate)

	Alternative 2	Alternative 3	Alternative 4
Costs			
Implementation Costs	-	(17,200)	(35,490)
Power	-	-	(267,500)
Transportation	-	-	(33,346)
Water Supply	-	-	(10,746)
Avoided Costs	-	(60)	-
Total Costs	**-**	**(17,260)**	**(347,082)**
Benefits			
Avoided Costs	-	-	33,890
Recreation	1,382	1,371	79,339
Commercial Fishing	176	170	1,930
Implementation Costs	2,560	-	-
Power	8,500	8,500	-
Total Benefits	**12,618**	**10,041**	**115,159**
Net Benefits	**12,618**	**(7,219)**	**(231,923)**

Notes:
1. These costs and benefits, calculated for a 100-year period of study extending from 2005 to 2104, are discounted using a 4.75 percent discount rate and converted to 1998 dollars.
2. Costs and benefits are presented for Alternatives 2 through 4 net of the base case (Alternative 1—Existing Conditions).
3. A positive monetary value indicates that the alternative being evaluated has a lower cost or greater benefit than Alternative 1—Existing Conditions. A negative monetary value indicates that the evaluated alternative has a higher cost or lower benefit than Alternative 1—Existing Conditions. Positive monetary values, therefore, represent benefits, while negative values represent costs.

Source: Appendix I, Economics (Table ES-12).

Table 5.16-3. Summary—Average Net Annual Economic Effects, 1998 Dollars ($1,000s of dollars) (0.0% Discount Rate)

	Alternative 2	Alternative 3	Alternative 4
Costs			
Implementation Costs	-	(4,930)	(8,350)
Power	-	-	(263,500)
Transportation	-	-	(25,064)
Water Supply	-	-	(2,241)
Avoided Costs	-	(1,520)	-
Total Costs	**-**	**(6,450)**	**(299,155)**
Benefits			
Avoided Costs	-	-	33,870
Recreation	987	809	103,573
Commercial Fishing	198	182	3,279
Implementation Costs	660	-	-
Power	8,000	8,000	-
Total Benefits	**9,845**	**8,991**	**140,722**
Net Benefits	**9,845**	**2,541**	**(158,433)**

Notes:
1. These costs and benefits, calculated for a 100-year period of study extending from 2005 to 2104, are discounted using a 0.0 percent discount rate and converted to 1998 dollars.
2. Costs and benefits are presented for Alternatives 2 through 4 net of the base case (Alternative 1—Existing Conditions).
3. A positive monetary value indicates that the alternative being evaluated has a lower cost or greater benefit than Alternative 1—Existing Conditions. A negative monetary value indicates that the evaluated alternative has a higher cost or lower benefit than Alternative 1—Existing Conditions. Positive monetary values, therefore, represent benefits, while negative values represent costs.

Source: Appendix I, Economics (Table ES-13).

5.16.1.2 Uncertainty

Uncertainties in economic costs and benefits of the alternatives are addressed in Sections 5.6 through 5.10, 5.12, and 5.13 and in Appendix I, Economics (Section 8). Uncertainties in net NED costs and benefits are fairly broad, in particular because of uncertainties in recreational values. Further work by PATH, the DREW Anadromous Fish Workgroup, and the DREW Recreation Workgroup could significantly improve the reliability of these analyses. Other NED uncertainties, although significant in an absolute sense, are unlikely to affect decisions about whether it would be more cost-effective to breach the four lower Snake River dams.

5.16.2 Passive Use Values

5.16.2.1 Overview and Results

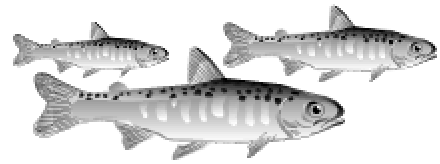
This section presents the findings of the passive use analysis conducted for this analysis by the DREW Recreation Workgroup. This passive use analysis is discussed in more detail in Section 4 of Appendix I, Economics. Economists generally recognize that there is a benefit associated with knowing that a resource exists, even if no use is made of it. These values are typically referred to as passive use, non-use, or existence values. There are, however, disagreements about how to measure passive use values. Although DREW originally requested that an original passive use survey be conducted for this study, this was not possible and passive use values were estimated using a benefit transfer approach. Corps Planning Guidance does not allow passive use values to be included in NED analysis. However, since these values could be useful as a social indicator, they are presented here as additional information for the decision-maker to consider.

