Executive Summary

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This Final Feasibility Report/Environmental Impact Statement (FR/EIS) and its 21 appendices document the results of a comprehensive analysis of the four dams on the lower Snake River (collectively called the Lower Snake River Project) and their effects on four lower Snake River salmon and steelhead stocks listed for protection under the Endangered Species Act (ESA). The U.S. Army Corps of Engineers (Corps), along with the Bonneville Power Administration (BPA), U.S. Environmental Protection Agency (EPA), and U.S. Bureau of Reclamation (BOR) as cooperating agencies, analyzed four alternatives to evaluate the best way to improve juvenile salmon migration through Lower Snake River Project. The Final FR/EIS includes the best available information on the biological effectiveness, engineering components, costs, economic effects, and other environmental effects associated with the four alternatives: Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, Alternative 3—Major System Improvements (Adaptive Migration), and Alternative 4—Dam Breaching. In the Final FR/EIS, the Corps identifies Alternative 3—Major System Improvements (Adaptive Migration) as the recommended plan (preferred alternative) and explains the process for selecting that alternative.

ES.1 Study Area

The FR/EIS coverage of the affected environment and the effects of the alternatives on environmental resources and economic uses, focuses on the 140-mile long lower Snake River reach between Lewiston Idaho, and the Tri-Cities in Washington.

The Snake River is the principal tributary to the Columbia River, draining approximately 109,000 square miles in Idaho, Wyoming, Utah, Nevada, Washington, and Oregon. The Lower Snake River Project features four locks and dams in the state

of Washington: Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam.

Juvenile fish from the lower Snake River drainage system may have to travel past as many as eight Federal dams before reaching the Pacific Ocean. The four dams on the mainstem Columbia River are addressed in the Feasibility Study, where appropriate, because they are part of the corridor juvenile salmon travel between the Lower Snake River Project and the ocean. Federal and private dams on the middle and upper Snake River are not included in this study.

ES.2 Decline of Salmon and Steelhead

The decline of salmon and steelhead in Pacific Northwest rivers is a complex problem. It is not possible to point to one specific cause. The problem stems from a variety of interrelated sources that regional scientists are working hard to evaluate and understand. Factors contributing to the decline of salmon and steelhead runs in the Columbia-Snake River Basin are: overharvest; loss and degradation of habitat in rivers and tributaries; destruction of estuary habitat used for rearing; competition and other dangers posed by hatchery fish; altered habitat and related challenges posed by dams and reservoirs; and other human-related causes such as timber harvest, farming, industrial facilities, urbanization, etc. Each of the above factors either individually or in combination may be major contributors to the decline of anadromous fish runs in the Snake River.

Because of the continued decline of some Columbia-Snake River Basin salmon and steelhead populations, the National Marine Fisheries Service (NMFS) listed the Snake River sockeye salmon as endangered under the ESA in 1991. In 1992, Snake River spring/summer chinook and Snake River fall chinook salmon were listed as threatened. In 1997, lower Snake River steelhead were listed as threatened. By 1999, NMFS had placed another nine anadromous fish species throughout the Columbia-Snake River Basin on the Endangered Species List. This Feasibility Study focuses on one piece of an overall regional salmon decline with causes above and beyond the four lower Snake River dams.

ES.3 The Feasibility Study

The genesis of this Feasibility Study was the 1995 NMFS *Biological Opinion for the Reinitiation of Consultation on 1994-1998 Operation of the Federal Columbia River Power System (FCRPS) and Juvenile Transportation Program in 1995 and Future Years* (1995 Biological Opinion). In 1998, NMFS issued a supplement to the 1995 Biological Opinion, and, in 2000, it issued an updated Biological Opinion on FCRPS operations. The Final FR/EIS responds to the reasonable and prudent alternative in these documents.

ES.3.1 Background

The Feasibility Study was officially announced to the public on June 5, 1995. In July 1995, the Corps conducted public scoping meetings to initiate the Feasibility Study and begin the National Environmental Policy Act (NEPA) process. The stated purpose of the Feasibility Study was to evaluate and screen structural alternative measures that may increase the survival of juvenile anadromous fish through the Lower Snake River Project and assist in the recovery of listed salmon and steelhead stocks. In December 1996, the Corps issued the Interim Status Report, which marked

the decision point to elevate dam breaching—removal of the earthen embankments and shutdown of hydropower operations at all four dams to allow for a near-natural flow—as the drawdown alternative that would be evaluated in the EIS.

Because the alternatives considered in this study would affect resources of concern to all people of the Pacific Northwest, the Corps structured the Feasibility Study process to involve participation of the whole region. During the alternative development stage, the Corps provided numerous opportunities for public input through Regional Roundtable Workshops and a series of public information meetings held in 1997 and 1998.

Biological data were collected and analyzed to allow for the best possible comparison of alternatives and their associated effects on the migration of juvenile salmon and steelhead, and on other environmental resources. Most of the data related to anadromous fish were provided by NMFS and a workgroup called the Plan for Analyzing and Testing Hypotheses (PATH). Engineering analysis and design reviews of the alternatives were also conducted to present key engineering and cost information as well as the engineering/construction process necessary for implementation. Additional economic data were collected and analyzed to allow for an accurate cost comparison of the alternatives at both the regional and national levels. The Drawdown Regional Economic Workgroup (DREW), a group of regional economists convened for the Feasibility Study, provided input on the economic issues associated with the alternatives. All of this biological, environmental, engineering, and economic information was collected, reported, and evaluated in the Draft FR/EIS and its associated appendices.

ES.3.2 Draft FR/EIS

The Draft FR/EIS and its appendices were released for public review and comment in December 1999. The Draft FR/EIS synthesized the biological, environmental, engineering, and economic information and evaluation to allow for a comparison between four selected alternatives.

The comment period on the Draft FR/EIS began December 1999 and extended through April 30, 2000. Formal public meetings were conducted after the Draft FR/EIS was distributed for public review. In conjunction with the Federal Caucus (a group of Federal agencies with interests in salmon recovery efforts), a series of 15 formal meetings were held around the region in February and March 2000 to provide an opportunity for public questions and comments on the Draft FR/EIS, the Corps' John Day Drawdown Study, and the Federal Caucus Conservation of Columbia Basin Fish "All H" Paper. A total of nearly 9,000 participants consisting of stakeholders, special interest groups, elected officials, and individuals from the public presented 1,787 oral and taped comments. Oral comments, taped comments, and written comments (over 230,000 written comment documents) were received during the comment period. Written comments were received in the form of individual letters, reports, notecards, petitions, emails, etc.

The Corps evaluated each comment received so that issues of concern could be identified and considered by technical experts. Issues raised in public comment were summarized into issue statements and are provided, along with a response, in Appendix U to the Final FR/EIS.

NMFS released their most recent Biological Opinion on Federal Columbia Power System Operations in December 2000. The Final FR/EIS incorporates considerations

of the applicable aspects of the NMFS 2000 Biological Opinion. The Final FR/EIS also incorporates considerations from the U.S. Fish and Wildlife Service (USFWS) Biological Opinion and the Federal Caucus' Basinwide Recovery Plan released in December 2000.

ES.3.3 The Final FR/EIS

The Corps released the Final FR/EIS and its 21 appendices in February 2002. The Final FR/EIS incorporates evaluation of additional data, comments, and other information gathered since release of the draft document.

The Final FR/EIS combines the format of a traditional Corps feasibility planning document and a NEPA EIS. The FR/EIS and associated technical appendices provide: 1) a complete presentation of study results and findings; 2) compliance with applicable statutes, Executive Orders, and policies; 3) a sound and documented basis with which both Federal and regional decision makers can judge the recommended solution; 4) scope, schedule, budgets, and technical performance requirements for the implementation of the selected alternative; and 5) documentation for subsequent funding for the implementation of specific measures associated with the preferred alternative (recommended plan).

At least 45 days after release of the Final FR/EIS to the public, the Corps will prepare a Record of Decision (ROD) documenting the recommended action resulting from the Feasibility Study process.

ES.4 The Lower Snake River Project

The dams became operational between 1961 and 1975. The four dams are all run-of-river facilities, which means that they have limited storage capacity in their reservoirs and pass water through the dam at about the same rate as it enters the reservoir. All four of these dams are multiple-use facilities that provide navigation, hydropower, irrigation, recreation, and fish and wildlife conservation benefits. These dams were not built to control floods. Storage reservoirs, such as the Dworshak Reservoir on the North Fork of the Clearwater River, are used to store water and adjust the river's natural flow patterns. The normal operating ranges and usable storage volumes for the affected four lower Snake River facilities are listed in Table ES-1.

Table ES-1. Characteristics of the Four Lower Snake River Facilities

Facility	Type of Facility	Snake River Mile	Reservoir Name	Reservoir Capacity 1/ (acre-feet)	Total Reservoir Capacity (acre-feet)	Reservoir Elevation 1/ (NGVD29)
Lower Granite	run-of-river	107.5	Lower Granite Lake	49,000	483,800	733 to 738
Little Goose	run-of-river	70.3	Lake Bryan	49,000	565,200	633 to 638
Lower Monumental	run-of-river	41.6	Lake Herbert G. West	20,000	432,000	537 to 540
Ice Harbor	run-of-river	9.7	Lake Sacajawea	25,000	406,500	437 to 440

1/ normal operating range
NGVD29 = National Geodetic Vertical Datum
Source: Corps and NMFS, 1994

ES.5 Current Fish Passage at the Lower Snake River Project

The four lower Snake River dams were designed with features to aid the migration of both juvenile and adult fish. In the last 25 years, the Corps has consistently investigated and adopted new technologies for maximizing the number of fish that safely pass the dams in both directions. Successful features at the lower Snake River dams include adult fish ladders, juvenile bypass systems, and the fish transportation program.

For adult fish returning from the Pacific Ocean to spawn, fish ladders and devices to attract fish to the entrances of the ladders are the primary aid to their passing the dams. Fish ladders have been in place since the dams were built in the 1960s and early 1970s. Improvements to these ladders have been made at all four dams. Since 1996, the cumulative survival for adult salmon through all four lower Snake River dams and reservoirs ranges from 92 to 98 percent. The survival rate through each dam and reservoir is 96 to 100 percent.

For juvenile fish traveling downriver, the dams and reservoirs present a more complex set of hazards. The slower water exposes juvenile fish to resident fish predators for a longer time. In addition, spill below the dam increases turbulence and exposure of juvenile salmon to predatory birds. When juvenile fish arrive at a dam, they can pass it in three ways: through the turbines (about 90 to 95 percent survival past a dam), through the spillway with the water (about 98 percent survival past a dam), or through bypass systems, where most are diverted to trucks or barges for transport downriver (about 98 to 99 percent survival to the point of release below Bonneville Dam).

Currently, the Corps, in coordination with NMFS, manages juvenile fish passage to "spread the risk." This spread-the-risk policy balances the number of fish that pass through the Lower Snake River Project in the river versus those that are diverted and transported below Bonneville Dam by barge or truck. About 50 to 65 percent of all fish traveling through the lower Snake River are diverted and collected for transport. The remainder are left in the river. The spread-the-risk policy is necessary because the long-term positive and negative effects of both in river and barge/truck transportation are not clear. Balancing the two approaches is a prudent course of action while there is still some uncertainty because it ensures that no inadvertent reduction in survival occurs if one approach is significantly favored over another.

Short-term (direct) survival of juvenile fish through the Lower Snake River Project is measurable, and the numbers are generally positive. The average survival through a dam and reservoir on the lower Snake River for most stocks of juvenile salmon is in the 90-percentile range. Cumulative survival for juvenile salmon through all four dams and reservoirs is over 80 percent. Cumulative survival for juvenile salmon through all eight dams on the Columbia River System ranges from 45 to 60 percent.

Scientists do not know the cause of mortality for a certain portion of salmon who make it to the ocean as juveniles, but then do not return upriver to spawn as adults. Some suspect that a portion of this "extra mortality" is delayed mortality that may occur after juvenile salmon have passed Bonneville Dam. Scientists are unsure whether this delayed mortality could be caused by passing in river through the series of eight dams and reservoirs from Lower Granite Dam to Bonneville Dam, from the transportation of fish by barge or truck, or by non-hydropower related causes.

The anticipated effects of each alternative on listed Snake River anadromous fish are shown in Table ES-2.

Table ES-2. Anticipated Effects of Each Alternative on Snake River Anadromous Fish

Alternatives	Extinction 1/	Recovery 1/	Juvenile Survival 2/	Adult Survival 3/	Habitat 4/
Alternative 1- Existing Conditions 5/					
SPRING/SUMMER CHINOOK	⚪	⚪	🟠	🟠	🟠
FALL CHINOOK	⚪	⚪	🟠	🟠	🟠
STEELHEAD	🟠	⚪	🟠	🟠	🟠
SOCKEYE	⚪	⚪	🟠	🟠	🟠
PACIFIC LAMPREY	6/	6/	🟠	🟠	🟠
Alternative 2 - Maximize Transportation 5/					
SPRING/SUMMER CHINOOK	🔴	⚪	🔴	🔴	🟠
FALL CHINOOK	🔴	🔴	🔴	🔴	🟠
STEELHEAD	🔴	⚪	🔴	🔴	🟠
SOCKEYE	🔴	⚪	🔴	🔴	🟠
PACIFIC LAMPREY	6/	6/	🟠	🟠	🟠
Alternative 3 - Major Systems Improvements (Adaptive Migration) 5/					
SPRING/SUMMER CHINOOK	🔴	🟠	🔴	🔴	🔴
FALL CHINOOK	🔴	🟠	🔴	🔴	🔴
STEELHEAD	🔴	🟠	🔴	🔴	🔴
SOCKEYE	🔴	🟠	🔴	🔴	🔴
PACIFIC LAMPREY	6/	6/	🔴	🔴	🟠
Alternative 4 - Dam Breaching 5/					
SPRING/SUMMER CHINOOK	🔴	🔴	🔴	🔴	🔴
FALL CHINOOK	🔴	🔴	🔴	🔴	🔴
STEELHEAD	🔴	🔴	🔴	🔴	🔴
SOCKEYE	🔴	🔴	🔴	🔴	🔴
PACIFIC LAMPREY	6/	6/	🔴	🔴	🔴

🔴 A positive change 🔴 Slight positive change 🟠 No change ⚪ Slight negative change ⚪ A negative change

1/ Extinction and Recovery parameters are estimates limited to the contributions of lower Snake River hydrosystem actions as evaluated by CRI (Extinction) and PATH (Recovery). They are represented by the NMFS lambda estimates reported in Table 6-3 of the FR/EIS main report.

2/ Estimate of effects based on total system juvenile passage survival through the eight lower Snake/lower Columbia River Federal mainstem dams, with and without transportation, as applicable to the alternative operations using ranges found in the FR/EIS.

3/ Estimate of effects based on total system adult passage survival through the four lower Snake River dams.

4/ Habitat effects are estimated based on fish passage, rearing, and spawning.

5/ Alternative 1 is change through time relative to existing conditions; Alternatives 2, 3, and 4 are compared to Alternative 1.

6/ No estimate of extinction or recovery is available for Pacific lamprey (not an ESA-listed species).

ES.6 FR/EIS Alternatives

The four alternatives that are evaluated in detail in the FR/EIS are:

- Alternative 1—Existing Conditions
- Alternative 2—Maximum Transport of Juvenile Salmon
- Alternative 3—Major System Improvements (Adaptive Migration)
- Alternative 4—Dam Breaching

Figure ES-1 highlights the features of each of the alternatives. A brief description of the components of the alternatives is provided here.

ES.6.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions consists of continuing the operation of the fish passage facilities and project operations that were in place or under development at the time that this FR/EIS was initiated. Operations under Alternative 1—Existing Conditions would continue to meet the authorized uses of the Lower Snake River Project. In addition to the structural changes that would be implemented (e.g., additional barges for transporting juvenile fish, new turbine cams and runners, and upgraded Lower Granite juvenile fish facilities), it is assumed that flow augmentation would continue. Project operations—including all ancillary functions such as fish hatcheries and Habitat Management Units (HMUs), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions. Alternative 1—Existing Conditions would include the spread-the-risk strategy for downstream juvenile fish passage using existing or currently planned facilities. This alternative is the base case or "no action" alternative considered in this NEPA process.

ES.6.2 Alternative 2—Maximum Transport of Juvenile Salmon

All of the existing or planned structural configurations and flow augmentation of 427 thousand acre-feet (KAF) from the existing conditions would be included in this alternative. However, this alternative assumes that the juvenile fish transportation systems would be operated to maximize fish transport and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor). To accommodate maximum transport of juvenile salmon, measures would be used to maintain, upgrade, and significantly improve fish facilities that would focus on limiting in-river migration.

ES.6.3 Alternative 3—Major System Improvements (Adaptive Migration)

The Corps has selected Alternative 3 as the recommended plan (preferred alternative). This alternative has been modified slightly since the Draft FR/EIS to provide more of a focus on adaptive migration, reflecting the strategies in the 2000 NMFS Biological Opinion. Adaptive migration is an approach that provides greater flexibility to switch between in river migration and barge or truck transportation as conditions require, and as new information becomes available.

Figure ES-1. Lower Snake River Juvenile Salmon Migration Feasibility Study, Alternatives Matrix

	Alternative 1 —Existing Conditions	**Alternative 2** —Maximum Transport	**Alternative 3** —Major System Improvements	**Alternative 4** —Dam Breaching
Existing System Operations				
Adult Fish Passage Systems				
Fish Ladders	√	√	√	
Pumped Attraction Water Supplies	√	√	√	
Powerhouse Fish Collection Systems	√	√	√	
Juvenile Fish Bypass and Collection Systems				
STS – IHR, LMO	√	√	√	
ESBS – LGO, LGR	√	√	√	
Collection and Transportation Facilities	√	√	√	
Trash Shear Boom	√	√	√	
Minimum Operating Pool – During Fish Migration	√	√	√	
Turbine Operations – Within 1 percent Peak Efficiency	√	√	√	
Voluntary Spill				
Current Operations	√			
Minimize Operations – IHR Only		√		
Optimize Operations			√	
No Spill				√
Flow Augmentation (Dworshak)	√	√	√	√
Flow Augmentation (Upper Snake River) – 427,000 acre feet	√	√	√	√
Dissolved Gas Abatement Measures				
Spillway Gas Control Measures (Deflectors)	√	√	√	
Spillway Gas Monitoring	√	√	√	
Continue Fish Facility Operations	√	√	√	
Continue AFEP Evaluations	√	√	√	
Power				
Current Production	√		√	
Increased Production		√		
No Production				√
Navigation				
Current Operations	√	√	√	
No Operations				√
Fish Transportation				
Spread-the-Risk	√			
Optimize Transportation			√	
Maximize Transportation		√		
No Transportation				√

STS submerged traveling screen
ESBS extended submerged bar screen
IHR Ice Harbor Dam
LMO Lower Monumental Dam
LGO Little Goose Dam
LGR Lower Granite Dam
AFEP Anadromous Fish Evaluation Program

Alternative 3—Major System Improvements (Adaptive Migration) assumes that juvenile fishway systems would be operated under an adaptive migration strategy that balances the passage of fish between in-river and transport (via barge or truck) methods. It would allow the flexibility for implementing operational changes within a migration season, if necessary. This alternative would include all of the existing or planned structural configurations from Alternative 1—Existing Conditions and Alternative 2—Maximum Transport of Juvenile Salmon. For example, spillway flow deflectors and pier extensions would be used to help lower total dissolved gas (TDG) concentrations. In addition, Alternative 3—Major System Improvements (Adaptive Migration) would include major system improvements that would provide a greater ability and more options to better adjust migration approaches (i.e., either in-river or transport).

Operations under Alternative 3—Major System Improvements (Adaptive Migration) would include activities prescribed in the 1995, 1998, and 2000 Biological Opinions to improve juvenile fish passage conditions.

Alternative 3 would incorporate several recently developed and/or tested technological improvements to increase survival through the Lower Snake River Project. Figures illustrating surface bypass collectors (SBC), behavioral guidance structures (BGS), removable spillway weirs (RSW), and technology for reducing total dissolved gas are provided in Section 2.1 of the FR/EIS.

Even though survival rates through the Lower Snake River Project dams are high, prototype systems of the SBC, BGS, and RSW have been tested at Lower Granite Dam to see if survival and passage conditions can be improved. Preliminary tests indicate increased fish passage efficiency through a combined system, including submerged screens. Development of additional system technologies is one of the measures recommended in the 2000 NMFS Biological Opinion.

ES.6.4 Alternative 4—Dam Breaching

Dam breaching would create a 140-mile stretch of river with near-natural flow by removing the earthen embankment section of each dam and eliminating the reservoirs at all four lower Snake River dams. The powerhouses, spillways, and navigation locks would not be removed, but would no longer be functional. All facilities for transporting fish would cease to operate, as would hydropower operation. The navigation locks would no longer be operational, and navigation for commercial and large recreation vessels would be curtailed. Similarly, recreation opportunities, operation and maintenance of hatcheries and Habitat Management Units (HMUs), and other activities associated with the modification from a reservoir environment to an unimpounded river in the lower Snake River would entail important changes in these activities. Under Alternative 4—Dam Breaching, some water quality conditions such as TDG concentrations, would likely be at or near natural conditions. However, other conditions such as water temperature, would still be affected by upstream conditions or releases.

ES.7 Economics

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. To reduce conflicting analyses and

pool resources for a more efficient effort, the Corps convened DREW to develop a combined economic and social analysis. Members of DREW included representatives of various Federal and regional agencies, tribal representatives, and other interested parties.

Primary areas of analysis included power, recreation, transportation, irrigation, water supply, commercial fishing, avoided costs, implementation costs, and tribal circumstances. The final analysis addresses potential economic and social effects at three geographic scales—national, regional, and local. National and regional effects are addressed in separate accounting stances. The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services, while the Regional Economic Development (RED) account addresses changes in the distribution of regional economic activity. Local effects—specifically those to potentially affected local communities and tribes—are addressed under separate accounts. The results of the tribal analysis conducted as part of the Feasibility Study are discussed in the Native American Indian section of the FR/EIS.

ES.7.1 National Economic Development (NED)

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.

NED costs are:

- 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 U.S. Bureau of Reclamation, 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)
- Transportation cost increases associated with the shift of barge-transported commodities to more costly truck and rail systems (Alternative 4—Dam Breaching)
- Construction/operation and maintenance costs for irrigation and water supply systems (Alternative 4—Dam Breaching)
- Avoided costs—costs incurred under Alternative 3—Major System Improvements (Adaptive Migration) that would not be incurred under Alternative 1—Existing Conditions, or under Alternatives 2 and 4 (turbine maintenance and replacement, lock and dam maintenance, etc.)

NED benefits are:

- 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
- Power benefits from increases in system hydropower generation (Alternatives 2 and 3).

Table ES-3 summarizes average annual NED costs/benefits for Alternatives 2, 3, and 4.

Table ES-3. Summary of Average Net Annual Economic Effects, 1998 Dollars in Thousands of Dollars at 6.875 Percent 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 (in parentheses) 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).

ES.7.2 Regional Economic Development (RED)

The RED account measures the impacts that the types of economic effects addressed in the NED account would have upon the regional economy. Direct changes in one sector of the economy have indirect and induced effects distributed throughout the regional economy. Economic activity within one industry ("direct" activity) generates activity in others as firms purchase services and materials as inputs ("indirect" effects) and employees spend their earnings within the local economy ("induced" effects).

ES.7.3 Passive Use Estimates

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. Passive use values were estimated by transferring and adapting values from other passive use studies. 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 were calculated as part of the Feasibility Study to provide additional information for the decision maker to consider.

ES.8 Effects of the Alternatives

Before making its selection of a recommended plan (preferred alternative), the Corps evaluated the implications of each alternative. The effects of the four alternatives on key environmental resources and economic factors were evaluated. Table ES-4 summarizes the effects on some of these resource areas and economic uses. Details are provided in the FR/EIS and associated appendices.

Table ES-4. Summary Resource Comparisons

Resource List	Alternative 2 Maximum Transport	Alternative 3 Adaptive Migration	Alternative 4	
			Dam Breaching Short Term	Dam Breaching Long Term
Aquatic Resources—Anadromous Fish				
Spring/Summer Chinook Salmon Passage	◒	●	○	●
Fall Chinook Salmon Recovery Passage	◒	●	○	●
Steelhead Passage	◒	●	○	●
Sockeye Salmon	◒	●	○	●
Aquatic Resources—Resident Fish				
Resident Fish	◒	◒	○	◒
Lamprey	◒	◒	○	●
Bull Trout	◒	◒	○	●
Water Resources				
Sediment	◒	◒	○	○
Temperature	◒	◒	◒	◒
Dissolved Gas	●	●	●	●
Contaminants	◒	◒	○	◒
Air Quality				
Fugitive Dust Emissions	◒	◒	○	◒
Transportation Emissions	◒	◒	◒	◒
Replacement Power Emissions	◒	◒	○	○
Terrestrial Resources	◒	◒	○	◒
Cultural Resources	◒	◒	◒	◒
Electric Power	●	●	○	○
Transportation (Navigation)	◒	◒	○	○
Recreation and Tourism	◒	◒	○	●
Water Supply/Irrigation	◒	◒	○	○
Commercial Harvest	◒	◒	○	◒
Implementation/Avoided Costs	◒	○	○	○
Native American Indians (Tribal Values)	◒	◒	●	●
Social Effects				
Community Views	◒	◒	○	○
Low Income and Minority Pop.	◒	◒	○	○
Traffic Safety	◒	◒	◒	◒
Geological Resources	◒	◒	○	◒
Aesthetic Resources	◒	◒	○	◒

● A Positive effect
◒ Minimal or No notable change in effect
○ A Negative effect

Bolded resources indicate those that would have the greatest impact or potential effect. Table reflects relative change as compared Alternative 1—Existing Conditions.

When evaluating the effects of the alternatives on the environmental resources and economic factors summarized in this document, it is important to note that some of the analyses carry with them varying degrees of uncertainty. Uncertainty is inherent in any planning effort, especially when the period of implementation may span several years, as is likely for this FR/EIS. Information might be unavailable, incomprehensive, and scientifically untestable or reflect wide natural variability in the resource studied. There are also uncertainties in the assumptions and models used to extrapolate this information to future conditions. Relevant uncertainties are described in the FR/EIS, where appropriate. For this Feasibility Study, noticeable uncertainty exists in the effects analyses for salmon, recreation, and economics.

ES.9 The Recommended Plan (Preferred Alternative)

Based on a thorough examination of the best available biological, economic, social, environmental and other related information, the Corps has selected a recommended plan (preferred alternative). The recommended plan (preferred alternative) is a modified version of Alternative 3—Major System Improvements (Adaptive Migration), with increased focus on adaptive migration capabilities. The alternative analysis and evaluation of impacts summarized in this document and described in detail in Chapter 5 of the Final FR/EIS include all components or actions contained in the recommended plan (preferred alternative). Sensitivity and trade-off analyses were conducted and considered for each alternative.

The recommended plan (preferred alternative) combines a series of the structural and operational measures described and evaluated in the FR/EIS for Alternative 3 that are intended to improve fish passage through the four lower Snake River dams. This alternative provides the maximum operational flexibility for juvenile fish passage; it optimizes in river passage when river conditions are best for fish and optimizes the juvenile transportation program when that operation is best for fish. It also allows for optimized combined passage when necessary for spread-the-risk operation or to conduct needed research. These improvements are not only intended to reduce direct mortality associated with dam passage, but also to reduce stress on juvenile fish, reduce total dissolved gas, and improve operational reliability.

The rationale for selecting the recommended plan (preferred alternative) is a composite of analyses, information briefings, evaluations, technical expertise, and comments concerning the factors evaluated as part of the Feasibility Study. The selection of the recommended plan (preferred alternative) resulted from the evolution and development of the extraordinary collection of scientific data and information presented in the FR/EIS, its associated appendices, and supporting research materials and reports. Although not without uncertainties, the Corps believes the information collected represents the best available science and information to date.

The key factors supporting the selection of this alternative were:

- High current juvenile and adult salmon and steelhead survival rates through the Lower Snake River Project
- Proposed improvements provide the maximum flexibility of all alternatives in terms of optimizing both in river migration conditions and transport conditions
- Lesser magnitude of uncertainty in current biological information

- Minimal economic impacts to users
- Compatibility with NMFS and USFWS 2000 Biological Opinions
- Minimal effects to other environmental resources.

Other factors considered in this selection include, but were not limited to, those effects associated with social and community resources, Native American Indians, technical feasibility, effectiveness of structural modifications, regional acceptability, public comments, and length of implementation.

The structural and operational measures identified for the recommended plan (preferred alternative) are considered to be technically feasible, implying that the Corps has the capability to design, construct, and operate these measures.

ES.9.1 Structural Measures

The structural improvements associated with the recommended plan (preferred alternative) can be placed into two categories. The first category is near-term improvements, consisting of modifications to existing systems using current technology. These require little or no additional study or research. Near-term improvements can be implemented relatively quickly (within the first 5 years after the final ROD is signed). The second category is long-term improvements. These improvements require additional evaluation, prototype development, and testing. Therefore, these improvements take more time to put into place. The actual determination on if, where, how, and when these long-term improvements are implemented would be contingent on the prototype testing and evaluation results. Implementation would also be dependent on a continued need for improvements in the hydropower system.

Near-term improvements proposed as part of the recommended plan (preferred alternative) are:

- Complete installation of spillway flow deflectors at Lower Monumental and Little Goose
- Upgrade auxiliary fish ladder water supply systems at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite
- Modify extended submerged bar screens at Little Goose and Lower Granite
- Use additional barges for transport with upgraded mooring facilities at Lower Granite.

Long-term improvements proposed as part of the recommended plan (preferred alternative) are:

- Install new juvenile facility at Lower Granite
- Install new cylindrical dewatering screens at all dams
- Replace submerged traveling screens with extended-length submerged bar screens at Ice Harbor and Lower Monumental
- Install new wet separators at Lower Monumental and Little Goose
- Install turbine improvements (as powerhouses are rehabilitated)

- Install removable spillway weirs with or without behavioral guidance structure at all four dams
- Install two-unit powerhouse surface bypass with or without dewatering system at Lower Monumental and Lower Granite
- Build full-length powerhouse occlusion structure at Little Goose.

ES.9.2 Operational Measures

In addition to current operational measures and continued participation in ongoing monitoring, evaluation, and regional coordination programs, there are two principal areas where potential future operational changes for the lower Snake River need to be further investigated. These areas are:

- Develop and implement biological rules for flow augmentation
- Develop and implement biological rules for smolt transportation including optimal spill for salmon.

The Corps plans to coordinate with Federal agencies to establish these specific rules for both smolt transportation and flow augmentation. All such operational rule development will continue to be regionally coordinated in a manner consistent with the NMFS 2000 Biological Opinion.

ES.9.3 Consistency with Planned Regional Salmon Recovery Efforts

Of all the alternatives investigated in the FR/EIS, the recommended plan (preferred alternative) most closely matches recommendations in the NMFS 2000 Biological Opinion for the Lower Snake River Project. The NMFS 2000 Biological Opinion concluded that dam breaching on the lower Snake River is not necessary at this time, but reserved this action as a contingency management alternative if the listed stocks continue to decline in the near future (2005 to 2008). The Corps' selection of a modified version of Alternative 3—Major System Improvements (Adaptive Migration) as the recommended plan (preferred alternative) is consistent with this conclusion. The plan includes implementation of the actions applicable to the Corps as recommended in the NMFS 2000 Biological Opinion and the USFWS 2000 Biological Opinion for system operations, configuration measures, habitat restoration, and continued research and monitoring activities (or alternative measures that result in achieving the current or revised established performance standards).

In implementing the Biological Opinions' lower Snake River actions, the Corps will also contribute to the attainment of the goals identified in the Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery dated December 2000. This strategy was developed by several Federal agencies (including the Corps) as part of the Federal Caucus. It is a comprehensive, long-term plan to recover 12 anadromous fish stocks and other listed species (i.e., bull trout and sturgeon) in the Columbia-Snake River Basin.

ES.10 Future Actions

A final Notice of Availability will appear in the Federal Register indicating that the Final FR/EIS is ready for release to the public. The public will have at least 45 days to consider the recommendation and the rationale before a ROD is signed. During the

preparation of the ROD, the Corps will consider new data, science, objections, comments, or opinions brought forward to the Corps during the 45-day period.

The Final FR/EIS, including the recommended plan (preferred alternative) and ROD, will be forwarded to the Northwestern Division Engineer for approval and signature. Since the recommended plan (preferred alternative) is consistent with existing project authorities and does not require additional Congressional authorization, the Division Engineer is slated as the signatory of the ROD. However, many of the proposed actions will be included in the Corps' regular appropriation and budget process, which provides opportunity for input from Congress.

The near-term and long-term actions described in the recommended plan (preferred alternative) will be folded into the existing processes for consideration and coordination with the regional recovery efforts, as they proceed towards implementation, etc., become available on future proposed actions.

Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement (Final FR/EIS)

Lead Agency: Department of the Army
Walla Walla District Corps of Engineers
201 North Third Avenue
Walla Walla, WA 99362-1876

For further information contact: Lonnie Mettler
Project Manager
Department of the Army
Walla Walla District, Corps of Engineers
Walla Walla, WA 99362-1876
(509) 527-7268

Record of Decision: At least 45 days after publishing the Notice of Availability of the Final FR/EIS in the Federal Register, the Corps will prepare a Record of Decision documenting the action resulting from the Feasibility Study process.

Abstract:

The Corps of Engineers, along with the Bonneville Power Administration, U.S. Environmental Protection Agency, and U.S. Bureau of Reclamation as cooperating agencies, analyzed four general alternatives intended to provide information on the technical, environmental, and economic effects of actions related to improving juvenile salmon passage. The four alternatives include Alternative 1—Existing Conditions (the no-action alternative) and three different ways to further improve juvenile salmon passage. The action alternatives are as follows: Alternative 2—Maximum Transport of Juvenile Salmon; Alternative 3—Major System Improvements; and Alternative 4—Dam Breaching. Based on a thorough examination of the best available biological, economic, social, and other environmental information, Alternative 3—Major System Improvements has been selected as the recommended plan (preferred alternative).

Lower Snake River Juvenile Salmon
Migration Feasibility Study

Final Feasibility Report/
Environmental Impact Statement

Part I
Chapters 1 through 4

February 2002

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Acronyms and Abbreviations

λ	(lambda) population growth rate
°F	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
AAQS	ambient air quality standards
ACHP	Advisory Council on Historic Preservation
ADP	acoustic Doppler profiler
AET	apparent effects threshold
AIRFA	American Indian Religious Freedom Act
AMPA	aminomethylphosphoric acid
aMW	average megawatt
ARPA	Archaeological Resources Protection Act
BA	Biological Assessment
BGS	behavioral guidance structure
BIA	Bureau of Indian Affairs
BKD	bacterial kidney disease
BLM	Bureau of Land Management
BNSF	Burlington Northern – Santa Fe Railroad
BOD	biochemical oxygen demand
BOR	U.S. Bureau of Reclamation
BOT	Board of Trustees
BP	before present
BPA	Bonneville Power Administration
BSM	Bayesian Simulation Model
CAA	Clean Air Act
CBB	Columbia Basin Bulletin
CBFWA	Columbia Basin Fish and Wildlife Authority
CC	combined-cycle combustion
CCAP	U.S. Climate Change Action Plan
CCC	criteria continuous concentration
CEAA	Canadian Entitlement Allocation Agreement
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFC	chlorofluorocarbons
CFR	Code of Federal Regulations
cfs	cubic feet per second

Acronyms and Abbreviations (continued)

CH_4	methane
CLR	Columbia River Mile
CMC	criteria maximum concentration
CO	carbon monoxide
CO_2	carbon dioxide
Comp Plan	Lower Snake River Fish and Wildlife Compensation Plan
Corps	U.S. Army Corps of Engineers
CR	County Road
CRBG	Columbia River Basalt Group
CRFMP	Columbia River Fish Mitigation Program
CRI	Cumulative Risk Initiative
CRITFC	Columbia River Inter-Tribal Fisheries Commission
CRMP	Cultural Resources Management Plan
CSPE	Columbia Storage Power Exchange
CTCIR	Confederated Tribes of the Colville Indian Reservation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
DDT	dichloro-diphenyl-trichloroethane
DGAS	Dissolved Gas Abatement Study
DMEF	Dredged Material Evaluation Framework
DO	dissolved oxygen
DREW HIT	Drawdown Regional Economic Workgroup Hydropower Impact Team
DREW	Drawdown Regional Economic Workgroup
DSI	direct service industries
Ecology	Washington Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EQ	environmental quality
ESA	Endangered Species Act
ESBS	extended submerged bar screen
ESL	Endangered Species List
ESU	Evolutionarily Significant Unit
EWITS	Eastern Washington Intermodal Transportation Study
FCRPS	Federal Columbia River Power System

Acronyms and Abbreviations (continued)

Feasibility Study	Lower Snake River Juvenile Salmon Migration Feasibility Study
FELCC	firm energy load-carrying capacity
FERC	Federal Energy Regulatory Commission
FGE	fish guidance efficiency
FIRE	finance, insurance, and real estate
FIRFA	Federal Insecticide, Fungicide, and Rodenticide Act
FPC	Fish Passage Center
FPE	fish passage efficiency
FPOM	Fish Passage Operations and Maintenance Coordination Team
FR	Federal Register
FR/EIS	Lower Snake River Juvenile Salmon Migration Study Feasibility Report and Environmental Impact Statement
ft/sec	feet per second
FTE	full-time equivalent
FTU	Formazin Turbidity Unit
FWCA	Fish and Wildlife Coordination Act
FWCAR	Fish and Wildlife Coordination Act Report
GBD	gas bubble disease
GBT	gas bubble trauma
GHG	greenhouse gas
GIS	geographic information system
GSA	General Services Administration
HCFC	partially halogenated fluorocarbons
HEP	Habitat Evaluation Procedures
HIT	Hydropower Impact Team
HMU	habitat management unit
HTRW	hazardous, toxic, or radioactive wastes
HU	habitat unit
HYDROSIM	Hydro Simulation Program
HYSSR	Hydro System Seasonal Regulation Program
ICBEMP	Interior Columbia Basin Ecosystem Management Project
IEAB	Independent Economic Analysis Board of the Northwest Power Planning Council

Acronyms and Abbreviations (continued)

IPP	Independent Power Producer
ISAB	Independent Scientific Advisory Board
ISG	Independent Scientific Group
ISRT	Integrated Scientific Review Team
IT	Implementation Team
JFTP	Juvenile Fish Transportation Program
KAF	thousand acre-feet
kcfs	thousand cubic feet per second
kg/m^2	kilogram per meter squared
KW	kilowatt
KWh	kilowatt hour
LOA	Letter of Agreement
LPMS	Lock Performance Monitoring System
LWCFA	Land and Water Conservation Fund Act
M&I	municipal and industrial
MAF	million acre-feet
mills/kWh	mils per kilowatt hour
mm	millimeter
MOP	minimum operating pool
msl	mean sea level
MW	megawatt
MWh	megawatt hour
N_2O	nitrous oxide
NAGPRA	Native American Graves Protection and Repatriation Act
NED	national economic development
NEPA	National Environmental Policy Act
Nez Perce	Nez Perce Tribe
NGVD29	National Geodetic Vertical Datum 1929
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOx	nitrogen oxide
NPPC	Northwest Power Planning Council
NPS	National Park Service
NPTEC	Nez Perce Tribe Executive Council

Acronyms and Abbreviations (continued)

NRHP	National Register of Historic Places
NTMB	neotropical migratory bird
NTU	nephelometric turbidity unit
O&M	operation and maintenance
O_3	ozone
OA	Columbia River Salmon Flow Measures Options Analysis
OSE	other social effects
PAH	polynuclear aromatic hydrocarbon
PATH	Plan for Analyzing and Testing Hypotheses
Pb	lead
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo dioxins
PCDF	polychlorinated dibenzo furans
PDO	Pacific Decadal Oscillation
PIT	passive integrated transponder
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameters less than 10 micrometers
PMOA	Programmatic Memorandum of Agreement
PNCA	Pacific Northwest Coordination Agreement
PNI	Pacific Northwest Index
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PSEP	Puget Sound Estuary Program
PUD	Public Utility District
RCRA	Resource Conservation and Recovery Act
RED	regional economic development
RM	River Mile
ROCASOD	Record of Consultation and Statement of Decision
RPA	reasonable and prudent alternative
RSW	removable spillway weir
SAR	smolt-to-adult survival ratio
SBC	surface bypass collector
Scenic Area	Columbia River Gorge National Scenic Area

Acronyms and Abbreviations (continued)

SCS	System Configuration Study
SCT	System Configuration Team
SDWA	Safe Drinking Water Act
Shoshone-Bannock	Shoshone Bannock Tribes
SHPO	State Historic Preservation Office
SIA	social impact assessment
SNL	speed no load
SNR	Snake River Mile
SO_2	sulfur dioxide
SOR	System Operation Review
SR	State Route
SRP	Science Review Panel
STS	submerged traveling screen
SWI	simulated Wells Dam intake
TAP	toxic air pollutant
TCDD	tetra chloro dibenzo-p-dioxin
TCDF	2,3,7,8-tetra chloro dibenzo furan
TCM	Travel Cost Method
TCR	transport:control ratio
TDG	total dissolved gas
TDGMS	total dissolved gas monitoring station
TEQ	toxicity equivalency quotient
TIR	transport to in-river ratio
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TMT	Technical Management Team
TPH	total petroleum hydrocarbons
TPY	tons per year
TSCA	Toxic Substance Control Act
TSS	total suspended solid
TVA	Tennessee Valley Authority
UI	University of Idaho
Union Pacific	Union Pacific Railroad
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Acronyms and Abbreviations (continued)

VOC	volatile organic compound
WAC	Washington Administrative Code
Warm Springs	Confederated Tribes of the Warm Springs of Oregon
WCSC	Waterborne Commerce Statistics Center
WDFW	Washington Department of Fish and Wildlife
WQT	Water Quality Team
WRC	U.S. Water Resources Council
WRDA	Water Resources Development Act
WSCC	Western Systems Coordinating Council
WSU	Washington State University
WTP	willingness to pay
Yakama	Yakama Nation

ENGLISH TO METRIC CONVERSION FACTORS

To Convert From	To	Multiply By
LENGTH CONVERSIONS:		
Inches	Millimeters	25.4
Feet	Meters	0.3048
Miles	Kilometers	1.6093
AREA CONVERSIONS:		
Acres	Hectares	0.4047
Acres	Square meters	4047
Square Miles	Square kilometers	2.590
VOLUME CONVERSIONS:		
Gallons	Cubic meters	0.003785
Cubic yards	Cubic meters	0.7646
Acre-feet	Hectare-meters	0.1234
Acre-feet	Cubic meters	1234
OTHER CONVERSIONS:		
Feet/mile	Meters/kilometer	0.1894
Tons	Kilograms	907.2
Tons/square mile	Kilograms/square kilometer	350.2703
Cubic feet/second	Cubic meters/sec	0.02832
Degrees Fahrenheit	Degrees Celsius	(Deg F –32) x (5/9)

UNIT DEFINITIONS

parts per million (ppm) ≅ mg/L
parts per billion (ppb) ≅ µg/L
parts per trillion (ppt) ≅ ng/L

Chapter 1

Introduction

1.1 Historical Overview
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1. Introduction

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1.1 Historical Overview

Historically, runs of spring/summer chinook salmon (*Oncorhynchus tshawytscha*) were found throughout the accessible and suitable reaches of the Snake River and its tributaries. On the Snake River, they spawned as far upstream as Auger Falls in Idaho, some 930 miles from the mouth of the Columbia River. Fall chinook (*O. tshawytscha*) were also widely distributed in the mainstem of the Snake River (as far upstream as Shoshone Falls, Idaho) and the lower reaches of its tributaries. Snake River sockeye salmon (*O. nerka*) were found in five lakes in the Stanley Basin, Big Payette Lake on the North Fork of the Payette River in Idaho, and Wallowa Lake in the Grande Ronde River Basin. Steelhead, the anadromous form of rainbow trout (*O. mykiss*), were also widely distributed in most accessible and suitable habitats.