The passive use value estimates for salmon were calculated on a per fish basis based on the preliminary PATH results, as extended by the DREW Anadromous Fish Workgroup. Values were calculated for Alternatives 2 through 4 net of Alternative 1—Existing Conditions. Based on these results, salmon and steelhead runs projected for Alternative 2—Maximum Transport of Juvenile Salmon were on average slightly lower than those projected for Alternative 1—Existing Conditions. There were, however, more fish in the first few decades under Alternative 2—Maximum Transport of Juvenile Salmon than under Alternative 1—Existing Conditions, which resulted in small average annual increases in passive use values once discounting was taken into consideration. Net gains were estimated to range from $0.25 million to $4.02 million per year. Salmon and steelhead runs projected for Alternative 3—Major System Improvements were less than those projected for Alternative 1—Existing Conditions, resulting in a net average annual reduction in passive use values under Alternative 3—Major System Improvements. Net reductions were estimated to range from about $0.7 million to about $31.1 million per year. Salmon and steelhead runs projected for Alternative 4—Dam Breaching were higher than those projected for Alternative 1—Existing Conditions. The average annual passive use value associated with Alternative 4—Dam Breaching, was estimated to range from $22.8 million to $301.5 million per year. The passive use value of a near-natural lower Snake River was estimated at $420 million per year.

Using the 1999 PATH model results would reduce the difference between Alternatives 1 through 3 and Alternative 4—Dam Breaching. This would lower the estimated passive use value for Alternative 4—Dam Breaching, which, as noted above, is calculated net of Alternative 1—Existing Conditions. The passive use values associated with the near-natural river would not change.

5.16.2.2 Uncertainty

Estimated ranges of passive use values associated with breaching are very broad (about $22 million to about $300 million) and reflect considerable uncertainties in measurement techniques and in estimated future returns of anadromous fish. An additional estimate of the passive use value of a free flowing river is estimated at $420 million (no range of values was estimated). Appendix I, Economics, Section 8.4.4 addresses the uncertainty associated with both the concept and calculation of passive use values.



5.17 Cumulative Effects

The National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations require Federal agencies to consider the cumulative impacts of their actions. Cumulative impacts are defined as the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what other agency or person undertakes the other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time (40 CFR 1506.7).

Cumulative impact analyses are incorporated throughout this FR/EIS. In Section 4 of the FR/EIS, each affected resource is described as to its current condition and history with respect to past and present forces that have contributed to its current status. Taken together, these forces are cumulative effects. Natural resources, like anadromous fisheries, are in their present condition as a result of an accumulation of impacts from a variety of past, present, and ongoing incremental and synergistic effects. There have been many factors that, when taken together, contribute to the decline of salmon and steelhead throughout the Columbia-Snake River Basin. As described in Section 4.5, salmon require numerous specific habitat conditions to thrive, including sufficient flows of cool, clean water; gravel beds free of sediment where they can spawn; a healthy nutrient base; and passable migration corridors. These types of factors are considered and incorporated into the environmental analyses within this FR/EIS.