Both the distribution and abundance of these anadromous fish species have declined significantly. As a result, on November 20, 1991, the National Marine Fisheries Service (NMFS) declared the Snake River sockeye salmon endangered effective December 20, 1991 (56 Federal Register [FR] 58619). Snake River spring/summer chinook and Snake River fall chinook salmon were listed as threatened on April 22, 1992 (57 FR 14653). Critical habitat was designated for Snake River sockeye, spring/summer chinook, and fall chinook on December 28, 1993 (58 FR 68543). Snake River wild steelhead was formally listed as threatened on August 18, 1997 (62 FR 43937). Table 1-1 identifies the current status of listings for Columbia River salmon and trout species under the Endangered Species Act (ESA) of 1973, as amended.

Many past and present anthropogenic (human-caused) factors have contributed cumulatively to the decline of the anadromous fish runs within the Snake River Basin. For example, between 1910 and 1967, several hundred miles of spawning area were lost because dams were built upstream from Hells Canyon Dam. Approximately 46 percent of the pre-dam anadromous fish habitat in the Snake River Basin was blocked by the construction of Brownlee Dam in 1958. This dam originally had fish passage facilities, but they were not successful in maintaining upstream runs. In addition, completion of Hells Canyon and Oxbow Dams, downstream of Brownlee Dam, further blocked access to 247 miles of habitat in the Snake River (U.S. Bureau of Reclamation [BOR], 1993).

Hells Canyon Dam is the current barrier to upstream migration of adult fish on the Snake River. Similarly, Dworshak Dam, completed in 1974, is a barrier to upstream migration on the North Fork Clearwater River.

Factors contributing to the decline of runs in the Snake River Basin are discussed in the following subsections:

1.1.1 Harvest

Historically, harvest of Snake River salmon and steelhead has occurred in the Snake River, mainstem and estuarine waters of the Columbia River, and in marine waters of the North Pacific. Although current management policies highly restrict harvest and include extensive monitoring, much less restrictive approaches in the past have helped to decrease overall fish populations, thus reducing the number of adults needed to maintain sustainable run populations. Harvest continues to contribute significantly to reduced numbers of returning adults for some salmon and steelhead stocks.

Table 1-1. Federally Listed, Proposed, or Candidate Anadromous Fish Species (Evolutionarily Significant Units [ESUs]) in the Columbia River Basin

	Primary Region of Origin[1/]			
Species and ESU (Status, Fed. Reg. Month/Year)	**Snake River**	**Upper Columbia River (above McNary Dam)**	**Middle Columbia River (Between McNary and Bonneville Dams)**	**Lower Columbia River (Below Bonneville Dam)**
Snake River Fall Chinook Salmon (T, 4/92)	X		X (Deschutes)	
Snake River Spring/Summer Run Chinook Salmon (T, 4/92)	X		X (Deschutes)	
Snake River Sockeye Salmon (E, 11/91)	X		X (Deschutes)	
Snake River Steelhead (T, 8/97)	X		X (Deschutes)	
Upper Columbia River Spring Chinook Salmon (E, 3/99)		X	X (Deschutes)	
Upper Columbia River Steelhead (E, 8/97)		X	X (Deschutes)	
Middle Columbia River Steelhead (T, 3/99)		X (Below Priest Rapids Dam)	X	
Southwest WA/Columbia River Coastal Cutthroat Trout (T, 4/99)			X (Below The Dalles Dam)	X
Lower Columbia River/Southwest WA Coho Salmon (C, 7/95)			X (Below The Dalles Dam)	X
Lower Columbia River Chinook Salmon (T, 3/99)				X
Lower Columbia River Steelhead (T, 3/98)				X
Columbia River Chum Salmon (T, 3/99)				X
Upper Willamette River Chinook Salmon (T, 3/99)				X
Upper Willamette River Steelhead (T, 3/99)				X

[1/] Minor exceptions to distribution region may occur.
E = Endangered, T = Threatened, C = Candidate

1.1.2 Loss of Habitat

Land uses throughout the Columbia and Snake river basins have altered the original habitat significantly. For example, loss of riparian areas along streams from logging, farming and urban development, water diversion (including unscreened diversion) and impoundment of free flowing rivers in tributaries as much as on the mainstem, and increased infrastructure (e.g., roads, facility development, and added areas of impervious surfaces) have changed the original habitat and decreased or eliminated favorable habitat conditions. Salmon and steelhead runs adapted to habitat conditions over many thousands of years. In many areas of the Columbia and Snake river basins, these conditions have been significantly changed, or no longer exist.

1.1.3 Estuary Destruction

Estuarine habitat involves critical life stages for anadromous juvenile fish transitioning from freshwater to marine waters or when they return from marine waters to freshwater as adults. This transition involves the physiological changes needed to survive in saline and freshwater systems. Also, for some juvenile anadromous fish species (particularly chinook salmon), the estuary provides important habitat for rearing. The habitat available in the lower Columbia River estuary has been altered and the aerial extent diminished through filling, diking, and other development, thus decreasing the original habitat that was available to support larger fish populations.

1.1.4 Hatchery Salmonids

Large-scale hatchery programs have been implemented throughout the Columbia and Snake river basins as mitigation for loss of habitat and to enhance anadromous fish runs. These programs have been in operation for many decades. In recent years, however, the use of hatcheries has been extensively questioned. Issues include hatchery practices and high hatchery fish harvest rates that may be detrimental to wild runs; potential loss of desirable wild fish genetic characteristics through interbreeding with hatchery fish in the wild; competition between hatchery and wild fish for habitat and food; and predation by hatchery fish on wild fish. Many of these issues are the subject of ongoing research but may contribute to the overall decrease in wild fish populations.

1.1.5 Dams and Reservoirs

Dams and reservoirs have altered the natural characteristics of the Columbia and Snake Rivers, thus changing or eliminating many of the habitat conditions needed to sustain anadromous fish runs. These changes include, for example, inundation of spawning and rearing habitat; total blockage of access to large areas of historical habitat; alteration of depth, flow, and velocity; water quality changes; direct and indirect mortality (e.g., mortalities due to passage through turbines or delayed mortality may occur at a later time due to passage through the hydrosystem or fish being transported); increased predation in reservoirs, and others.

1.1.6 Other Human-related Problems

In addition to the above factors, use of the Columbia and Snake river basins for timber harvest, farming, industrial facilities, urbanization, water supply for municipal and industrial purposes, and other effects directly related to human activities, has

contributed cumulatively to habitat changes that have often not been favorable for supporting healthy anadromous fish populations.

Each of the above factors either individually or in combination may be major contributors to the decline of anadromous fish runs in the Snake River Basin.

While the cumulative impact of overfishing and habitat degradation is considerable, NMFS has determined that the cumulative mortality of spring/summer chinook passing mainstem hydroelectric dams to be an important contributor to the decline of this species in the Columbia River. However, NMFS has determined that no single factor can be isolated as a primary cause of the decline in numbers of listed species (NMFS, 1995). Therefore, a multi-faceted ecosystem approach to species recovery with unified Federal coordination is desired to reverse the declines.

Historically, the main focus of salmon recovery efforts was to develop methods that reduce direct fish passage mortality from the hydrosystem. Examples include operating turbines at levels that reduce injuries or mortality, improving turbine designs, or collecting and transporting juveniles downstream past dams. In more recent years, a major concern has also been the indirect effects of the hydrosystem. For example, one major question is how to improve overall survival by increasing survival of juvenile fish after they have passed Bonneville Dam. While mortality of fish downstream of Bonneville is generally caused by natural processes (e.g., predation, competition, ocean productivity), some may result from anthropogenic factors (e.g., poor fitness of hatchery fish, degradation of the estuary) which may include delayed effects of the hydrosystem on fish survival. This mortality component, characterized as delayed mortality, is a major area of research and development relating to operations of the Lower Snake River Project (the name for the Corps' four lower Snake River facilities combined).

Two sources of delayed mortality have been hypothesized as they relate to the hydrosystem; one being the effects of fish transport, and the other indirect effects to fish from passing through the hydrosystem. The amount of delayed mortality that actually results either from fish being transported or passing through the hydrosystem has not been fully developed and will remain a major area of study in the future.

1.2 Feasibility Study Process

On March 2, 1995, NMFS issued its *Biological Opinion for the Reinitiation of Consultation on 1994 to 1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years*. The 1995 Biological Opinion established measures necessary for the survival and recovery of Snake River salmon stocks listed under the ESA.

The U.S. Army Corps of Engineers' (Corps') response to the 1995 Biological Opinion and, ultimately, this Feasibility Study evolved from a System Configuration Study (SCS) initiated in 1991. The SCS was undertaken to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs on the Snake and Columbia Rivers to improve survival rates for anadromous salmonids. This process began in response to the Northwest Power Planning Council's (NPPC's) *Fish and Wildlife Program Amendments (Phase II)* issued in December 1991 (NPPC, 1991).

The SCS was conducted in two phases. Phase I of the SCS was completed in June 1995. This was a reconnaissance-level assessment of multiple concepts, including

drawdown, upstream collection, additional reservoir storage, migratory canal, and several other alternatives for improving conditions for anadromous salmonid migration. The results of the study were reported in the *Columbia River Salmon Migration Analysis, System Configuration Study, Phase I* (Corps, 1994). Alternatives that displayed the most potential benefit to anadromous fish were carried into Phase II (see Appendix J, Plan Formulation).

Since 1995, Phase II has developed into a major program containing many separate and specific studies. Evaluation of structural changes for juvenile salmon migration improvements within the lower Snake River are only a portion of the total program. This growth in the scope of Phase II was considered necessary to adequately and efficiently respond to the requirements for multiple evaluations addressed in the 1995 Biological Opinion.

In December 1996, the Corps issued the *System Configuration Study, Phase II, Lower Snake River Juvenile Salmon Migration Feasibility Study, Interim Status Report* (Corps, 1996a) in response to the 1995 Biological Opinion requirement for a preliminary decision regarding the selection of drawdown alternatives. The alternatives evaluated in the *Interim Status Report* included:

- Existing conditions
- Three alternatives for lower Snake River drawdown, including:
    1. Seasonal drawdown, near spillway crest
    2. Seasonal drawdown, near natural river levels
    3. Permanent drawdown, near natural river levels
- System improvements that could be accomplished without a drawdown, primarily through facilities that would improve downstream passage of juvenile fish.

None of these alternatives specifically incorporated a dam breaching scenario.

The findings published in the *Interim Status Report* indicated there was insufficient information at the time for the Corps to make a recommendation on the best configuration of the hydropower system to safely pass juvenile salmon in the lower Snake River. However, preliminary conclusions on the drawdown options indicated that seasonal spillway crest and seasonal natural river should be eliminated from further consideration. Consequently, the Corps recommended the continued investigation of three courses of action to improve salmon migration:

- Current fish programs
- Maximum collection and transport of juveniles with and without installation of surface bypass/collectors
- Dam breaching with permanent drawdown of all four lower Snake River reservoirs to a near-natural river.

Evaluation of breaching only one, two, or three dams was not considered because removal of only one dam would eliminate major navigation and restrict options for collection and transportation of juvenile fish.

Because a decision on the best configuration of the hydrosystem for passage of juvenile salmon on the lower Snake River could not be made in 1996, a second decision point in 1999 was established, as identified in the 1995 Biological Opinion. This decision point was subsequently shifted to 2001. The second decision point involving structural or operational changes to the lower Snake River dams resulted in the December 1999 document, *Draft Lower Snake River Juvenile Salmon Migration Feasibility Report and Environmental Impact Statement* (FR/EIS). The Draft FR/EIS was released for public review and comment. As a result of the review process, the document was revised and updated, culminating in this Final FR/EIS.

In the interim period between the draft and this final document, two new Biological Opinions for the operation of the FCRPS were released in December 2000. One opinion was prepared by NMFS and addresses anadromous salmon and steelhead. The other was prepared by the U.S. Fish and Wildlife Service (USFWS) and focuses primarily on bull trout in the Columbia River Basin and Kootenai River sturgeon. The main emphasis in this FR/EIS is on the NMFS opinion because it has direct bearing on juvenile salmon migration and approaches for improving survival during this migration, particularly past the four dams on the lower Snake River.

The NMFS opinion supercedes the previous opinions developed in 1995 and 1998. Many of the aspects of the 2000 opinion, however, involve the current and future operation of the Corps' lower Snake River dams that were included in the 1995 and 1998 Biological Opinions.

This Final FR/EIS incorporates considerations of the applicable aspects of the NMFS 2000 Biological Opinion. Federal agencies involved in the development of this FR/EIS, besides the Corps, are the cooperating agencies: Bonneville Power Administration (BPA), U.S. Environmental Protection Agency (EPA), BOR, and other participating agencies, including NMFS and USFWS.

1.3 Purpose and Need

A primary responsibility of the Corps in implementing long-term biological opinion alternatives is to conduct a study of those measures that are associated with dams and reservoirs and that influence migration through the hydrosystem. The purpose of the *Lower Snake River Juvenile Salmon Migration Feasibility Study* (Feasibility Study) is to evaluate and screen structural alternative measures that may increase the survival of juvenile anadromous fish through the Lower Snake River Project (which includes the four lowermost dams operated by the Corps on the Snake River—Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) and assist in the recovery of listed salmon and steelhead stocks. Incorporated into this evaluation is the analysis of direct effects from the hydrosystem (e.g., mortalities that might occur as a result of passage through a turbine), and delayed or indirect effects that may occur after fish have passed through the hydrosystem (e.g., effects that may result in mortality after fish have passed below Bonneville Dam (possibly delayed mortality due to stress from passage or transport).

This FR/EIS combines the format of a traditional Corps feasibility planning document and an EIS. The FR/EIS and associated technical appendices provide: 1) a complete presentation of study results and findings; 2) compliance with applicable statutes, Executive Orders, and policies; 3) a sound and documented basis with which both Federal and regional decision makers can judge the recommended solution; 4) scope, schedule, budgets, and technical performance requirements for the implementation of the selected alternative; and 5) documentation for Congressional authorization (if

necessary) and/or subsequent funding for the implementation of any specific alternatives that need regional and Federal support. Therefore, in addition to describing the evaluation and screening of alternative measures that may increase the survival of juvenile anadromous fish through the Lower Snake River Project, this FR/EIS also meets the Corps' need to comply with the National Environmental Policy Act (NEPA).

1.4 Background

Numerous studies and decision documents have been prepared by the Corps and other FCRPS operating and resource agencies that address salmon recovery and improved conditions for salmon survival. Important documents that provide specific background to this study on the lower Snake River include the *Final Columbia River System Operation Review EIS (*BPA et. al., 1995*);* the *Columbia River Salmon Flow Measures Options Analysis (OA) EIS (*Corps, 1992*);* and the *Corps Interim Columbia and Snake River Flow Improvement Measures for Salmon Final Supplemental EIS* (Corps, 1993). These documents are incorporated by reference. Several of these documents and significant events are discussed in more detail in Appendix R, Historical Perspectives. This FR/EIS tiers off previous studies and is being prepared directly in response to the requirements outlined in the 1995 and 1998 opinions.

1.4.1 1995 Biological Opinion

In the 1995 Biological Opinion, NMFS determined that the planned and proposed actions for operation and juvenile transport programs were likely to jeopardize the continued existence of listed spring/summer chinook salmon. The 1995 Biological Opinion presented a "reasonable and prudent alternative" (RPA) for operation of the FCRPS. In the 1995 Biological Opinion, NMFS concluded that implementation of the RPA was not likely to jeopardize listed Snake River salmon. In the course of review and through the adaptive management process, NMFS further modified the RPA on November 14, 1996. These modifications primarily addressed ongoing fish enhancement projects at Bonneville Dam and provided clarification for some typographical errors in the 1995 Biological Opinion (e.g., places where spring/summer chinook salmon were inadvertently substituted for "fall" chinook salmon in the incidental take statements).

The RPA in the 1995 Biological Opinion provided the basis for the actions contemplated in the Draft FR/EIS released in December 1999. As described above, the RPA was designed to provide measures for the survival (and eventual recovery) of spring/summer chinook, fall chinook, and sockeye salmon. The RPA used an adaptive management approach for increasing survival and the probability of recovery of listed salmon by:

- Improved bypasses
- Increased spills and spring/summer flows
- Reduced fish handling
- Better fish transportation conditions.

Decision points outlined in the 1995 Biological Opinion included:

- 1996 — The Corps was to complete an interim status report on natural river drawdown, spillway crest drawdown, and surface collectors (Corps, 1996a).

The completed report provided the basis for a preliminary decision on drawdown of the lower Snake River reservoirs.

- 1996 — Engineering and design work on preferred drawdown alternative and surface bypass systems, unless the Corps and NMFS agree on a different course of action.
- December 1998 — Engineering and design work to be completed.
- 1999 (extended to 2001) — NEPA compliance in time to ensure a decision on drawdown or surface bypass systems.

1.4.2 1998 Biological Opinion

On August 18, 1997, NMFS announced the proposed listings of Snake River and Upper Columbia River Steelhead ESUs (62 FR 43937). An ESU is defined as a distinct population segment of vertebrate fish or wildlife that is: 1) substantially reproductively isolated from other nonspecific (same species) population units, and 2) represents an important component in the evolutionary legacy of the species (Waples, 1991).

The Federal operating agencies transmitted their *Biological Assessment for 1998 and Future Operation of the Federal Columbia River Power System, Upper Columbia and Lower Snake River Steelhead* to NMFS on January 21, 1998 (NMFS, 1998). This Biological Assessment (BA) included a request to consult further on lower Columbia River steelhead, which had only been proposed for listing at that time. On March 13, 1998, the lower Columbia River Steelhead ESU was listed as "threatened" by NMFS and was included in the consultation. Consultations ensued over the next two months and on May 14, 1998, NMFS issued its Supplemental Biological Opinion to the March 2, 1995 Biological Opinion (NMFS, 1998).