The FR/EIS evaluates actions that are intended to enhance the passage and survival of juvenile fish within their migration corridor of the lower Snake and lower Columbia Rivers. While improving juvenile salmon passage at the Snake River dams can improve overall conditions for salmon and steelhead, other factors influencing the health of the salmon populations continue to be present and those factors are considered in the Section 5 environmental effects analysis. The analyses of resources in Sections 4 and 5 identify a wide variety of past and present incremental effects that culminate in the current and projected effects on each resource. The influences that affect a given resource are typically described as being positive or negative, direct or indirect. The overall effects, when taken together, are presented in the concluding parts of each resource section. In Section 4, past cumulative impacts are described in terms of their probable contribution to the present and ongoing condition of each resource. Section 5 evaluations also consider the cumulative impacts of past, present, and ongoing conditions by presenting the overall impacts that can be expected as a result of implementing each alternative.

While the FR/EIS analyses incorporate cumulative evaluations of past, present, and ongoing impacts of each individual resource, there are some reasonably foreseeable future actions that are likely and could affect the outcome of any alternative chosen for the lower Snake River. Discussions of these future actions are designed to assess how the various actions, when taken together, might affect the outcome of resources under consideration in this FR/EIS.

The following summary observations attempt to identify the likely cumulative context of the expected effects for each resource area:

- **Geology and Soils**—Erosion caused by reservoir operations and drawdown can add to sediment contributions from other activities in the basin. It is unknown whether sediment from these other sources will increase or decrease significantly in the future. Cumulatively, Alternatives 1 through 3 are far more predictable than Alternative 4—Dam Breaching, where the greatest unknowns exist.
- **Water Quality**—Land use practices elsewhere in the Snake River Basin affect water temperature conditions in the river system. It is not known whether these activities will tend to increase or decrease temperatures. While natural sources can cause dissolved gas supersaturation, falling water at river system dams appears to be the primary source of this water quality problem. The continued operation of the Lower Snake River Project will not produce an additional impact above current conditions.
- **Air Quality**—Blowing dust generated from exposed reservoir sediments would add to ambient dust from other sources, primarily agriculture and unpaved roads. Under a dam breach scenario, it is possible that more dust from these areas could combine with existing ambient levels to cause increased exceedances of air quality standards for particulates in highly localized areas. With other alternatives, minimal or no change to cumulative impacts is anticipated.
- **Anadromous Fish**—River system operations, along with many other sources, have contributed to the historical declines in anadromous fish populations. In the future, however, it is likely that the general direction of change will be positive, as recovery measures involving habitat, harvest, and hatchery operations are undertaken. Fish survival benefits associated with

implementation of a Lower Snake River Project alternative should add to improvements in other areas, resulting in higher long-term population levels.

- **Resident Fish**—The effects of the alternative actions on resident fish take place within the context of potential changes in sport fishing pressure, water quality, and management of other aquatic species, among other factors. Section 5.5.2, Resident Fish, identifies pertinent effects based on existing conditions that include changes as a result of other actions. Overall short-term negative impacts are anticipated with long-term positive impacts resulting in minimal change cumulatively.
- **Wildlife**—The loss of wildlife habitat throughout the region as a result of development and habitat conversion has been widely noted. Consequently, wildlife habitat within the system that can be protected and maintained will take on increasing regional significance, and any loss of this habitat through operational changes would be cumulative. Alternative 4—Dam Breaching was determined to have more long-term positive cumulative effects than the other 3 alternatives, even though it could take 20 to 30 years to see the results of the benefits.
- **Cultural Resources**—The situation for cultural resources is similar to that of wildlife. The continued loss and degradation of cultural resources in other areas increases the significance of those resources that can be protected and maintained. Impacts are considered to have cumulative effects under all alternatives.
- **Aesthetics**—The visual environment of all of the lower Snake River facilities has been modified to varying degrees by human activities. The immediate effects of dam breaching would diminish visual quality and would therefore have cumulative effects for the region, although it appears the long-term change would be small. Some people may find the change interesting, and thus it could be perceived as a positive change for those interested in viewing a restoration project.
- **Recreation**—If the supply of recreation opportunities does not keep pace with population growth and demand, the relative significance of the recreation opportunities provided by the river system will increase in the future.
- **Navigation**—Trends that would change the context of potential navigation impacts have been identified and incorporated in the transportation study (see Appendix I, Economics). Alternative 4—Dam Breaching would stop commercial navigation within the Lower Snake River Project, resulting in a negative cumulative effect on commerce tied to commercial navigation (i.e., barge transportation).
- **Power**—Power supply costs and electric rates have increased in recent years as a result of several factors, including drought and the Bonneville Power Administration's (BPA's) debt repayment obligations. Cost and rate impacts associated with the alternatives would cumulatively add to the level of financial strain on the regional electric system and ratepayers.
- **Irrigation**—Impacts on irrigators due to dam breaching are described in Section 5.11, Agriculture, Municipal, and Industrial Water Uses. In addition to

those effects cumulatively, irrigation pumping operations are also relatively sensitive to energy prices and can be adversely affected by electric rate increases.

- **Economic and Social Effects**—Under Alternative 4—Dam Breaching, some of the adverse economic effects associated with the alternatives would be region-wide, while others would tend to be concentrated in selected rural areas. Some of the communities likely to be affected have been experiencing long-term economic stagnation or declines through job and income losses in traditional resource-based industries. The cumulative effects of additional cost or employment impacts in these areas could be significant. Both Hispanic and tribal people might be affected by dam breaching and these effects. Tribal peoples would likely benefit from any alternative that assists in salmon recovery while Hispanics may have more economic hardships if jobs are lost in those sectors dominated by them.

Several reasonably foreseeable future major actions have been identified in the Snake River and Columbia River Basins that may add to cumulative effects from the alternatives evaluated in this FREIS. Representative actions include: Snake River Flow Augmentation (an additional 1 million acre-feet [MAF] flow augmentation from the middle and upper Snake River Basins), Interior Columbia Basin Eastside Ecosystem Management Project, Hells Canyon Relicensing Project, Conservation of Columbia Basin Fish—Federal Final Basinwide Salmon Strategy, Starbuck Power Plant, Wallula Power Plant, the Nez Perce Tribal Hatchery Program, and the Oregon Plan for Salmon and Steelhead. The latter two projects are the only projects that have been implemented. The other projects have only been studied. While the 1 MAF flow augmentation project is not necessarily a reasonably foreseeable action, it is representative of the tradeoffs future changes in flow augmentation may have. There are other projects and ongoing actions such as the Corps' efforts to relocate Caspian terns on Rice Island in the Columbia River, that have possible effects on the survival of Snake River salmon. Most of these projects, including state and county habitat restoration efforts (like those identified in the Oregon Plan for Salmon and Steelhead) will benefit salmon populations in the lower Snake River (see Section 5.5.1.1 for further analysis of cumulative effects on salmon). The following subsections summarize the projects that may adversely and/or beneficially affect the proposed alternatives for the lower Snake River.

5.17.1 Snake River Flow Augmentation Analysis

An option to provide an additional MAF of water for flow augmentation from the Snake River Basin was considered during this study, but a fully developed alternative was not formulated and this option is not considered further in this analysis.

Based upon initial study findings, the MAF option did not meet Federal criteria for completeness and public acceptability and it is not considered further in this analysis. Some background information concerning the 1 MAF analysis follows.

The 1995 Biological Opinion called on the BOR to provide 427,000 acre-feet of water for flow augmentation by acquiring water supplies from willing sellers in the middle and upper Snake River Basin. With the exception of 2001, when approximately 90,000 acre-feet were provided due to severe drought and power conditions, the BOR has provided these flows each year by leasing or acquiring water supplies and by releasing water from uncontracted storage space in BOR-owned reservoirs (see Section 2.1.7 of this FR/EIS for additional details). The Idaho statute that authorized release of the additional 427,000 acre-feet expired on January 1, 2000. This was extended until January 1, 2001. The NMFS 2000 Biological Opinion addresses flow augmentation. The Corps, BPA, and BOR are currently developing implementation plans in response to this opinion. However, with the expiration of the Idaho statute, the issue of providing augmented flows to achieve Snake River flow objectives are being addressed in a separate Section 7 consultation (NMFS, 2000a).