The 1998 Biological Opinion endorsed most parts of the 1995 Biological Opinion except that it modified plans for fish transportation and spill frequency. It also modified the spill criteria at Lower Granite in light of the success of new extended length screens and modified flow dates and specifications for spill operations at lower Snake River dams. The 1998 Biological Opinion laid out numerous specific terms and conditions for operations of the FCRPS to reduce juvenile and adult mortality.

The conclusions of the 1998 Biological Opinion were that the biological requirements of juvenile and adult Snake River steelhead and spring/summer chinook salmon are similar and that what helps one species will likely help the other. It was also determined that existing information is not sufficient to determine if the interim operations will meet the long-term biological needs of the listed species.

The 1998 Biological Opinion considered the alternative actions from the Interim Status Report (Corps, 1996a). These alternatives were needed to help with recovery of listed species evaluated in the Draft FR/EIS. Importantly, the 1998 Biological Opinion found that lifecycle analyses for estimating probability of survival and recovery did not exist at that time.

In March 1999, NMFS listed six additional anadromous fish ESUs in the Columbia River Basin. These included three chinook salmon ESUs, one Columbia River chum salmon ESU, and two more listings of steelhead ESUs. As a result, the recovery actions on the lower Snake River required further coordination to ensure actions on

the lower Snake River would not adversely affect recovery plans for other Columbia River Basin listed fish and wildlife.

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.

1.4.3 2000 NMFS and USFWS Biological Opinions

The 1995 and 1998 Biological Opinions on the operation of the FCRPS were effective until the 2000 Biological Opinion was signed. A new BA that addresses the effects of the FCRPS on listed species in the Columbia River Basin was completed on December 21, 1999. This BA was developed as part of the continuing consultation between the Federal agencies ("action agencies") that operate and market power from the FCRPS (BPA, Corps, and BOR), NMFS, and USFWS. The BA was submitted to NMFS and USFWS for review. These agencies responded with two Biological Opinions, which were released as final documents in December 2000 (see Section 1.1).

The action area for the NMFS 2000 Biological Opinion encompasses the mainstem Columbia and Snake Rivers from Chief Joseph Dam and Hells Canyon Dam down to and including the estuary and plume (nearshore ocean) of the Columbia River. This opinion supersedes all previous opinions NMFS has issued, including the 1995 and 1998 Biological Opinions. However, it provides a continuum from these previous opinions and incorporates many of their planning objectives.

The NMFS 2000 Biological Opinion, like many of the previous opinions, includes a RPA. The RPA establishes performance standards that would avoid jeopardizing the continued existence of listed species or adversely modifying their critical habitat. These standards are established in three tiers including:

- Population-level: needed for the listed population to achieve an adequate likelihood of survival and recovery
- Life-stage specific: needed across the lifecycle to achieve the population level performance standards
- Categorized action in habitat, harvest, hatcheries, and hydropower. These standards are applicable to all activities in the specific category and are intended to achieve the life-stage-specific performance standards.

The categorized performance standards in hydropower are very focused on the project operations of Federal dams on the Columbia and Snake Rivers. The full details of the standards are presented in Sections 6.1 and 9.7 and Appendix D of the NMFS 2000 Biological Opinion.

The hydropower actions presented to meet the performance standards are primarily aimed at improving fish passage survival. Specific measures include:

- Enhanced spill and spillway improvements to facilitate higher spill levels without exceeding harmful total dissolved gas (TDG) levels
- Improved flow management

- Physical improvements to both juvenile and adult fish passage facilities
- Increased use of barges and less reliance on trucks to transport summer migrants
- Continuation of spill at collector projects to maximize the survival rate of inriver migrants.

The RPA in the NMFS 2000 Biological Opinion includes nearly 200 action items that are part of the overall approach for the entire FCRPS to meet the performance standards. Many of these actions are specifically aimed at improving passage survival of salmonids through the four dams and reservoirs on the lower Snake River. The RPA also includes an annual and multiyear planning process to refine, implement, evaluate, and adjust ongoing efforts to achieve performance standards. Under the 2000 NMFS Biological Opinion, both annual (1-year) and 5-year plans will be developed and implemented. The plans will cover all operations, configurations, research, monitoring, and evaluations leading to the full attainment of the performance standards by 2010.

In addition, the RPA calls for annual progress reports with major progress reports in 2003, 2005, and 2008. It also requires the pursuit of other ways to avoid jeopardy in the future, including possible breaching of lower Snake River dams, if necessary. The 2005 report will be a rigorous mid-point review. The 2008 report must include a determination of whether or not (under certain conditions) to pursue breaching if NMFS issues a report indicating the efforts to meet performance standards have failed following one of these reviews. Specific steps are described in the 2000 Biological Opinion for advanced planning to reduce the time needed to seek congressional authorization for breaching, which should reduce the time needed for possible implementation. This should avoid delays in schedule if breaching becomes a preferred approach.

1.5 Scope

This FR/EIS provides river managers, users, and the general public with the information and evaluation processes that were used to select a preferred alternative. It also assists these groups in determining how each alternative affects other uses and considers the consequences of changing the way the lower Snake River currently operates.

This first section of this FR/EIS lays the groundwork for later sections and describes the background on how the FR/EIS has arrived at this point in the review process. This section also describes major entities and programs that are involved in the management of the Columbia River System, with particular emphasis on those that manage the system and the effects it may have on listed species. Subsequent sections describe the existing Lower Snake River Project, detail the alternatives developed through this EIS process, discuss the effects of changing how the system functions, and explain the tradeoffs among uses that the various alternatives would precipitate. These sections include:

- **Chapter 2–Affected Projects and Programs.** This chapter describes key features of the Lower Snake River Project, with specific details on each facility (i.e., Ice Harbor, Lower Monumental, Little Goose, and Lower Granite).

- **Chapter 3–Plan Formulation.** This chapter identifies the four alternatives that were evaluated. It also describes other potential actions that may affect the survival of juveniles, but were outside the scope of this FR/EIS. Finally, it addresses alternatives that were considered but eliminated from further consideration for various reasons.
- **Chapter 4–Affected Environment.** This chapter describes current conditions for a number of resource areas (e.g., fish, wildlife, water quality, historic resources, recreation, economics, and others). The current condition of each resource area is described in terms of past and present natural and human actions that have incrementally resulted in the status and condition of the resource today. Ongoing effects on affected resources are cumulative effects that help describe the overall health or status of each resource area. This comprehensive analysis provides the basis upon which the alternatives are evaluated in Section 5.
- **Chapter 5–Environmental Effects of Alternatives.** This chapter evaluates the potential direct, indirect, and cumulative effects of each alternative (1 through 4) on the affected resources and in fulfilling the need for action. The cumulative effects of each alternative are considered in each section. The alternatives are evaluated for each resource area by considering how the alternative actions will effect each resource with respect to any continued incremental effects of ongoing cumulative impacts. The cumulative analysis of reasonably foreseeable future actions.
- **Chapter 6–Plan Selection/Implementation.** This chapter provides detailed information on the evaluations and approaches that were used in the selection of the preferred alternative. This chapter also describes the steps and regulatory processes for implementing the preferred alternative.
- **Chapter 7–Public Involvement.** This chapter describes the public involvement activities (e.g., scoping meetings, informational meetings, newsletters, internet sites) that have taken place to date for this FR/EIS.

Chapters 1 through 7 introduce and address the environmental consequences of the alternatives. Chapters 8 through 13 provide information on compliance with other regulations, information required by the NEPA process, or useful supporting documentation:

- **Chapter 8–Compliance with Applicable Federal Environmental Statutes and Regulations**
- **Chapter 9–Literature Cited**
- **Chapter 10–Glossary**
- **Chapter 11–List of Preparers**
- **Chapter 12–Distribution List.**
- **Chapter 13–Index**

The main text of this FR/EIS is further supported by more detailed technical appendices (Technical Appendices A through U) that address specific topics (e.g., anadromous fish biology, economics, engineering).

Because the alternatives considered in this study would affect resources of concern to all people of the Pacific Northwest, the Corps structured the Feasibility Study process

to involve participation of the whole region. The ultimate decision and process for decision making in this study is regional in scope and therefore several Federal agencies, states, and tribes were direct participants in the Feasibility Study process. The BOR, BPA, and EPA were all cooperating agencies of this study. The Corps also worked with American Indian representatives, elected officials, other Federal and state agencies, and special interest groups throughout the region. The Corps has gathered input from interested parties to define and evaluate the primary alternatives identified for improving juvenile salmon and steelhead survival rates.

1.5.1 Scoping and Public Involvement

The Feasibility Study was officially announced to the public on June 5, 1995. On that date, the Corps' notice of intent to prepare a Draft FR/EIS was published in the *Federal Register* (Monday, June 5, 1995, Vol. 60, No. 107, p. 29578).

In July 1995, the Corps conducted four public scoping meetings to initiate the Feasibility Study and begin the NEPA process. Each public meeting consisted of an open house and formal meeting. Since the scoping meetings, the Corps has conducted numerous other regional meetings, known as Regional Roundtable Workshops, as well as public outreach meetings to allow the public an opportunity to participate further in the study. Four public information meetings were held throughout the region in September 1997 and another five were conducted in November 1998 (see Appendix O, Public Outreach Program, for additional details).

Formal public meetings were conducted after the Draft FR/EIS was distributed for public review. The series of 15 formal meetings around the region in cooperation with the Federal Caucus, included presentations on the Draft FR/EIS, John Day Drawdown Study, and the Conservation of Columbia Basin Fish All-H Paper. These regional meetings held in February and March 2000 provided an opportunity for formal public questions and comments. A total of nearly 9,000 participants consisting of stakeholders, special interest groups, elected officials, and individuals from the public presented 1,786 oral and taped comments about the two studies and the Federal Caucus paper. Most meetings consisted of an open house, formal agency presentations, a question and answer session, and a public comment session. Oral comments were limited to 3 minutes in length. At some of the meetings, the attendance was so large the oral comments continued late into the night. Not all those wishing to speak stayed late enough to do so, although many provided taped comments instead. Written comments were also accepted at the meetings. In addition to oral and taped comments, the Corps received over 230,000 written comment documents from the public during the comment period. The comment period began December 1999 and extended through April 30, 2000. Written comments were received via mail, e-mail, fax, the Corps' web site, and hand-delivery. For a summary of the oral and written comments received and the responses to these comments, please see Appendix V, Response to Public Comments. Appendix O, Public Outreach Program, contains a detailed description of public involvement activities to date on the FR/EIS.

1.5.2 Screening Analysis

The technical analyses and screening of potential options in the Feasibility Study have been conducted in a variety of ways, including the use of workgroups. For example, there were workgroups for carrying out complex biological and economic evaluations. The Drawdown Regional Economic Workgroup (DREW) was a group

of regional economists studying the economic issues associated with alternative actions on the lower Snake River.

The Plan for Analyzing and Testing Hypotheses (PATH) workgroup was a group of state, tribal, Federal, and independent scientists from within and outside the region that projected salmon and steelhead survival rates under various alternatives. PATH is a structured program of formulating and testing hypotheses involving the fundamental biological issues surrounding recovery of ESA-listed salmon and steelhead species in the Columbia River Basin. PATH evaluated all aspects of lifecycles of listed salmon and steelhead to determine the overall present and future population trends. One of the key aspects of this evaluation was estimates of delayed mortalities that occur to juvenile fish after they are collected, transported downstream, and released below Bonneville Dam. The causes of this delayed mortality are not known, but the rate of return of adult fish arriving below Bonneville Dam that had been transported as juveniles is often lower than similar groups of fish that migrate in-river. (This implies that a higher rate of mortality occurs with transported fish below Bonneville Dam.)

NMFS performed additional modeling for use in its evaluations. This additional modeling has been designated the CRI. It was developed by NMFS' Northwest Fisheries Science Center in Seattle, Washington. 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.

In addition to the workgroups, there were also engineers and planners that designed and evaluated specific structural changes that could help more salmon and steelhead pass safely through the dams. The results of these efforts were incorporated into this FR/EIS.

1.5.3 Geographic and Jurisdictional Scopes

The geographic and jurisdictional scopes for the proposed action were based on the purpose and needs identified in Section 1.2, Purpose and Need. The proposed actions contemplated would be implemented as appropriate at each of four dams along the lower Snake River.

The FR/EIS coverage of the affected environment and environmental consequences focuses on the 140-mile-long lower Snake River reach between Lewiston, Idaho, and the Tri-Cities in Washington (Figures 1-1 and 1-2). The study area does slightly vary by resource area in the FR/EIS because the affected resources have widely varying spatial characteristics throughout the Lower Snake River Project. From a socioeconomic perspective, the effects of a permanent drawdown could be felt throughout the whole Columbia River Basin region, with the most pronounced effects taking place in the counties of southeast Washington.

Lower Snake River Basin

Columbia River Basin

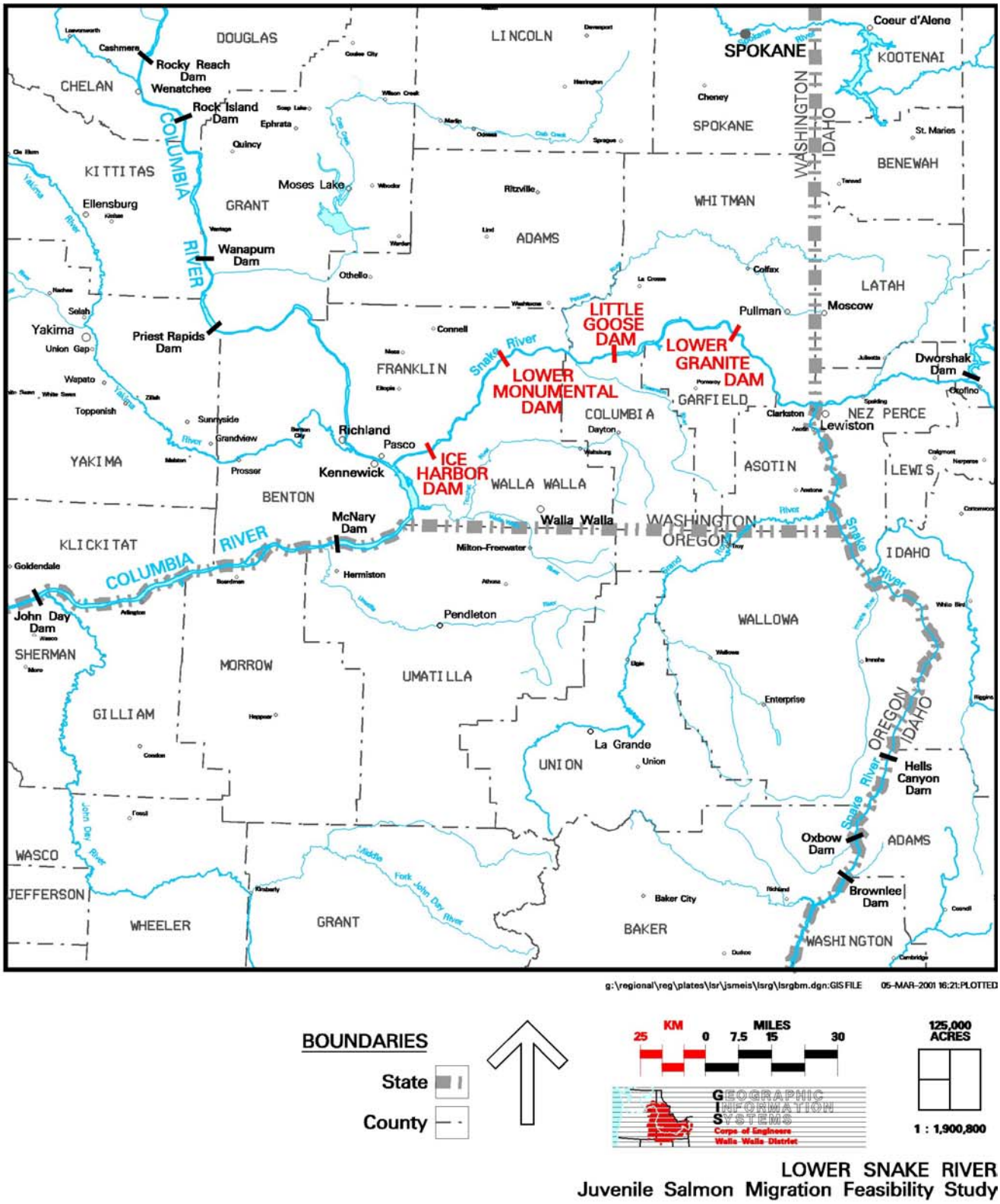
KILOMETERS 75 50 25 0 MILES 50 100 150

SQ. MILES 4,000

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

Lower Snake River
Juvenile Salmon Migration Feasibility Study

Figure 1–1.
PROJECT VICINITY



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 1–2.
REGIONAL BASE MAP

1.5.4 Regional Forum

This FR/EIS examines a number of alternatives that address just hydropower actions on the four lower Snake River dams. In order to meet the much broader needs of ESA-listed salmon of the entire Columbia River Basin, an inter-Governmental forum involving Federal, state, tribal, and other representatives for decisionmaking was formed. The forum, named the Regional Forum, is multi-leveled (see Figure 1-3).

The overall objective of the Regional Forum is for the technical teams to explore relevant facts and perform analyses, as necessary, in order to define the issues regarding ESA-listed salmon and steelhead in the Columbia River Basin. If an issue cannot be resolved at the technical levels, the issue is raised to the manager level for resolution. The main intent of the Regional Forum is to allow the Executive Committee, the Implementation Team, and the various technical teams to have opportunities for discussions of both scientific and management issues.

The Regional Forum includes the Technical Management Team which makes decisions about the in-season operation of the FCRPS to benefit salmon. In addition, it includes a parallel System Configuration Team (SCT) that was established to consider modifications to the physical structures of dams in the hydro system. PATH (see Section 1.4.2) is under the direction of the Implementation Team. PATH's decision analysis has been focused on alternative hydrosystem actions that may be used to prevent the extinction and aid in the recovery of listed stocks.

The Fish Passage Operations and Maintenance Coordination Team (FPOM) is an interagency team through which the Corps coordinates operations and maintenance (O&M) in response to fish passage issues at the Corps' mainstem Columbia River and lower Snake River projects. The Corps coordinates the annual Fish Passage Plan through the FPOM and coordinates priorities for O&M funding with FPOM. Active participation on the team is from the Corps, Columbia River Inter-Tribal Fish Commission (CRITFC), Fish Passage Center (FPC), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and NMFS. The FPOM is chaired by the Corps.

The Water Quality Team (WQT) provides scientific and technical recommendations and advice on water quality issues. The team's current emphasis is on water temperature and TDG in the Columbia River Basin.

The Implementation Team assists with resolution of the issues generated by the WQT and Integrated Scientific Review Team (ISRT), as well as others. The Executive Committee deals with issues at the policy level.

The results of this FR/EIS are major components of the overall Regional Forum's decisionmaking process. However, the Regional Forum is not only focused on the lower Snake River. In addition, work or studies on other projects in the basin (e.g., Bonneville, The Dalles, John Day, and McNary) are included in the Regional Forum's scope of activities in planning recovery efforts for ESA-listed fish.

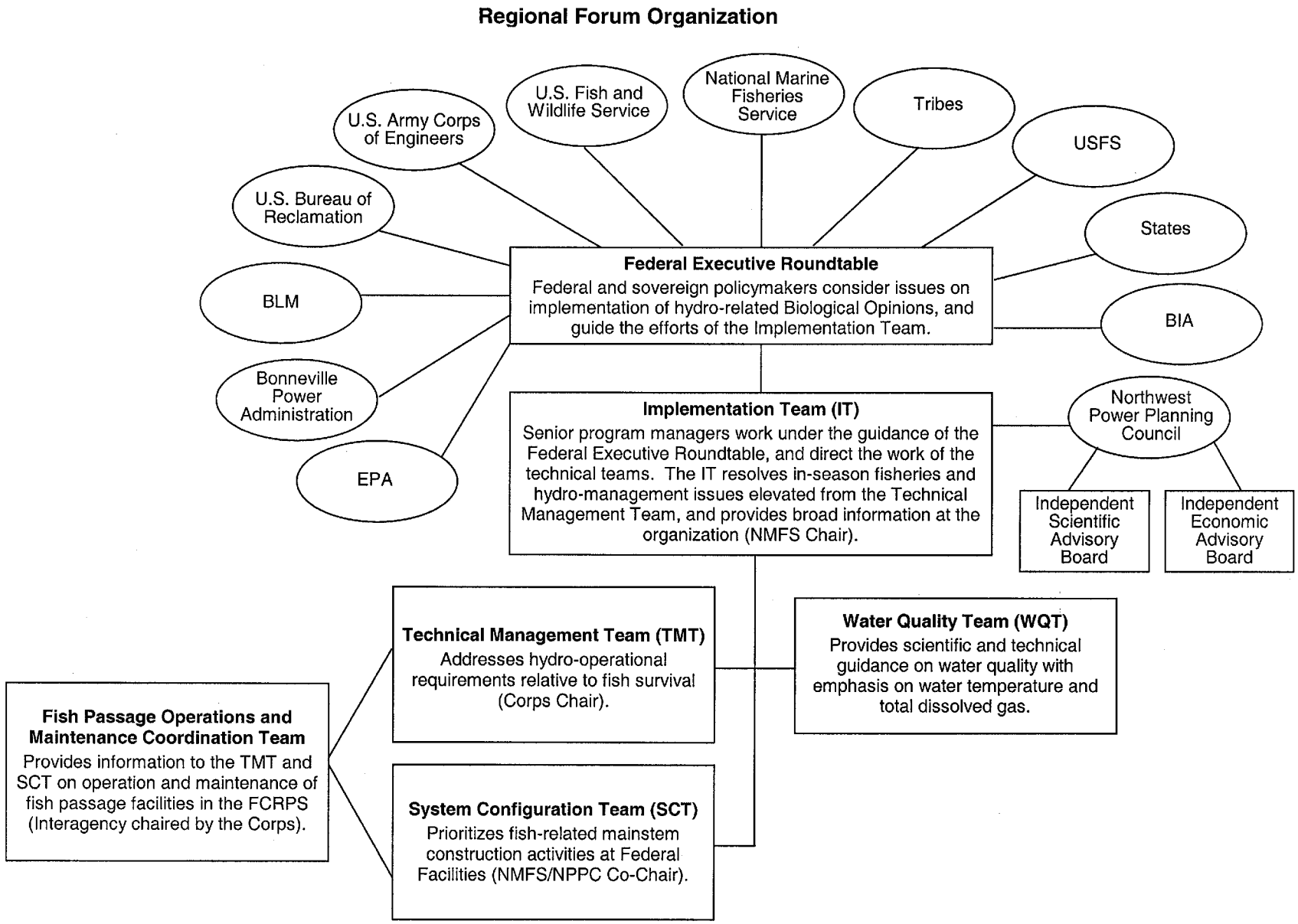


Figure 1-3. Regional Implementation Organization Chart

1.5.5 Additional Fish and Wildlife Planning Groups and Activities in the Columbia River Basin

A number of resource agencies, tribes, organizations, stakeholders, and the public have direct interest or responsibilities in developing management plans that affect recovery efforts of ESA-listed fish species in the Columbia River Basin and the operation of the FCRPS. The following identifies some of the main organizations and their roles in planning efforts for listed anadromous fish in the basin. Appendix R, Historical Perspectives, provides a more detailed description of the historical perspective of events or processes since 1990 that have led to the development of this FR/EIS.

1.5.5.1 U.S. Army Corps of Engineers/Bureau of Reclamation

The Corps and BOR are responsible for the operation and maintenance of Federal dams in the FCRPS. For example, major facilities under the Corps' management include the four lower Columbia mainstem dams (i.e., McNary, John Day, The Dalles, and Bonneville), the four dams on the lower Snake River (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor), and Chief Joseph and Dworshak Dams. The BOR is responsible for other mainstem Federal projects such as Grand Coulee Dam. Corps and BOR facilities affect biological, economic, social, and other resources in the Columbia River Basin. Both agencies are involved in the evaluations and implementation of measures that address ESA-listed fish species affected by their respective facilities.

1.5.5.2 Federal Energy Regulatory Commission

Major non-Federal dams are owned, operated, and maintained by various entities including Public Utility Districts (PUDs) (e.g., Chelan, Douglas, and Grant counties) and private utilities (e.g., Idaho Power Company). These non-Federal dams are regulated by the licensing process of the U.S. Federal Energy Regulatory Commission (FERC). Similar to the Corps and BOR facilities, the public and private utility projects also affect the resources of the Columbia River Basin. Through a licensing process, measures are evaluated and implemented that address ESA-listed fish species affected by FERC-licensed facilities.

1.5.5.3 Bonneville Power Administration

BPA markets and distributes power generated from Federal dams in the Columbia River Basin and other generating plants. The agency sells the power to public and private utilities and large industries, and it builds and operates transmission lines that deliver electricity. BPA funds a wide range of fish and wildlife programs throughout the Columbia River Basin. Funding for these programs is derived from revenues produced through sales of power generated from Federal dams in the Columbia River Basin.

1.5.5.4 National Marine Fisheries Service

In the Pacific Northwest, NMFS' responsibilities are to conserve, protect, and manage Pacific salmon, groundfish, halibut, and marine mammals and their habitats under the ESA and other laws. Species in the Columbia River include salmon, steelhead, and other anadromous fish. NMFS prepared the 2000 Biological Opinion which addressed anadromous fish aspects of the FCRPS.

1.5.5.5 U.S. Fish and Wildlife Service

The responsibilities of the USFWS are similar to NMFS, but apply to resident fish, wildlife, and plant species and their habitat. USFWS also prepared a Biological Opinion in 2000 which addressed the resident fish, wildlife, and plant species aspects of the FCRPS. In addition, the USFWS has prepared the Fish and Wildlife Coordination Act Report (FWCAR) for the Corps' FR/EIS (see Appendix M, Fish and Wildlife Coordination Act Report).

1.5.5.6 U.S. Environmental Protection Agency

The EPA is responsible for managing and enforcing water quality regulations in the nation's waters. It also regulates discharge of pollutants into water and air. Under the Clean Water Act, EPA, the states, tribal governments, other Federal agencies, and private landowners will implement numerous programs throughout the Columbia River Basin that are aimed at watershed and tributary improvements to meet requirements of the Clean Water Act. These programs will be implemented in the mainstem and tributaries and will focus on improving water quality, restoration of habitat, and recovery of ESA-listed species. The EPA also conducts various studies throughout the Columbia River Basin. For example, it is currently developing a Total Maximum Daily Loading (TMDL) program on the lower Snake River, which includes the Lower Snake River Project and upstream tributaries.

1.5.5.7 Federal Caucus/Basinwide Recovery Strategy

The Federal Caucus includes NMFS, Corps, BOR, BPA, EPA, Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), USFWS, and United States Department of Agriculture (USDA) Forest Service. The primary role of the Federal Caucus is to develop a comprehensive multi-species recovery plan that describes a range of potential Federal activities that could meet ESA obligations and rebuild Columbia Basin stocks (Basinwide Recovery Strategy). Non-federal (tribe, state, local, and private) activities are also considered in the Basinwide Recovery Strategy to the extent that they contribute to recovery of ESA-listed species in the Columbia River basin. The multi-species recovery plan is focused on the so-called four H's (hydro, habitat, harvest, and hatcheries), which are broad categories of the human activities that may affect listed species in the Columbia River System. The plan is not a decision document. Its content is neither regulatory or binding in nature. Rather, it presents a set of strategies, goals, and overall direction toward which the agencies in the Federal Caucus will commit to direct their programs and policies.

1.5.5.8 Columbia River Basin Forum

The Columbia River Basin Forum (formerly known as the Three Sovereigns) was formed to allow regional governments, interested parties, and the general public the opportunity to discuss management approaches for Columbia River Basin resources and to determine if regional agreement can be made on possible alternatives. The goal of the Columbia River Basin Forum (which has representatives from the Tribes, state, and Federal governments) is to develop regionally agreed upon recommendations for fish and wildlife recovery. A goal of the Columbia River Basin Forum is to improve the coordination of the many decision processes in the Columbia River Basin.

1.5.5.9 Tribal Caucus

There are 13 Federally recognized tribes and one non-Federally recognized Indian community in the study area. The 13 Federally recognized Indian tribes have management authority for fish, wildlife, and water resources within their reservations, as well as other legal rights included in Treaties and Executive Orders. These tribes are members of the Tribal Caucus. The primary role of the Tribal Caucus is to identify consensus views among the participating tribes. The 13 tribes are the Confederated Tribes of the Colville Reservation (Colville), the Confederated Tribes of the Umatilla Indian Reservation (Umatilla), the Confederated Tribes of the Warm Springs Reservation (Warm Springs), the Confederated Tribes and Bands of the Yakama Nation (Yakama), the Nez Perce Tribe (Nez Perce), the Spokane Tribe of the Spokane Reservation, the Coeur d'Alene Tribe, the Kalispel Indian Community of the Kalispel Reservation, the Kootenai Tribe of Idaho, the Shoshone-Bannock Tribes of the Fort Hall Reservation, the Burns-Paiute Tribe of the Burns Paiute Indian Colony, and the Shoshone-Paiute Tribes of the Duck Valley Reservation. The one non-Federally recognized Indian community is the Wanapum Band.

1.5.5.10 Columbia River Inter-Tribal Fish Commission (CRITFC)

The CRITFC is the technical support and coordinating agency for fishery management policies of the four Columbia River treaty tribes. These tribes include: the Warm Springs, the Yakama, the Umatilla, and the Nez Perce. Membership is composed of the fish and wildlife committees of these tribes. CRITFC responsibilities include fisheries research and analyses, advocacy, planning and coordination, harvest control, and law enforcement.

1.5.5.11 Wy-Kan-Ush-Mi Wa-Kish-Wit

Wy-Kan-Ush-Mi Wa-Kish-Wit is the Columbia River Anadromous Fish Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama tribes. The plan provides a framework for restoration of Columbia River salmon.

1.5.5.12 State Agencies

Washington, Oregon, Idaho, and Montana represent distinct management entities with authority over fish, wildlife, and water resources within their jurisdictions. The agencies in these states have developed a number of management and recovery plans for fish and wildlife in the Columbia River Basin.

1.5.5.13 Columbia Basin Fish and Wildlife Authority

The Columbia Basin Fish and Wildlife Authority (CBFWA) was established to coordinate the efforts of its members (state, tribal, and Federal fish managers) to protect and enhance fish and wildlife resources by:

1. Coordinating the fish and wildlife activities of concern to the members
2. Facilitating the members' involvement in the implementation of the NPPC's Fish and Wildlife Program
3. Interfacing with water and land planning and management authorities of the Columbia River Basin.

1.5.5.14 Northwest Power Planning Council

The NPPC is a regional agency of the states of Idaho, Montana, Oregon, and Washington that was created under the authority of the Pacific Northwest Electric Power Planning and Conservation Act of 1980. The NPPC's primary role is to conduct long-range energy and fish and wildlife planning in the region. The NPPC has three distinct tasks:

1. Prepare a regional conservation and electric power plan to meet future energy needs, giving first priority to cost-effective energy conservation and second priority to cost-effective renewable resources.
2. Prepare a program to protect, mitigate, and enhance fish and wildlife, including spawning grounds and habitat, on the Columbia River and its tributaries.
3. Ensure widespread public involvement in the formulation of the power plan and the NPPC's Fish and Wildlife Program.

The NPPC makes recommendations to BPA on the utilization of ratepayer funds for the Fish and Wildlife Program. The Fish and Wildlife Program is revised periodically and will respond to the decisions made in the FR/EIS process.

1.5.5.15 Multi-Species Framework/Ecosystem Diagnosis and Treatment Analysis

In response to two scientific reviews on the NPPC's Fish and Wildlife Program, a science-based framework was initiated to help guide management policy. The framework is used to develop options for future management of the Columbia River Basin, including the biological, social, and economic effects of the options. The Hydro Work Group of the Federal Caucus and the Framework Project staff jointly evaluated alternative measures for system configuration and operations and agreed to the specifications of those measures in seven Framework Project alternatives and three Federal scenarios. The joint group also coordinated the analysis of hydrosystem operations, the biological studies and evaluations, and other Federal and Framework Project tasks related to the hydrosystem.

The Framework Project will characterize a set of alternative futures for the Columbia River basin that focus on a long-term vision for the region. The Framework Project uses an analytical technique called ecosystem diagnosis and treatment (EDT) to compare the ecological effects of various alternatives and describe their economic, social, and cultural impacts. The analysis focuses on long-term conditions and emphasizes habitat actions.

1.6 Alternatives

This FR/EIS analyzes a range of possible actions on the lower Snake River. Other aspects of the Columbia River and upper Snake River operations are addressed under other related study processes. For example, there are several related processes underway that address structural and operational changes in other parts of the Columbia River System (see Section 3.5, Other Potential Actions Outside the Scope of the FR/EIS, for additional discussion of these related processes). Many alternatives were considered and are being considered in this study process. As described above, there are numerous study groups and collaborative efforts underway that have assisted in the evaluation of alternatives.

Since the beginning of the Feasibility Study, alternatives have been identified and given numbering or lettering schemes to serve as unique identifiers. However,

different study groups have used slightly different numbering or lettering schemes. Rather than try to carry forward the complex, and often conflicting, numbering and lettering schemes, this FR/EIS uses short names to label the alternatives that are considered in detail (Table 1-2). The alternatives that are considered in detail include:

- **Alternative 1—Existing Conditions** (commonly called Alternative A1 in supporting study reports and A-1 by PATH)—the existing hydrosystem operations under the 1995 and 1998 Biological Opinions.
- **Alternative 2—Maximum Transport of Juvenile Salmon** (called Alternative A2a in supporting study reports and A-2 by PATH)—the existing hydrosystem operations and maximum transport of juvenile salmon, but without surface collectors or other major improvements.
- **Alternative 3—Major System Improvements** (called Alternative A2d in supporting study reports and A-2′ by PATH)—the existing hydrosystem operations but with major system improvements that could be accomplished without a drawdown. This alternative emphasizes adaptive migration which involves development of major system improvements that provide improved conditions for either in-river migration of juvenile fish or collection and transport downstream by barge or trucks. This alternative provides the flexibility and opportunity to adjust downstream migration management strategies to achieve optimum passage conditions for survival with dams in place.
- **Alternative 4—Dam Breaching** (called Alternative A3 in supporting study reports and A-3 by PATH)—drawdown of the four lower Snake River reservoirs (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) to near-natural river conditions.

Table 1-2. Alternative Designations for this FR/EIS and Previous Designations in Other Reports

FR/EIS Alternative	Supporting Studies/Other Alternative Designations	PATH Alternative
Alternative 1—Existing Conditions	A1	A-1
Alternative 2—Maximum Transport of Juvenile Salmon	A2a	A-2
Alternative 3—Major System Improvements	A2d	A-2′
Alternative 4—Dam Breaching	A3	A-3

1.7 Authority

The Lower Snake River Project (which is the name for the Corps' four lower Snake River facilities combined) was constructed and is operated and maintained under laws that may be grouped into three categories: 1) laws initially authorizing construction of the project (i.e., Public Law 79-14); 2) laws specific to the project passed subsequent to construction; and 3) laws that generally apply to all Corps projects. Using these and other authorities, the Corps operates multiple-use water resource development projects to balance operation of individual functions with operations for all functions. This operation is coordinated with BPA, BOR, and other regional interests. The authorized uses of the Lower Snake River Project are power generation

and inland navigation, fish and wildlife, irrigation, and recreation. (These facilities operate as run-of-river dams and are not authorized for flood control). These uses have been authorized under several public laws (Table 1-3).

Table 1-3. Authorized Uses of Lower Snake River Project Facilities

Authorized Uses	Authorizing Laws
Navigation	Public Law 79-14
Irrigation	Public Law 79-14
Recreation	Public Law 78-534
Hydroelectric Power	Public Law 79-14
Fish/Wildlife	Public Law 85-624

Source: Corps, 1992

This Feasibility Study was conducted with consideration of authorization legislation and other laws including ESA; the Pacific Northwest Electric Power Planning and Conservation Act; the Fish and Wildlife Coordination Act; Section 216 of the 1970 Flood Control Act; River and Harbor Act of 1945; Sections 103, 105, and 905 of the 1986 Water Resources Development Act; Water Supply Act; Federal Water Pollution Control Act; and the water resources appropriations bills passed by Congress in 1996, 1997, and 1998. In particular, the ESA requires all Federal agencies to ensure that actions taken by the agency are not likely to jeopardize the continued existence of a species that has been listed as threatened or endangered or result in the destruction or adverse modification of critical habitat. In addition, the ESA provides agencies with the responsibility to carry out programs for the conservation of listed species.

Chapter 2

Affected Projects and Programs

2.1 Project Characteristics
2.2 Facility Operations and Structures

2. Affected Projects and Programs

2. AFFECTED PROJECTS AND PROGRAMS 2-1

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The Columbia River is the fourth largest river in North America. It originates at Columbia Lake in the Columbia Mountains of British Columbia, Canada and flows 1,214 miles to the Pacific Ocean (Figure 1-1). From its source, the river flows northwest for approximately 200 miles, then reverses course and travels south for nearly 300 miles through mountainous terrain in southeastern British Columbia. The Columbia River crosses into the United States near the northeastern corner of Washington State and continues south through highlands before bending westward. After looping again to the east, the river turns westward and flows for over 300 miles between Washington and Oregon to the sea.

The Columbia River Basin drains over 259,000 square miles. It produces an average annual runoff at The Dalles of about 173 million acre-feet (MAF) (enough water to cover 173 million acres to a depth of 1 foot). The drainage area comprises most of Washington, Oregon, and Idaho; the western quarter of Montana; the southeastern corner of British Columbia; and small portions of Wyoming, Utah, and Nevada. There are more

than 150 dams and reservoirs whose operations are coordinated in the basin—31 of them are operated by Federal agencies.

The Snake River is the principal tributary of the Columbia River. The Snake River drains an area of about 109,000 square miles, including portions of Idaho, northwestern Wyoming, northern Utah and Nevada, southeastern Washington, and eastern Oregon) (Figure 1-1). Major tributaries downstream of Hells Canyon Dam include the Salmon, Grand Ronde, Imnaha, Clearwater, Tucannon, and Palouse Rivers. The Snake River flows through a canyon of varying depths from about 5,500 feet in upstream Hells Canyon to less than 450 feet near its confluence with the Columbia River. Much of the lower Snake River Canyon is generally steep, with basalt bluffs rising up to 2,000 feet to rolling uplands.

Most juvenile salmon originating from the Snake River Basin make their way past eight Federal dams and reservoirs on the lower mainstem Snake and Columbia Rivers before reaching the Pacific Ocean (Figure 1-1).

This Feasibility Report/Environmental Impact Statement (FR/EIS) is concerned with actions for improving fish passage at the four Federal dams on the lower Snake River. This section summarizes key project and program information for these four dams, which make up the Lower Snake River Project. It includes a description of the facilities at each dam and a discussion of existing river system fish programs. These four dams are all equipped with passage systems for adult and juvenile fish. The systems are continually being improved as new technologies for passage are developed.

2.1 Project Characteristics

The four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) are multiple-use facilities that provide public benefits in many different ways. The Lower Snake River Project uses are inland navigation, hydropower generation, irrigation, recreation, and fish and wildlife. Project facilities include dams and reservoirs, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish passage structures, fish hatcheries, parks and recreational facilities, lands dedicated to project operations, and areas set aside as wildlife habitat.

All four lower Snake River dams are run-of-river facilities. They are not authorized, designed, or operated for flood control. These run-of-river facilities have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for hourly regulation of powerhouse discharges to follow daily and weekly demand patterns. This storage is not enough to allow seasonal regulation of streamflows. Other Federal dams on the Columbia River and its tributaries were developed for storage purposes. Storage reservoirs, such as the Dworshak Reservoir on the North Fork of Clearwater River, are used to store water and adjust the river's natural flow patterns to conform more closely with water uses.

The normal operating ranges and usable storage volumes for the affected four lower Snake River facilities are listed in Table 2-1. While it is physically possible to draw run-of-river reservoirs well below their normal minimum pool levels, the four lower Snake River facilities are not designed to operate below minimum pool levels.

Table 2-1. Characteristics of the Four Lower Snake River Facilities

Facility	Type of Facility	Snake River Mile	Reservoir Name	Reservoir Capacity 1/ (acre-feet)	Total Reservoir Capacity (acre-feet)	Reservoir Elevation 1/ (NGVD29)
Lower Granite	run-of-river	107.5	Lower Granite Lake	49,000	483,800	733 to 738
Little Goose	run-of-river	70.3	Lake Bryan	49,000	565,200	633 to 638
Lower Monumental	run-of-river	41.6	Lake Herbert G. West	20,000	432,000	537 to 540
Ice Harbor	run-of-river	9.7	Lake Sacajawea	25,000	406,500	437 to 440

1/ normal operating range
NGVD29 = National Geodetic Vertical Datum
Source: Corps and NMFS, 1994

The following sections describe the features that are generally present at all four lower Snake River facilities.