In 1997, the Columbia River Intertribal Fish Commission (CRITFC) asked the Corps to consider additional flow augmentation (beyond the 427,000 augmentation) as an alternative in the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study). The Implementation Team also asked the Corps to consider providing an additional 1 MAF in its Feasibility Study. Based on these requests, the Corps asked BOR to analyze the local impacts from providing an additional 1 MAF for flow augmentation. In 1997, BOR initiated the requested investigation. Findings of the 1 MAF analysis were provided to the Corps in the *Snake River Flow Augmentation Impact Analysis Appendix* dated February 1999. This appendix summarizes study findings which focus upon 1) two identified methods that might be considered to provide additional flows of 1 MAF from the Snake River System, and 2) estimated water acquisition costs and secondary economic and social impacts associated with those methods.

Acquiring a total 1.427 MAF from the Snake River Basin was analyzed conceptually—without specifying which water resources would be acquired due to uncertainty about quantifying acquisitions from the several Snake River tributaries and subbasins. The analysis did provide, however, some fundamental certainties:

- There are no sources of water in the Snake River Basin that are obvious candidates for reallocation. Within any scenario, some water users could be severely impacted while others could remain relatively untouched. Users with wide-ranging interests could be expected to vehemently oppose any effort to reallocate water from the local source
- BOR does not have sufficient storage space in its exclusive control to provide the requested volume of water. It would be necessary to reallocate existing irrigation water rights and/or contract entitlements in order to provide 1.427 MAF
- It is not possible to provide a total 1.427 MAF without reallocating existing irrigation water rights and/or contract entitlements
- If irrigation bears the primary burden for providing a total 1.427 MAF (thus protecting water quality, resident fish and wildlife, and recreation), the annual economic impact to the region is estimated to range from $76 to $130 million. Total annual acquisition costs from willing sellers could exceed $80 million
- If irrigation is protected—and instead water quality, resident fish and wildlife, and recreation bear the primary burden for providing 1.427 MAF by maximizing annual reservoir drawdowns— the annual economic impact to the

region's irrigation economy is estimated to range from $44 to $95 million. Total annual acquisition costs from willing sellers under this scenario could exceed $57 million.

With either of the evaluated scenarios, affected water interests would strenuously resist a call for this level of flow augmentation. Although various methods could be used to acquire significant volumes of water, virtually all would involve litigation, and may require congressional action to amend existing Federal BOR law and to appropriate the considerable level of funds required for water user compensation.

In summary, although a preliminary analysis of the 1 MAF option was evaluated in this study, great uncertainty and risk remains due to the difficulty at this level of analysis of specifying where water for augmentation would be obtained, predicting the likelihood of overcoming institutional constraints associated with acquiring that quantity of water, and the high level of predicted economic and social impacts. Further, data to assess the biological benefits of additional flow augmentation were not developed by the Plan for Analyzing the Testing Hypotheses (PATH); consequently, an alternative could not be formulated in sufficient detail to compare the relative benefits and costs of a 1 MAF alternative to the other alternatives developed for this FR/EIS.

5.17.2 Interior Columbia Basin Ecosystem Management Project

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) was initiated to:

- Identify existing or emerging resource problems that transcend jurisdictional boundaries, such as forest health problems and declining salmon populations, that can be addressed on a large scale
- Develop management strategies using a comprehensive "big picture" approach, and disclose interrelated actions and cumulative effects using scientific methods in an open public process
- Address certain large-scale issues such as species viability and biodiversity from a larger context using an interagency team
- Respond to President Clinton's July 1993 direction to develop a scientifically sound ecosystem-based management strategy for lands administered by the Bureau of Land Management (BLM) or Forest Service in the upper Columbia River Basin
- Replace interim management strategies with a consistent long-term management strategy.