2.1.1 Adult Fish

The Lower Snake River Project was originally designed and constructed with adult passage facilities at the four dams. These facilities include fish ladders, pumped attraction water supplies, and powerhouse fish collection systems (Table 2-2). The adult fish passage facilities at each dam have certain features in common (Figure 2-1). In general, there is a set of main fishway entrances near the far end of the spillway, between the spillway and powerhouse, and at the near end of the powerhouse. Two entrances are typically used at each location. Additional smaller entrances (floating orifice gates) are provided across the face of the powerhouse.

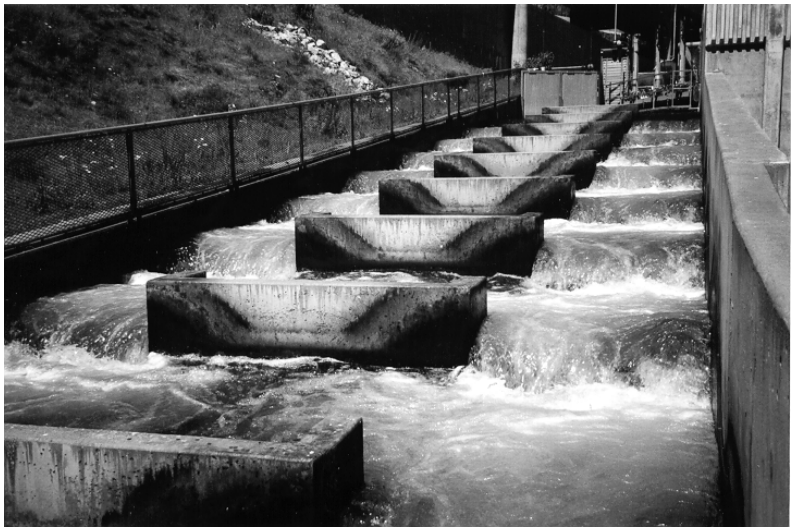


Figure 2-1. Existing Adult Fish Passage Systems

Table 2-2. Components of Juvenile and Adult Fish Passage Facilities at the Lower Snake River Project

	Juvenile Fish Passage Facilities	Adult Fish Passage Facilities
Lower Granite Dam	**Bypass System** • extended submerged bar screens (ESBSs) with flow vanes • improved modified balanced flow vertical barrier screens • gatewell orifices (10 inch) • bypass channel running the length of the powerhouse • bypass pipe to transportation facilities or river **Transportation Facilities** • upwell and juvenile/adult separator structure • raceways for holding fish • distribution system (to raceways, barge, or river) • sampling and marking building • truck and barge loading facilities • passive induced transponder (PIT) tag detection and deflection systems	**North Shore Fish Collection** • two downstream entrances • one side entrance into stilling basin on north end of spillway • tunnels connect these fishway entrances to powerhouse's collection system **South Shore Fish Ladder** • two south shore entrances **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • ten floating orifices **Auxiliary Water Supply System**
Little Goose Dam	**Bypass System** • ESBSs with flow vanes • vertical barrier screens • gatewell orifices (12 inch) • bypass channel running the length of the powerhouse • metal flume on face of dam and upper end of fish ladder • dewatering structure • two emergency bypass systems • corrugated metal flume (to transportation facilities or river) **Transportation Facilities** • upwell and juvenile/adult separator structure • raceways for holding fish • distribution system (to raceways, barge, or river) • sampling and marking building • truck and barge loading facilities • PIT tag detection and deflection systems	**North Shore Fish Collection** • two downstream entrances • one side entrance into stilling basin on north end of spillway • tunnels connect these fishway entrances to powerhouses collection system **South Shore Fish Ladder** • two south shore entrances **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • four floating orifices **Auxiliary Water Supply System**

Table 2-2. Components of Juvenile and Adult Fish Passage Facilities at the Lower Snake River Project (continued)

	Juvenile Fish Passage Facilities	Adult Fish Passage Facilities
Lower Monumental Dam	**Bypass System** • standard length submerged traveling screens (STSs) • vertical barrier screens • gatewell orifices (12 inch) • collection channel • dewatering structure • bypass flume (to tailrace below the dam) **Transportation Facilities** • upwell and juvenile/adult size separator structure • sampling facilities • raceways for holding fish • office and sampling building • truck and barge loading facilities • PIT tag detection and deflector systems	**North Shore Fish Ladder** • two north shore entrances • connects to powerhouse collection system **South Shore Fish Ladder** • two downstream entrances • one side entrance into spillway basin **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • ten floating orifices **Auxiliary Water Supply System**
Ice Harbor Dam	**Bypass System** • standard length STSs • vertical barrier screens • gatewell orifices (12 inch) • collection channel • dewatering structure • sampling and marking building **Transportation Facilities** • transportation flume/pipe to tailrace (below dam)	**North Shore Fish Ladder** • counting station **North Shore Collection System** • two downstream entrances • one side entrance into spillway basin • counting station **North Shore Auxiliary Water Supply System** **South Shore Fish Ladder** • counting station • two south shore entrances **South Shore Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • twelve floating orifices **South Shore Auxiliary Water Supply System**

Source: Corps, 1999a

Adult fish passage facilities are operated in accordance with the U.S. Army Corps of Engineers' (Corps) Fish Passage Plan (Corps, 2000a). Fish ladders typically operate all year with two weeks shutdown for maintenance in the January through March timeframe. Fish counting is done April through October at Ice Harbor, Lower Monumental, and Little Goose, and April through December at Lower Granite.

2.1.2 Juvenile Fish

Juvenile fish bypass facilities were installed at each of the four lower Snake River dams shortly after they were constructed (Figures 2-2a and 2-2b and Table 2-2). The facilities were upgraded as new technology developed.

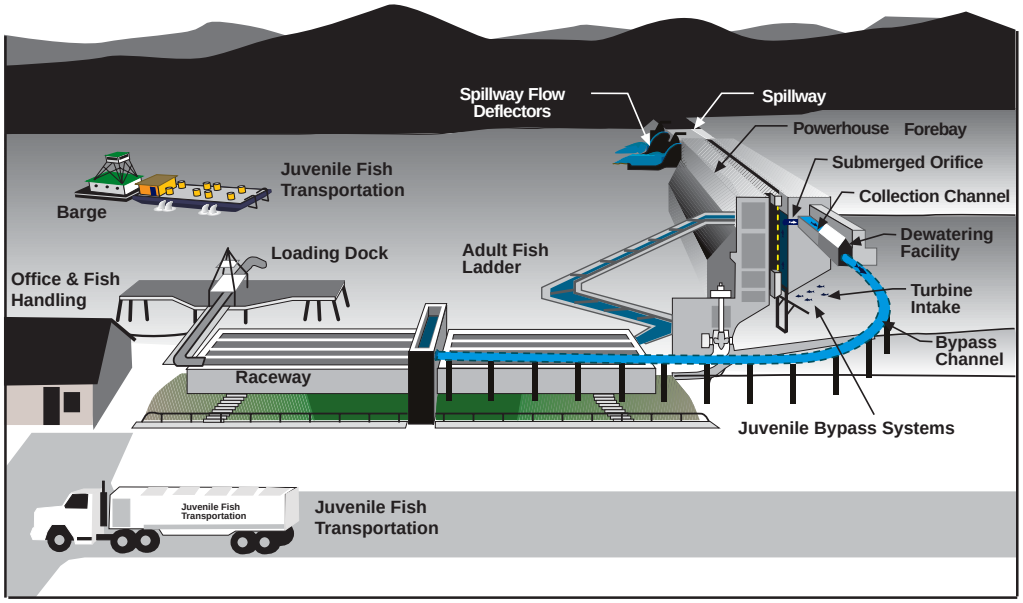


Figure 2-2a. Existing Fish Passage Systems

In 1987, the Columbia River Fish Mitigation Program (CRFMP) was initiated. Under this program, juvenile fish bypass/collection facilities were upgraded at Ice Harbor (1996), Lower Monumental (1993), and Little Goose (1998). Other improvements such as spillway flow deflectors at Ice Harbor and extended submerged bypass screens (ESBS) at Little Goose and Lower Granite, have also been added. Also, studies are underway to investigate ways to improve water quality (i.e., lower temperature) in the ladders.

The fish agencies and tribes recommended postponing the upgrade of the Lower Granite facilities, pending the decision on this FR/EIS. Although the existing facilities at Lower Granite currently provide high survival (99.5 percent) for juvenile passage, numerous studies have shown substantial stress occurs in fish that pass through the bypass system. However, the cost of replacing the facilities to eliminate these known stress problems would be lost if a decision is made to breach the dam. Therefore, if the decision is to continue current operations, replacing this facility would be an element of that action. Specific plans for upgrading the Lower Granite juvenile fish facility are presented in Appendix E, Existing Systems and Major System Improvements Engineering.

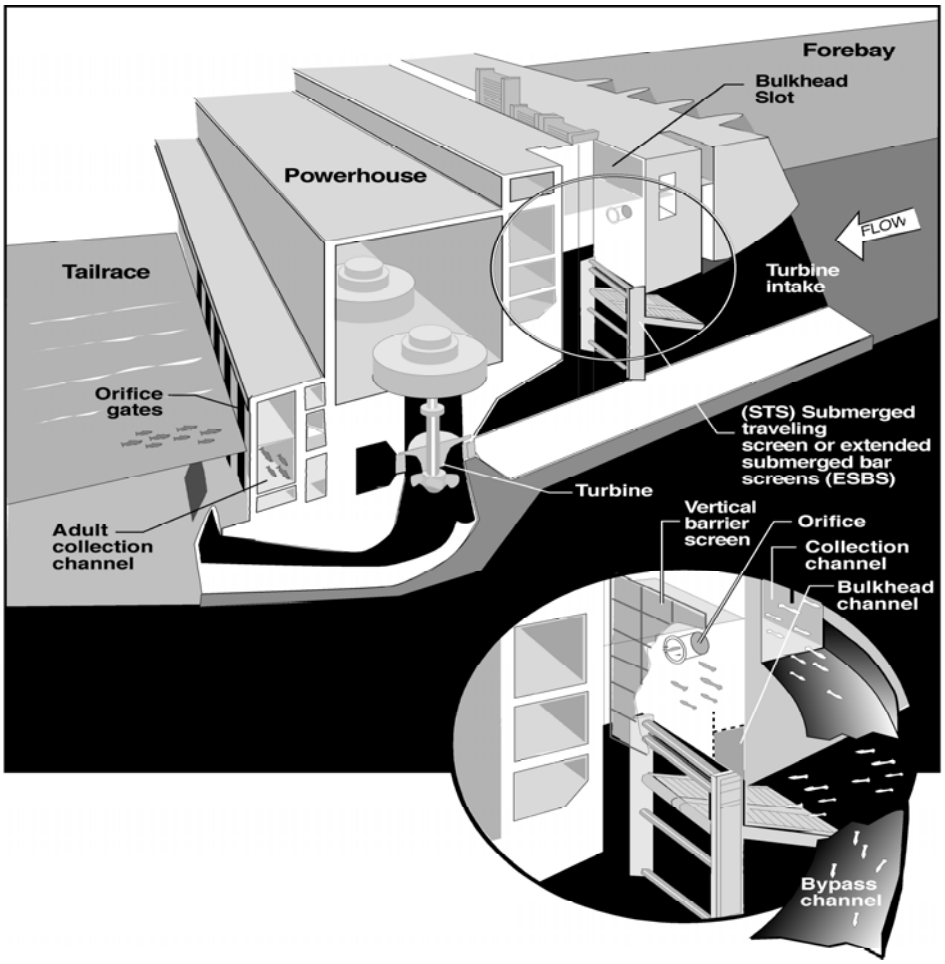


Figure 2-2b. Juvenile Fish Bypass Facilities

Current measures for collection and transportation of juvenile fish outmigration are identified in the 1995 and 1998 opinions, and the Endangered Species Act (ESA) Section 10 Permit (#895) for the Juvenile Fish Transportation Program (JFTP). The National Marine Fisheries Service [NMFS] and U.S. Fish and Wildlife Service [USFWS] 2000 Biological Opinions were released December 2000. The Corps operates the JFTP in cooperation with NMFS.

Typical existing facilities for juvenile fish (Figure 2-2b) that enter the turbine area (compared to those that would pass over the spillway) include the following:

- **Turbine Intakes**—Each generating unit at the lower Snake River dams has three turbine intakes. These intakes are similar at all four dams except that they are slightly smaller at Ice Harbor.
- **Turbine Intake Screens**—Standard length submerged traveling screens (STSs) are devices that are lowered into the turbine bulkhead slots to guide fish from the turbine intake and subsequent turbines. The screened area is 20 feet high and 20 feet wide. The screen is a continuous belt that travels around the frame like a

conveyor belt. The screen revolves so that debris collected on the front face is carried over to the back side where it is washed off by the flow through the screen. STSs are used at Lower Monumental and Ice Harbor. STSs were replaced with ESBSs at Lower Granite (1996) and Little Goose (1997). The ESBSs are 40 feet long and 20 feet wide and significantly increase the number of fish guided away from turbines.

- **Bulkhead Channel**—Fish guided into the bulkhead slot swim or are carried upward by the flow deflected by the fish screen. Fish not guided by the screen pass through the turbine.
- **Collection Channel**—The fish move through an orifice into the collection channel within the powerhouse. At Lower Granite, a collection channel was constructed in the dam and became operational in 1975. Little Goose and Lower Monumental were constructed with imbedded pipelines for juvenile bypass systems. Subsequent modifications at Little Goose (in 1984 and 1985) and Lower Monumental (1991) resulted in mining of tunnels similar to the collection channel at Lower Granite. At Ice Harbor, a collection channel was constructed in the ice/trash sluiceway along the upper face of the powerhouse in 1995.
- **Bypass Channel**—Fish are directed through a bypass pipe or flume to the fish collection/handling facilities (see Figures 2-2a and 2-2b).
- **Fish Collection/Handling**—Fish arriving at the juvenile fish facilities by pipe or flume are separated from adult fish and debris by a separator. They are then passed to holding ponds or raceways where they are held until being loaded into a truck or barge.
- **Transportation**—Juvenile fish are transported under the guidelines of the Fish Passage Plan and the Corps' JFTP. Juvenile fish are not transported at Ice Harbor, but the majority are bypassed directly to the tailrace below the dam. At Lower Granite, Little Goose, and Lower Monumental, juvenile fish that go through the bypass systems can be routed either directly back into the river below the dam, or to holding and loading facilities for loading into barges or trucks for transport. Trucks are used for transport when the number of fish collected is 20,000 or fewer per day at Lower Granite.

The transport barges and trucks carry the fish past the remaining projects in the Columbia-Snake River System for release below Bonneville Dam in high velocity waters at night to reduce predation. River water circulates through the barges, allowing the fish to imprint the chemicals and smells of the water during the trip downriver. Similarly, trucks are specially equipped to maintain proper conditions during transport (e.g., operation and maintenance of water temperatures). The adults use this "imprinting"

mechanism during upstream migration to guide them to the location where they originated (e.g., spawning area or hatchery).

Collection of juvenile fish generally starts March 25 at Lower Granite and a few days later at Little Goose and Lower Monumental. There are currently eight barges in the Corps' fish passage fleet. Early in the season (typically the second week in April), a barge leaves Lower Granite every other day. As numbers of fish increase, barging is increased to every day. In order to follow the "spread-the-risk" policy initiated in the 1995 and 1998 Biological Opinions, the current goal is to transport about half of the juvenile Snake River salmon and steelhead. The remainder are either bypassed back to the river, pass through the turbines, or may pass over the spillway if spill occurs. In its 2000 Biological Opinion, NMFS requested that summer migrants (those collected after June 20) be transported from all transport facilities.

2.1.3 Reservoir Operation Levels

Drawing down the reservoirs to increase water velocity and decrease travel time of downstream migrating juvenile salmon was first considered in the late 1980s. As identified in its 1995, 1998, and 2000 Biological Opinions, NMFS requested operation of the three lower Snake River facilities (Little Goose, Lower Monumental, and Ice Harbor dams) within 1 foot of reservoirs at minimum operating pool (MOP) from April 3 until adult fall chinook begin to enter the Snake River. This level is considered the bottom 1 foot of the operating range for each reservoir. Lower Granite Dam would be operated within 1 foot of the MOP from April 3 through November 15 of each year. After November 15, all four reservoirs would be operated within their normal 3- to 5-foot operating ranges.

2.1.4 Turbine Operation

Historical studies demonstrated that operating turbines within one percent of peak efficiency would maximize survival of juvenile salmon passing through the turbines (Bell, 1990). Since the mid-1980s, the Corps has made every effort to operate turbines at the four dams within the 1 percent peak efficiency rate. In its listing of the Snake River salmon in 1991 and 1992, and under the 1995 and 2000 Biological Opinions, NMFS requested that the Corps operate turbines within 1 percent of peak efficiency during juvenile and adult migration seasons, which extends from March 15 to November 30 on the lower Snake River.

Studies following this operational change have shown turbine mortality to be less than 7 percent (Normandeau Associates, et. al, 1996; Normandeau Associates, Inc. and Skalski, 1997) at each dam. Studies prior to this operational change typically showed about 15

percent mortality to juvenile salmon from passage through turbines at each dam (Bell, 1990).

2.1.5 Spill for Juvenile Passage

As previously mentioned, the Lower Snake River Project facilities are run-of-river with only a 3- to 5-foot operating range, which provides little storage of water. Therefore, when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs, water is involuntarily spilled. In contrast, voluntary spills would be those that are not required to pass excess flows downstream (e.g., the powerhouse could pass the flows and there is sufficient power demand). Voluntarily passing water over dam spillways rather than through the powerhouse is an operations approach used to divert juvenile fish from the turbines as they approach a dam. The majority of spill occurs at night to enhance downstream passage of juveniles that migrate past dams primarily during this period.

The Corps began spilling water for juvenile salmon at several lower Snake dams in 1977, as a way of improving juvenile fish passage survival. A more comprehensive spill program was initiated in 1989, when a long-term spill agreement was signed by BPA, the fisheries agencies, tribes, and others (BPA et. al., 1995). The Corps considers the spill requests each year when determining operations of its dams.

In response to the 1995 and 1998 Biological Opinions, spill at the dams has been increased substantially during juvenile fish migrations. However, spill has associated risks, because spilling water can entrain air when the water plunges into the spillway basins, causing raised levels of dissolved gas in the water (dissolved gas supersaturation) that can be harmful to fish. In addition, when spill occurs, fish that could be collected and transported around a series of dams are bypassed downstream to the next reservoir and whatever dams are left to pass. Therefore, the spread-the-risk policy in the 1995 and 1998 Biological Opinions was adopted to allow multiple ways of passing juvenile fish downstream (i.e., fish are either passed over the spillway into the tailrace, bypassed around the dam and transported by truck or barge, or are bypassed around the dam and released below the tailrace). Under the existing operations, spill is limited to the adjusted total dissolved gas "cap" (see Section 4.5, Aquatic Resources) as administered by the states of Oregon and Washington. The largest concentrations allowed are 115 percent in the forebays and 120 percent in the tailwaters. The NMFS 2000 Biological Opinion has requested the following spill criteria:

- Ice Harbor Dam—a 24-hour spill (with night-time spill limited to the total dissolved gas (TDG) at the cap and daytime spill limited to 45 thousand cubic feet per second (kcfs) for adult passage
- Lower Monumental Dam—a 24-hour spill at the gas cap

- Little Goose and Lower Granite Dams—a 12-hour spill (6 pm to 6 am) up to the gas cap.

2.1.6 Completion of Gas Abatement Measures

Dissolved gas supersaturation emerged as a major threat to the survival of the Snake River and Columbia River salmon runs in the late 1960s. This occurred from releases of large volumes of water over spillways. In response, the Corps initiated a major effort to modify Corps' dams to reduce the problem. The measures taken were: 1) completion and use of upstream storage to minimize spill, 2) installation of turbines in skeleton bays (unused turbine bays) at the lower Snake River and Columbia River dams to also minimize spill, and 3) installation of spillway flow deflectors in the spillbays at the lower Snake River and Columbia River dams.

Spillway flow deflectors (Figure 2-3) produce a more horizontal spill flow that limits the plunge depth of water over the dam spillway. This reduces the amount of TDG, but high spill can diminish the effectiveness of the flow deflectors. Spillway flow deflectors are installed in all eight spillbays at Lower Granite and all 10 bays at Ice Harbor.

Deflectors were installed in six of eight bays at Little Goose and Lower Monumental. Studies at these two dams by fishery agencies indicated that deflectors should not be added in the end bays because of concerns relating to the tailrace hydraulic conditions in the immediate vicinity of adult fish ladder entrances. These localized conditions could delay adult fish from finding the ladder entrances. However, NMFS' 2000 Biological Opinion has requested further investigations on spillway deflector optimization, including the addition of end-bay deflectors.

Spillway flow deflectors originally were not installed at Ice Harbor because of concerns over adult fish passage, and because it was only a few miles to low supersaturated waters in the Columbia River coming from the free-flowing yet controlled Hanford Reach. In 1996 and 1997, spillway flow deflectors were added to 8 of the 10 spillway bays at Ice Harbor as a result of increased spills to accommodate the requests made by NMFS in the 1995 Biological Opinion, which included keeping a portion of the downstream migrating fish in the river (versus transport) as part of the spread-the-risk policy. This action raised the spill cap from about 25 kcfs to about 75 kcfs at 120 percent gas concentrations, which benefited fish passage efficiency (FPE) (see Section 5.4, Aquatic Resources). In 1997 and 1998, flow deflectors were installed in the two remaining Ice Harbor spillway bays along with an added training wall which raised the spill cap (i.e., the maximum amount of spill that results in the highest allowed total gas concentration) from about 75 kcfs to about 105 kcfs at 120 percent gas concentrations.

Studies are continuing on structural measures to reduce TDG production as well as on TDG effects on juvenile fish mortality. In addition to studies on the potential installation of spillway flow deflectors in bays where they have not yet been installed, other studies involved evaluations of raising stilling basins and installing alternate methods of passing water. Under existing conditions, additional deflectors and other structural modifications would be added at Lower Granite, Little Goose, and Lower Monumental.

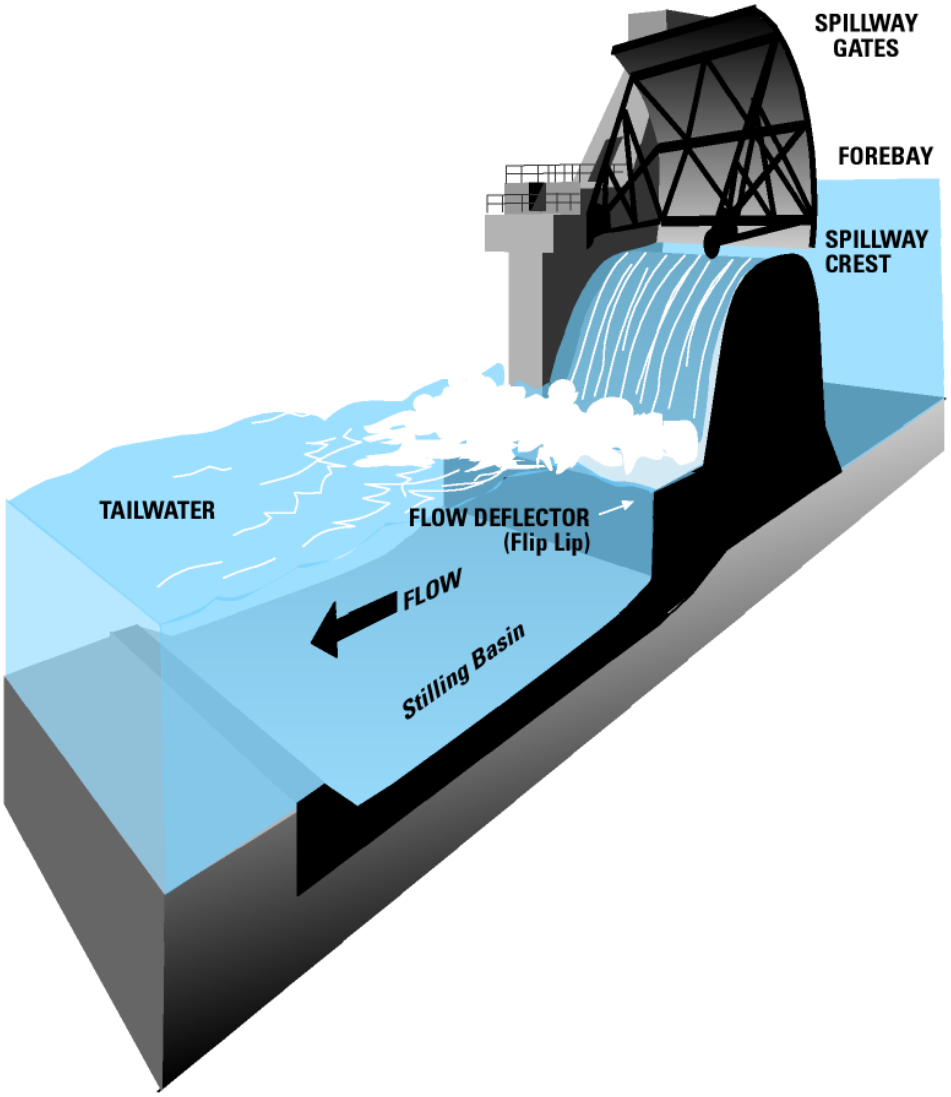


Figure 2-3. Spillway Flow Deflector (flip lip), Lower Granite Dam Spillway

Monitoring of dissolved gas concentrations has greatly advanced in the past 30 years. With the existing operations, a network of monitoring stations has been established above and below each dam, and at other major sites throughout the Federal Columbia River Power System (FCRPS). This network provides the Corps, the Fish Passage Center (a technical office of the Columbia Basin Fish and Wildlife Authority [CBFWA]), and NMFS with immediate access to dissolved gas information throughout the system. Under existing conditions, this monitoring of dissolved gas concentrations would continue. The NMFS 2000 Biological Opinion calls for some improvements in this monitoring plan.

2.1.7 Flow Augmentation

Dams upstream of Lower Granite can regulate water for flood control, irrigation, and other uses, interrupting the seasonal river flow patterns in downstream areas. Flow augmentation (i.e., increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs) can aid migration of juvenile salmon. The original Fish and Wildlife Program of the Northwest Power Planning Council (NPPC) (NPPC, 1982) included an amount of upstream storage to be controlled by the fishery agencies and tribes. This water (termed the "Water Budget") was used to simulate the natural spring freshet for the juvenile salmon outmigration. The increased flow is presumed to help flush fish downriver and reduce their exposure to predators and other potential hazards in reservoirs.

The Fish Passage Center was established to recommend management strategies concerning the Water Budget, which includes water releases from Dworshak plus additional water from the Hells Canyon complex and the upper Snake River. The amount and timing of release for the Water Budget were determined each year, based on the amount of water potentially available in storage.

The 1995 Biological Opinion changed the operating regime for flow augmentation volumes to target flows at Lower Granite. A Technical Management Team (TMT) was established to advise the operating agencies on dam and reservoir operations to optimize passage conditions for juvenile and adult anadromous salmonids. The TMT (see Section 1.4.4) consists of representatives from NMFS, USFWS, BOR, Corps, BPA, states, and tribes. It meets weekly during the juvenile fish migration seasons to discuss flows and spills, and to plan operations for fish.

All TMT recommendations are made to the Corps and BOR, which have authority to operate the FCRPS projects, and to the Corps and BPA, which have the authority to make agreements with Canada regarding storage in Canada (for mainstem Columbia River projects).

The 1995 Biological Opinion called on the BOR to provide 427 thousand acre-feet (KAF) 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 80,000 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. The Idaho statute that authorized release of the additional 427 KAF expired on January 1, 2000. This was extended until January 1, 2001. BOR is pursuing authorization to extend it. The statute covers only the release of water from storage (not natural flows) and specifies that the amount of flow augmentation that BOR can provide from all sources is limited to 427 KAF in any year.

NMFS' 2000 Biological Opinion addresses flow augmentation. The action agencies (Corps, BPA, and BOR) are currently developing implementation plans in response to this opinion. Although flow augmentation levels could change as a result of the planning efforts, the 427 KAF was assumed to be incorporated into each alternative evaluated in this FR/EIS.

In addition to the 427 KAF, Idaho Power Company also provides spring/summer storage releases from Brownlee Reservoir of about 237 KAF. Also during the summer period, the Corps releases about 1.2 million acre-feet (MAF) from Dworshak Reservoir. From these three entities (BOR, Idaho Power, and Corps), approximately 1.9 MAF of Snake River Basin storage is made available for augmentation.

The BOR conducted a study of the effects of providing 1.0 MAF; however, additional flow augmentation was eliminated from further analysis in this study due to issues/concerns raised in BOR's *Snake River Flow Augmentation Impact Analysis Appendix*, dated February 1999. Some of those issues/concerns are:

- Insufficient storage space in the Snake River basin under BOR and Corps exclusive control to provide large amount of water for flow augmentation without significant impacts to natural resources, recreations, and economic sectors.
- Inability of BOR to meet its historic obligations and commitments to project beneficiaries if additional flow augmentation was required.
- Inability of BOR to fully meet all congressionally authorized project purposes if required to provide 1,427,000 acre-feet for flow augmentation.
- Affected states general opposition to flow augmentation.
- Congressional action could be needed to clarify BOR's responsibilities or additional authorization and appropriate may be needed.

NMFS' 2000 Biological Opinion indicates that the existing seasonal flow objectives established by the 1995 Biological Opinion "represent a fair balance between flow and water quality/conditions." However, the issue of providing water from BOR's upper Snake Basin and Idaho Power's Hells Canyon projects to assist in achieving Snake River flow objectives are being addressed in a separate Section 7 consultation (NMFS, 2000).

2.1.8 Lower Snake River Fish and Wildlife Compensation Plan

The *Lower Snake River Fish and Wildlife Compensation Plan* (Comp Plan) was authorized by the Water Resources Development Act of 1976 to mitigate for fish and wildlife losses caused by construction and operation of the four lower Snake River dams. The Comp Plan consists of fish hatcheries, satellite fish facilities, a fish laboratory, wildlife habitat areas and development areas, and lands with fishing and hunting access. The facilities and lands of the Comp Plan are primarily located in the upper, middle, and lower subbasins of the Snake River Drainage, in Washington, Oregon, and Idaho. The remaining facilities and lands are located in the upper Columbia, Yakima, and Mid-Columbia

subbasins. Some facilities are located on existing Federal lands, but the majority are on deeded lands and easements.

The hatcheries developed under this plan were designed to produce about 28 million juvenile spring, summer, and fall chinook salmon, and steelhead as well as any other stock in need of supplementation. Nine hatcheries were modified or constructed along with a number of collection facilities for gathering adults, and acclimation ponds for acclimating juveniles to water sources where they would return as adults (Figure 2-4). These facilities are operated by state fisheries agencies or USFWS. Recently, additional acclimation facilities have been constructed by the Corps and are operated by the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation.

The Comp Plan includes a large number of Habitat Management Units (HMUs) that were developed as mitigation for the loss of habitat associated with the four dams and reservoirs (Figure 2-5). These were developed for a wide variety of habitat and species. HMUs range in size from less than 1 acre to over 3,000 acres. Initially, they were developed on existing project lands and subsequently, additional lands were purchased and leased for mitigation both along the lower Snake River or up to 100 miles or more from the river. Table 2-3 summarizes the number and area of HMUs for each dam.

Further detailed discussion of the HMUs is provided in Section 4.6, Wildlife, and in Appendix L, Lower Snake River Mitigation History and Status.

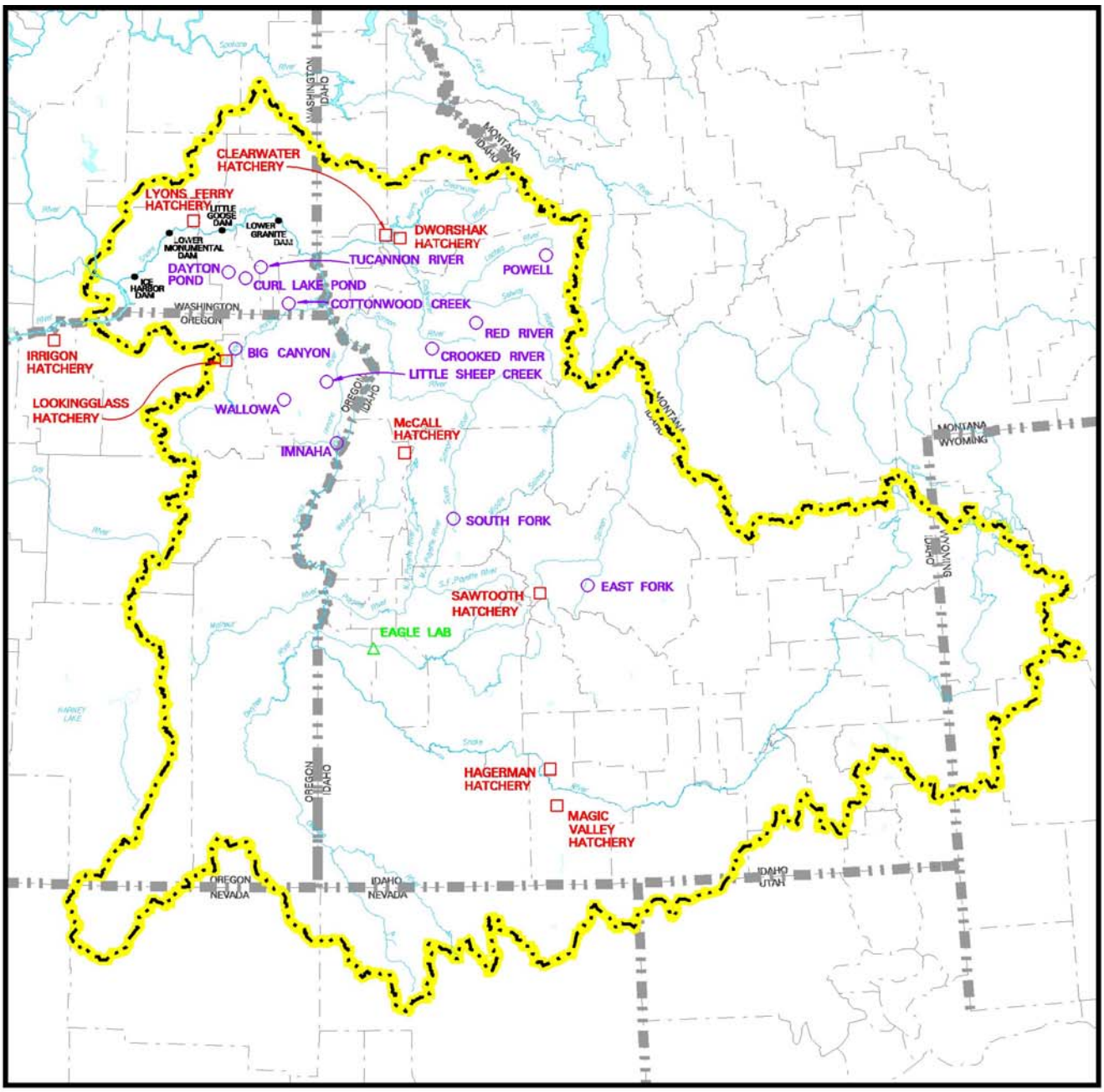
Table 2-3. Number of HMUs per Facility

Dam	No. of HMUs	Total Acres
Ice Harbor	14	2,032
Lower Monumental	13	4,381
Little Goose	18	3,019
Lower Granite	17	5,002
Total	**62**	**14,434**

2.1.9 Surface Bypass Collector Prototype Operation

The existing juvenile bypass facilities are constantly being evaluated and improved by scientists and engineers. For example, since 1996, a prototype surface-oriented bypass and collection system has been under evaluation by the Corps at Lower Granite. The system is designed to collect downstream migrating juveniles in the forebay and safely bypass them either over the dam or transport them downstream in trucks or barges (see Section 2.1.2, Juvenile Fish). The basis for the surface bypass collector (SBC) design was the successful surface-oriented bypass system currently in use at Wells Dam on the mid-Columbia River. At Wells Dam, the spillways are located on top of the submerged powerhouse turbines, causing a surface bypass effect. Fish are attracted to the water currents created by the turbines, but instead, pass over the spillway rather than diving to the turbine openings. At dams operated by the Corps, the spillways are next to, rather than over, the powerhouse.

Seven designs for SBCs are being evaluated (see Appendix E, Existing Systems and Major System Improvements Engineering). Each design emphasizes attraction of juvenile fish prior to diving and encountering the existing turbine screening bypass system (Corps, 1996b). These designs were evaluated from an engineering perspective only; there were no biological evaluations performed. The prototype study at Lower Granite has only evaluated one of the designs.



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SATELLITE

South Fork	A
East Fork	B
Wallowa	C
Big Canyon	D
Imnaha	E
Little Sheep Creek	F
Dayton Pond	G
Curl Lake Pond	H
Tucannon River	I
Cottonwood Creek	J
Red River	K
Crooked River	L
Powell	M

HATCHERY

Hatchery Name	Associated Satellite
McCall Hatchery	A
Magic Valley	B
Hagerman Hatchery	B
Lookingglass Hatchery	E
Irrigon Hatchery	C,D,F
Lyons Ferry Hatchery	G,H,I,J
Dworshak Hatchery Expansion	A
Sawtooth Hatchery	*(None)*
Clearwater Hatchery	K,L,M

FISH DISEASE LABORATORY

DISTRICT BOUNDARY

KM 70 35 0 MILES 35 70

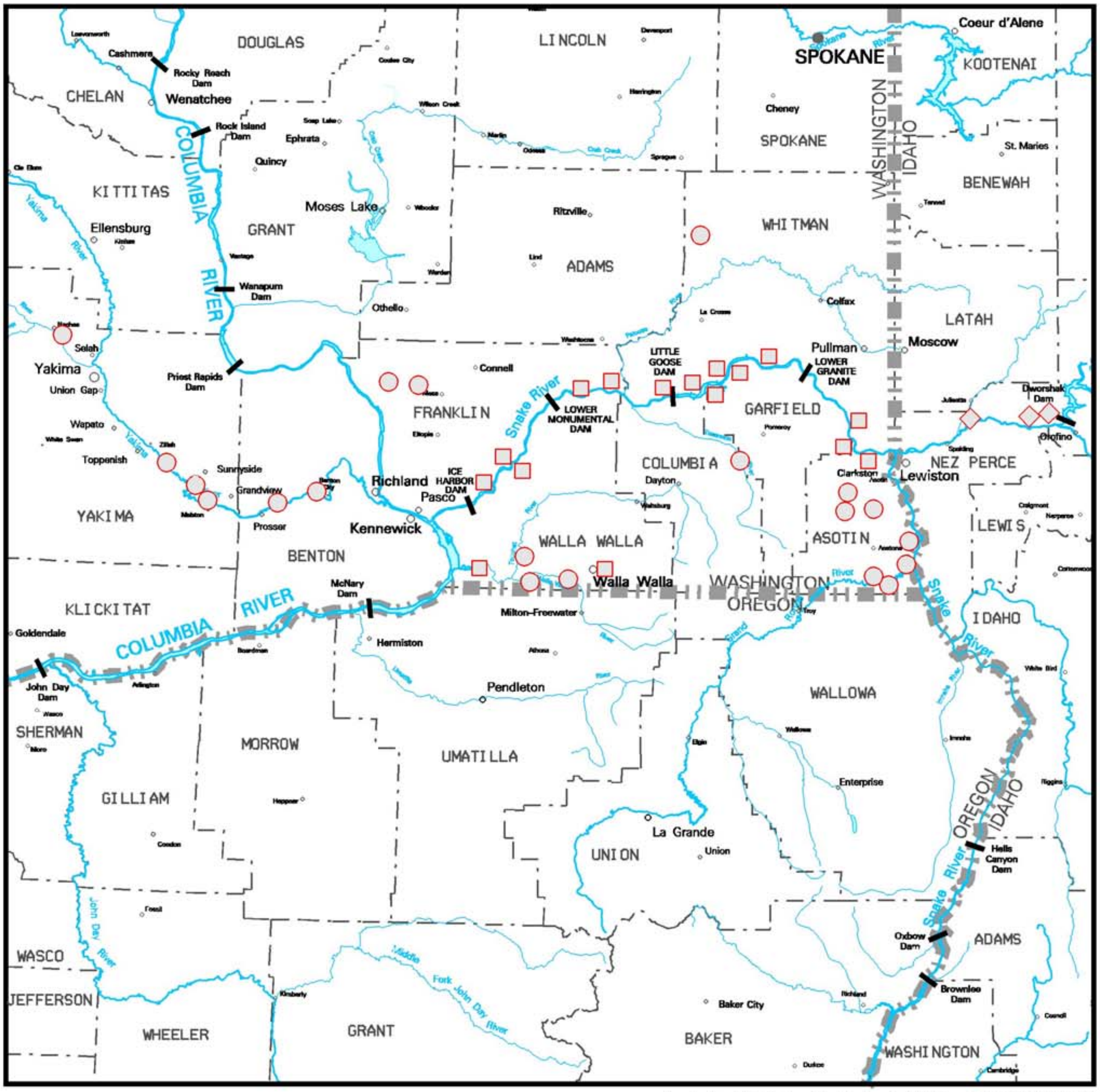
GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

490,000 ACRES

1 : 53,222,400

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–4.
REGIONAL HATCHERIES



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HABITAT MANAGEMENT UNIT

US Army Corps of Engineers Owned

WA Dept. of Fish and Wildlife Owned

To Be Developed

KM 25 0 MILES 7.5 15 30

125,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 1,900,800

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–5.