In response, management direction for Forest Service- and BLM-administered lands across parts of seven states in the Pacific Northwest was re-examined and two draft EISs were prepared for different portions of the area covered by the ICBEMP. The project area for the upper Columbia River Basin includes 45 million acres of lands administered by the BLM or Forest Service in parts of Idaho, western Montana and Wyoming, and northern Nevada and Utah that are drained by the Columbia River System. The planning area for the Eastside EIS (as it is commonly called) includes

30 million acres of lands administered by the BLM or Forest Service in the interior Columbia River Basin, upper Klamath Basin, and northern Great Basin that lie east of the crest of the Cascade Range in Oregon and Washington. A final EIS was issued on December 15, 2000 that covers both upper Columbia and eastside areas. Currently, the implementation strategy is being worked on by the BLM.

The two factors that underlie all of the management strategies of the alternatives selected for evaluation include: 1) ecosystem restoration, and 2) economic sustainability for people and communities dependent upon resources from Forest Service- and BLM-administered lands.

The final implemented management strategy that could cumulatively affect the Lower Snake River Project would likely involve riparian restoration that over time may improve the fish habitat on Federally administered lands in the Snake River watershed. High quality habitat alone could increase abundance of individual fish, but would not likely reverse current negative population trends in the short term.

5.17.3 Hells Canyon Relicensing Project

The Hells Canyon Relicensing Project is a series of efforts and studies required by the Federal Energy Regulatory Commission (FERC) to relicense operating hydroelectric projects. The Hells Canyon Complex is operated by Idaho Power and consists of three developments or dams, reservoirs, and hydroelectric facilities: 1) Brownlee Development, 2) Oxbow Development, and 3) Hells Canyon Development. The numerous studies include aquatic, wildlife, botanical, historical and archaeological, and aesthetic studies. The results of the studies may change the operations on the project which may have adverse or beneficial effects to the lower Snake River. Information from the studies will be used to develop a new license application that will be submitted to FERC in 2003. The current license for the Hells Canyon Dam expires in 2005. It is not known what environmental enhancement measures or operational changes will be implemented at the Hells Canyon Dam, but if enhancements and operation measures help to increase the survival of fish or increase habitat availability for fish and wildlife, these changes would contribute beneficially to the recovery of salmon in the lower Snake River.

5.17.4 Nez Perce Tribal Hatchery Program

The Nez Perce Tribal Hatchery Program is a salmon supplementation program that uses techniques compatible with existing aquatic and riparian ecosystems that would rear and release spring and fall chinook salmon, biologically similar to wild fish, to reproduce in the Clearwater Subbasin. The purposes of the program include:

- Protection, mitigation, and enhancement of Columbia River Basin anadromous fish resources, and development and reintroduction of natural spawning populations of salmon within the Clearwater Subbasin
- Long-term harvest opportunities for tribal and non-tribal anglers within Nez Perce treaty lands within four salmon generations (20 years) following project completion
- Sustainable long-term fitness and genetic integrity of targeted fish populations

- Acceptable limits of ecological and genetic impacts to non-targeted fish populations
- Promotion of Nez Perce management of tribal hatchery facilities and production areas within Nez Perce treaty lands.

The multi-million dollar Nez Perce Tribal Hatchery Program is in the pre-construction phase while securing final funding from BPA. The hatchery complex, as planned, will actually consist of 2 central incubation and rearing facilities, 6 satellite rearing facilities, and 11 temporary weir sites. Maximum production goals are 768,000 spring chinook and nearly 3 million fall chinook juveniles, although initial production will be far below the maximum. NMFS completed a Biological Opinion in 1997 for Nez Perce Tribal Hatchery operations in 1998-2002. The Nez Perce Tribe is also working on a project to restore coho to the Clearwater River, with initial funding provided by the Bureau of Indian Affairs (BIA) for the release of approximately one million coho juveniles, taken from lower Columbia hatcheries and reared at existing facilities in the Clearwater River. The Clearwater River has also been a focus watershed for habitat improvements under the Northwest Power Planning Council's program, with which the artificial production programs are intended to be linked.

Based on BPA conclusions and the NMFS Biological Opinions, this project would not likely adversely affect listed salmon on the Snake River. The hatchery program would have little or no adverse impact to fish mortality of listed fish, and would not interfere with other recovery actions or otherwise impede the recovery of spring/summer chinook and sockeye salmon (BPA et al., 1997). Threatened fall chinook populations would be supplemented and increased by the Nez Perce Tribal hatchery. This hatchery program would benefit the tribes and may have positive effects on wildlife and recreation and tourism resources.

5.17.5 Conservation of Columbia Basin Fish—Federal Final Basinwide Salmon Recovery Strategy

The Conservation of Columbia Basin Fish—Federal Final Basinwide Salmon Recovery Strategy (formerly the "All-H Paper") is a planning approach to restoring threatened and endangered salmon and steelhead throughout the Columbia River Basin (The Federal Caucus, 2001). This final strategy, released in December 2000 is a complementary document to the December 2000 Biological Opinion on continued operation of the Federal Columbia River Power System. The document outlines specific actions to be taken by the Federal government consistent with the 2000 Biological Opinion, and proposes additional actions for tribal, state and local governments, which together are intended to prevent extinction of the 12 salmon species listed under ESA and lead to their ultimate recovery.

At the core of the strategy are actions Federal agencies can take now to stabilize populations and show immediate results across all life stages. Habitat actions are identified as those necessary to protect and restore tributary habitat and to improve survival during spawning and rearing. Actions include removing passage barriers and screening diversions, purchasing in-stream flow rights, restoring water quality, and acquiring high-quality habitat. Included in the list of possible Federal actions is a call to improve passage through dams. However, removing Snake River dams is dismissed because breaching is thought to only benefit Snake River fish, with no benefit to the other eight listed populations; it has high costs; it is not within the existing authorities of Federal agencies; and it might take away from other actions necessary within the basin. Implementing these strategies in the basin would likely lead to positive impacts on salmon species regardless of which alternative is chosen under the Feasibility Study.

5.17.6 Starbuck Power Project

The Starbuck Power Project is a 1,200-megawatt natural gas-fired, combined-cycle combustion turbine plant proposed by Starbuck Power Company, LLC of Bellevue, Washington. The plant is proposed to be located on a 96-acre parcel adjacent to the Snake River along the upper reaches of Lake Herbert G. West in Columbia County. As currently designed, the plant would be located no closer than 200 feet from the Snake River and would be adjacent to the Columbia County Grain Growers' Lyons Ferry Grain Elevator. The proposed plant is currently being reviewed by the Washington State Energy Facility Site Evaluation Council and is proposed for commercial operation starting in 2004.

The Starback project would use groundwater from the town of Starbuck to supplement air cooling equipment and all wastewater would be disposed in a retention pond and then into the soil on the plant premises. The plant would be fueled by natural gas from Pacific Gas and Electric Gas Transmission Companies' 36-inch mainline natural gas pipeline which crosses within 200 feet of the plant site. Approximately 15 miles of new 500 kV transmission line would need to be constructed to interconnect the new plant with the BPA transmission system at the Lower Monumental Dam switchyard. Air emissions will include oxides of nitrogen, carbon monoxide, sulfur dioxides, and some volatile organic carbons. The project would be required to obtain a Prevention of Significant Deterioration permit from the local air pollution control authority, which would establish the conditions and limits of permitted air emissions. An estimated 550 individuals would need to be employed during construction and a total of 35 individuals would operate and maintain the plant after the 2-year construction period is completed.

Because there are no direct discharges planned for the lower Snake River, only indirect adverse effects from runoff are anticipated. A large influx of employment in the region could strain area housing and social services programs, particularly if dam breaching activities were occurring at the same time. It is not expected that this project would have any direct or significant fisheries impacts related to the construction or operation of the project.

5.17.7 Wallula Power Plant

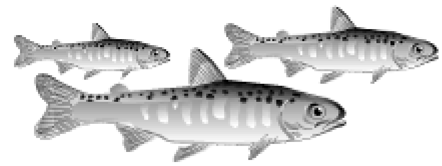
The Wallula Power Plant is a proposed 1,300 MW natural gas-fired, combined-cycle power plant to be located along State Highway 12 near Wallula in Walla Walla County, Washington. The site is to be located on an 80-acre industrial zoned site adjacent to a cattle feedlot and pulp and paper mill. A 6-mile-long natural gas pipeline and 6-mile-long electric transmission line would connect the proposed plant with existing gas and electric transmission lines in the area. Water for the proposed facility is proposed to come from a deep aquifer on site and from purchased water that could come from the Snake River, Touchet River, or other nearby industrial wastewater sources. At this time, a site study is underway by the applicants, Newport Northwest, LLC. Washington's Energy Facility Site Evaluation Council will evaluate the application and is expected to take 2 years to complete its application review. This project could have direct impacts to the lower Snake River if cooling water was withdrawn from the river; however, it is unknown if this will occur or not. There also could be severely strained social and public services within the region if construction of this facility was to take place at the same time as other large projects such as dam breaching.

5.17.8 Oregon Plan for Salmon and Steelhead

The Oregon Plan for Salmon and Watersheds was first adapted by the State of Oregon in 1997. The plan is a statewide approach to natural resource management. The plan currently has two main parts: the Coastal Salmon Restoration Initiative, focused on restoring coho, and the Healthy Streams Partnership, focused on improving water quality throughout Oregon. The plan focuses on conservation actions that are designed to improve water quality and includes measures to replace culverts at road crossings and modify diversion structures and apply fish screens where necessary. Implementing these strategies in the Columbia River Basin would likely lead to positive impacts on salmon species regardless of which alternative is chosen under the Feasibility Study.

5.17.9 Uncertainties in Cumulative Effects

Estimates of likely cumulative effects of the alternatives are sensitive to the factors discussed above for each of the resource areas and potential actions. Additional uncertainties are introduced by the inability to predict which of many possible future actions are likely to occur in conjunction with a selected alternative. To a large degree, these possible actions are still in the conceptual or early planning stages with detailed plans or implementation that would occur in the longer term (perhaps 5 to 10 years). Therefore, there is a high level of uncertainty concerning the cumulative effects of these potential actions.



5.18 Relationship Between Short-term Uses and Long-term Productivity

Throughout the Section 5 resource analyses, the resource effects are analyzed with respect to short-term and long-term effects. The long-term effects analyses include consideration of the short-term effect analyses. The following paragraph highlights some of the broader relationships and is not intended to repeat analyses already provided. This discussion presents some of the tradeoffs considering the relationship between short-term uses of humankind's environment and the maintenance and enhancement of long-term productivity.

The choices between Alternative 1—Existing Conditions through Alternative 3—Major System Improvements and Alternative 4—Dam Breaching represent stark tradeoffs between developmental and nondevelopmental values. Alternative 4—Dam Breaching would eliminate electrical energy generation via hydropower and navigation on the lower Snake River in the short term and long term. Breaching the dams would also cause short-term impacts including soil erosion, dust generation, degradation of water quality, loss of existing riparian or wetland vegetation, disruption of fish and wildlife habitat, disruption of recreation use, degradation of visual quality, and damage to cultural resources. If operational measures lead to increases in salmon populations in the long term, the productivity of salmon resources would increase and possibly contribute to the long-term recovery of species listed under ESA. Under Alternative 4—Dam Breaching, however, the long-term use of the river for navigation and power generation would be reduced and eliminated for most related uses. Loss of pumping abilities for irrigators could lead to long-term losses in agricultural productivity. On the positive side, there would be increased recreation opportunities for those activities that require or benefit from near-natural river conditions. The restoration of a riverine riparian zone and active floodplain may also provide long-term benefits to aquatic and terrestrial communities.

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