REGIONAL HABITAT MANAGEMENT UNITS

The Lower Granite SBC underwent a series of tests from 1996 through 2000. Generally the entrance configurations and project operations were not similar between test years. In 1998, modifications were made to the Lower Granite prototype to effectively make the collector deeper and to include a behavioral guidance structure (BGS) to guide fish to the SBC entrance. Preliminary results from the 1998 SBC/BGS prototype tests were used to develop estimates of what performance might be expected from a permanent SBC system at a dam. These results were applied to the seven SBC designs currently being evaluated (see Appendix E, Existing Systems and Major System Improvements Engineering). The evaluation suggests that between 46 and 78 percent of juveniles could be bypassed, depending on the particular design type. The remainder would be passed through the turbine (4 to 11 percent) or intercepted by the screened bypass (18 to 43 percent). SBC technology gained from this testing may be used in potential future applications on the Lower Snake River Project and at other surface bypass systems in the region. For example, Granite County PUD is currently testing a version of a surface bypass facility at Rocky Beach Dam.

2.1.10 Power Marketing

The integrated system of 30 Federal hydroelectric facilities in the Columbia River Basin, on average, accounts for approximately 60 percent of total regional energy and 70 percent of total electrical generating capacity. The four dams in the Lower Snake River Project have a total nameplate capacity of 3,033 megawatts (MW) (Table 2-4) or about 5 percent of the total regional energy or 7 percent of the total electrical generating capacity. When there is a surplus of hydropower, it is an important export product for the region. BPA markets and distributes the power generated by the Corps and BOR at the Federal dams in the Columbia River Basin, including power generated by the four dams on the lower Snake River. The power is sold to public and private utilities in the region, utilities outside the region, and some of the region's largest industries. Power lines originate at generators at the dams and extend outward to form key links in the regional power transmission grid. BPA owns and operates the transmission system. The Northwest grid is interconnected with Canada to the north, California to the south, and Utah and other states to the east. Power produced at dams in the Pacific Northwest is provided to customers both locally and thousands of miles away.

2.1.11 Navigation

The 465-mile Columbia-Snake Inland Waterway represents a key link to the Columbia-Snake River Basin interior region. It facilitates barge transport from the Pacific Ocean to Lewiston, Idaho, the most inland port. This transportation system consists of navigation channels and locks, port facilities, and shipping operations (see Table 2-4). The system is used for commodity shipments from inland areas of the Pacific Northwest and as far away as North Dakota. The

lower Snake River is part of the shallow draft portion of the waterway. The Corps maintains a navigation channel 250 feet wide and 14 feet deep from the mouth of the Snake River to the confluence of the Snake and Clearwater Rivers. The navigation channel accommodates tugs, numerous types of barges, log rafts, and recreational boats and connects the interior of the basin with deep water ports on the lower Columbia River. The average annual tonnage passing through Ice Harbor lock between 1987 and 1996 was 3,883,000 tons. Commodity movement on the lower Snake River is dominated by grain, with wheat and barley comprising about 75 percent of the average annual tonnage passing through Ice Harbor lock between 1992 and 1996. Wood chips and logs, and wood products accounted for 20 percent. Petroleum products accounted for another 3 percent, with the remaining 2 percent comprised of a variety of products including other farm products, chemicals, and sand and gravel.

2.1.12 Recreation

There are 33 developed recreation sites adjacent to the lower Snake River reservoirs. These include 29 boat ramps with 59 launch lanes, 9 campgrounds with approximately 435 individual campsites, and 49 day-use facilities (e.g., shelters, swimming beaches, and scenic views). There are also 22 access or primitive recreation areas where camping is allowed. Most of these recreation sites are located in rural areas removed from population centers. Exceptions include the sites at Ice Harbor, which are close enough to be used by residents of the Tri-Cities, and sites at Lower Granite near the Lewiston-Clarkston area. Several of the larger developed sites were constructed by the Corps and are operated by counties, states, or port districts under lease. The details of recreation aspects of the Lower Snake River Project are discussed in Section 4.12, Recreation and Tourism.

2.2 Facility Operations and Structures

The following sections discuss specific operations and structures at each of the hydropower facilities in turn, proceeding downstream from Lower Granite. Summary information for each facility is provided in Table 2-4. Detailed descriptions of fish facilities (Section 3.1, Alternative 1—Existing Conditions), park and recreation facilities (Section 4.12, Recreation), and wildlife habitat (Section 4.6.2, Wildlife) are provided in their respective sections. The four main features (powerhouse, spillway, navigation lock, and non-overflow embankment) common to all four dams are shown on Figure 2-6.

2.2.1 Lower Granite

Lower Granite is located on the Snake River at river mile (RM) 107 near Almota, Washington (Figure 2-6). The project is named after Granite Point, a rock formation 6 miles upstream from the dam. This rock outcropping is the only granite formation in an area of generally dark basalt. Lower Granite Lake extends 39.3 miles upstream on the Snake River and a further 4.6 miles on the Clearwater River. Lewiston, Idaho is located 33 miles upstream of the dam. Lower Granite was placed into service in 1975. Lower Granite has five major components (Figure 2-7). From the south (right bank) to north (left bank), they are the fish passage facilities, powerhouse, spillway, navigation lock, and non-overflow embankment. The dam, located at the head of Lake Bryan, is 3,200 feet long, with an effective height of 100 feet.

The normal operating range of Lower Granite Lake (the reservoir) extends from 733 to 738 feet above National Geodetic Vertical Datum (NGVD29). The powerhouse is 656

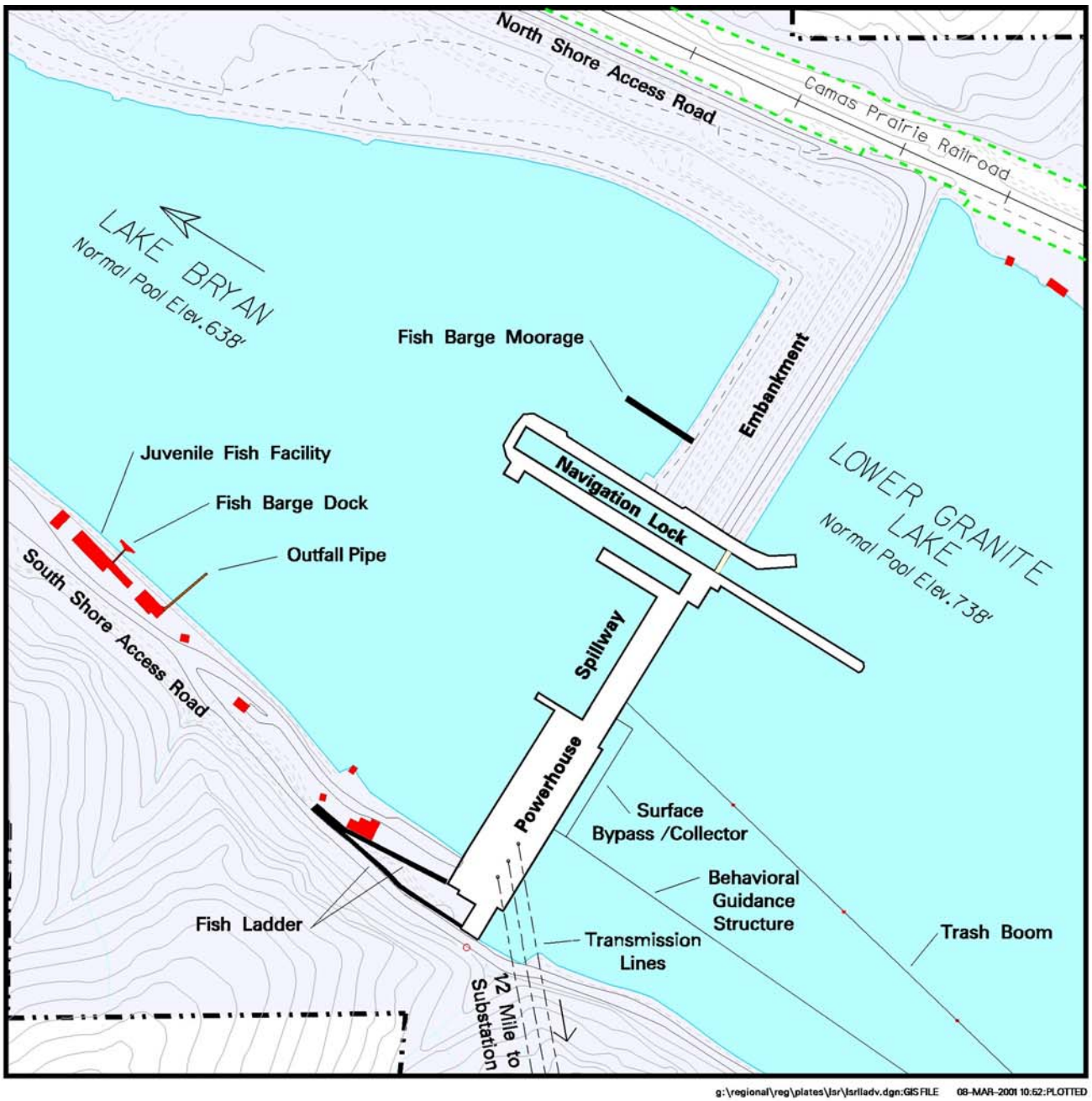
Table 2-4. Facility Operations and Structures

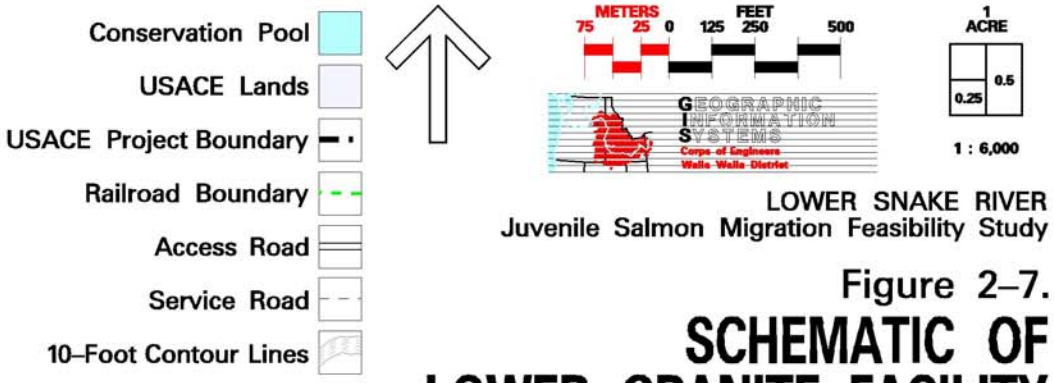
	Lower Granite	Little Goose	Lower Monumental	Ice Harbor
Reservoir				
Normal Pool Operating Range (feet above NGVD29)	733 - 738	633 - 638	537 - 540	437 - 440
Total Length (miles)	43.9	37.2	28.7	31.9
Length of Shoreline (miles)	92	93	86	83
Average Width (miles)	0.3	0.4	0.4	0.4
Surface Area (acres) 1/	8,448	10,825	4,960	9,002
General (Dam)				
Dam Length (feet)	3,200	2,655	3,791	2,822
Hydraulic Head (feet)	100	98	100	100
Powerhouse				
Powerhouse Length (feet)	656	656	656	671
Nameplate Capacity (MW)	810	810	810	603
Total Number of Units Installed	6	6	6	6
Spillway				
Spillway Length (feet)	512	512	498	590
Number of Spillway Bays	8	8	8	10
Stilling Basin Length (feet)	188	118	180	168
Navigation Lock and Channels				
Lock Chamber Length (feet)	675	668	650	675
Lock Chamber Width (feet)	86	86	86	86
Maximum Operating Lock Lift (feet)	105	101	103	105

NGVD29 = National Geodetic Vertical Datum
1/ At normal operating pool elevation (highest level of range)
Source: Corps, 1999c

feet long and 243 feet wide, and houses six 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 188 feet downstream from the spillway along the river bottom. The navigation lock at Lower Granite is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 756 feet long. This embankment is an earthfill structure with an impervious core. The core is protected both upstream and downstream by sand and gravel

Figure 2-6. Looking Upstream at Lower Granite Facility





LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–7.
SCHEMATIC OF LOWER GRANITE FACILITY

filter zones flanked by gravel shells. The upstream slope of the embankment is armored with riprap from elevation 756 feet down to 719 feet; below 719 feet, smaller rock fill provides bank protection.

Juvenile fish passage facilities at Lower Granite consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities include one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system. Components of the juvenile and adult fish passage facilities are presented in Table 2-2.

There are 9,220.4 acres of project lands surrounding Lower Granite Lake. These lands include fee lands that are Federally owned and managed by the Corps, as well as easement lands on which the Corps has designated rights (i.e., flowage or access). Approximately 515 acres are leased either to state or local public agencies. Port districts own lands adjacent to the project for industrial development. The majority of these project lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are 13 developed recreation areas adjacent to Lower Granite Lake. These include 12 boat ramps with 28 launch lanes, 2 moorage/marina facilities, 12 day-use facilities, and 3 campgrounds with a total of approximately 168 individual campsites.

Land surrounding the reservoir is also managed by the Corps for wildlife habitat enhancement. HMUs were established along the lower Snake River to compensate for wildlife habitat lost as a result of inundation by the Lower Snake River Project. There are 17 HMUs, totaling 5,002 acres, along Lower Granite Lake. Water pumped from the reservoir is used to irrigate one of these HMUs.

Water is withdrawn from Lower Granite Lake by six municipal and industrial pump stations. The water is used for municipal water system backup, golf course irrigation, industrial process water for paper production and concrete aggregate washing, and park irrigation. Two additional stations owned by Asotin Public Utility District (PUD) #1 have not been operated over the past few years and no plans exist to operate them in the immediate future.

There are three port facilities on Lower Granite Lake (Lewiston, Clarkston, and Wilma). They are used for grain, wood products, and other commodities. The port at Wilma is capable of handling petroleum products.

2.2.2 Little Goose

Little Goose Dam (Figure 2-8) is located on the Snake River at RM 70.3 near Riparia, Washington. The facility is named after an upstream island that was inundated following completion of the dam. Little Goose Reservoir, known as Lake Bryan, extends 37.2 miles

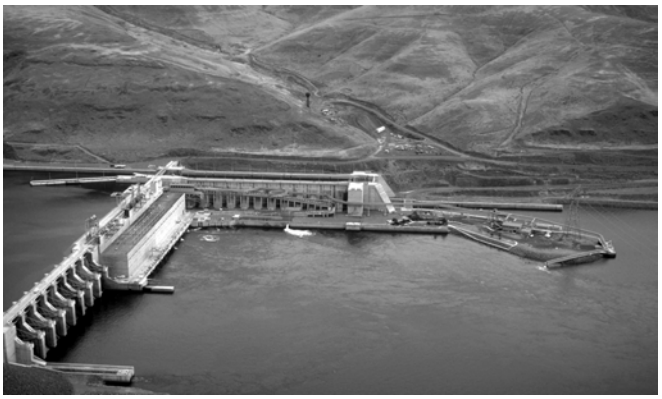
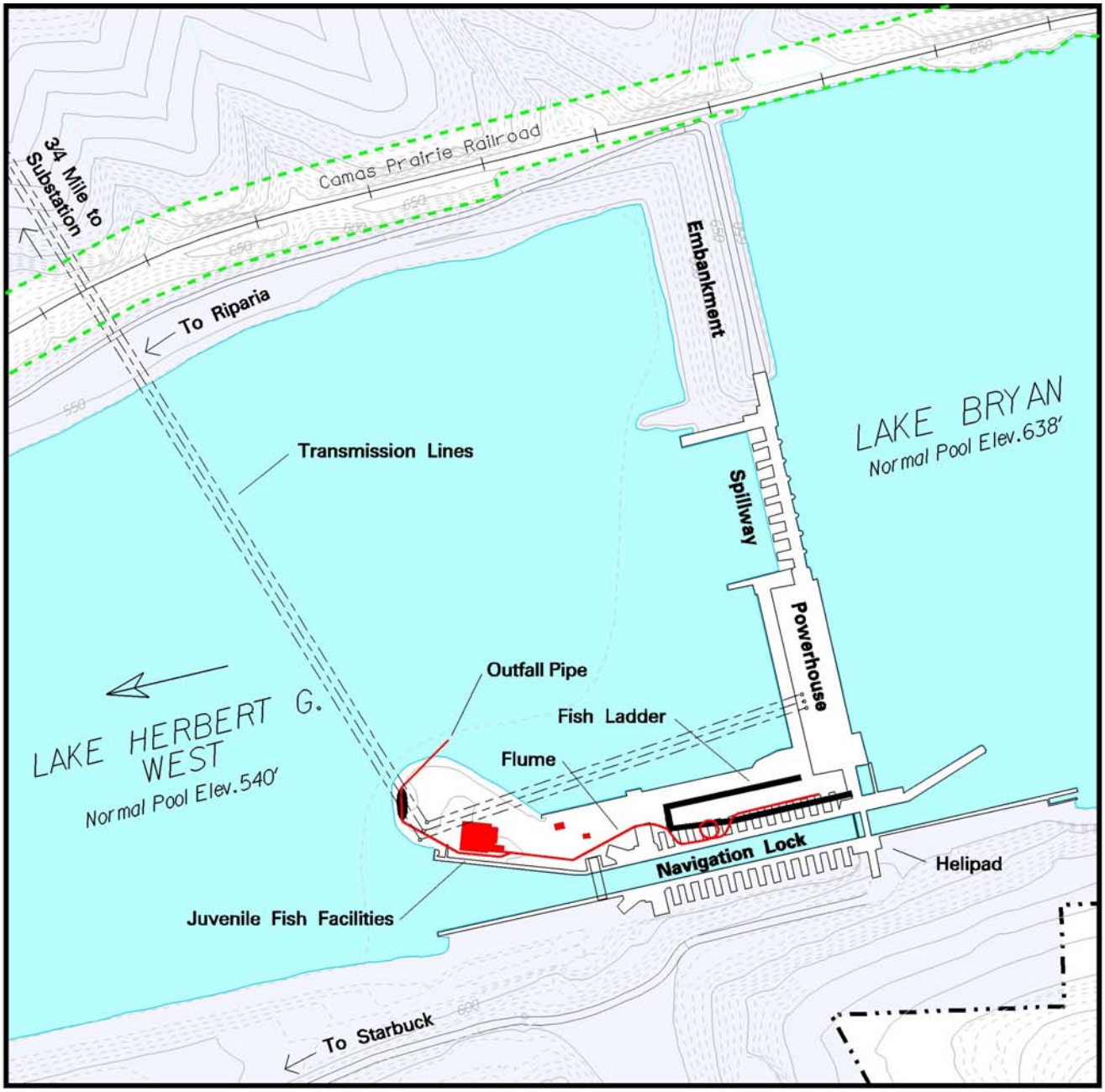


Figure 2-8. Looking South at Little Goose Facility



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Conservation Pool
USACE Lands
USACE Project Boundary
Railroad Boundary
Access Road
Service Road
10–Foot Contour Lines

METERS 75 25 0 FEET 125 250 500

1 ACRE 0.5 0.25

1 : 6,000

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–9.
SCHEMATIC OF LITTLE GOOSE FACILITY

upstream to Lower Granite. Little Goose was placed into service in 1970. Little Goose has several major components (Figure 2-9). From the south (top bank) to north (lower bank), they are the navigation lock, fish passage facilities, powerhouse, spillway, and non-overflow embankment. The dam, located at the head of Lake Herbert G. West, is 2,655 feet long with an effective height of 98 feet. The normal operating range of Lake Bryan (the reservoir) extends from 633 feet to 638 feet NGVD29. The powerhouse is 656 feet long and 243 feet wide, and houses six, 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 118 feet downstream from the spillway along the river bottom.

The navigation lock at Little Goose is a single-lift type, 668 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 101 feet. Next to the navigation lock is the north dam embankment, which is a gravel fill structure with rock facing and an impervious core. Juvenile fish passage facilities at Little Goose consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are composed of one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system.

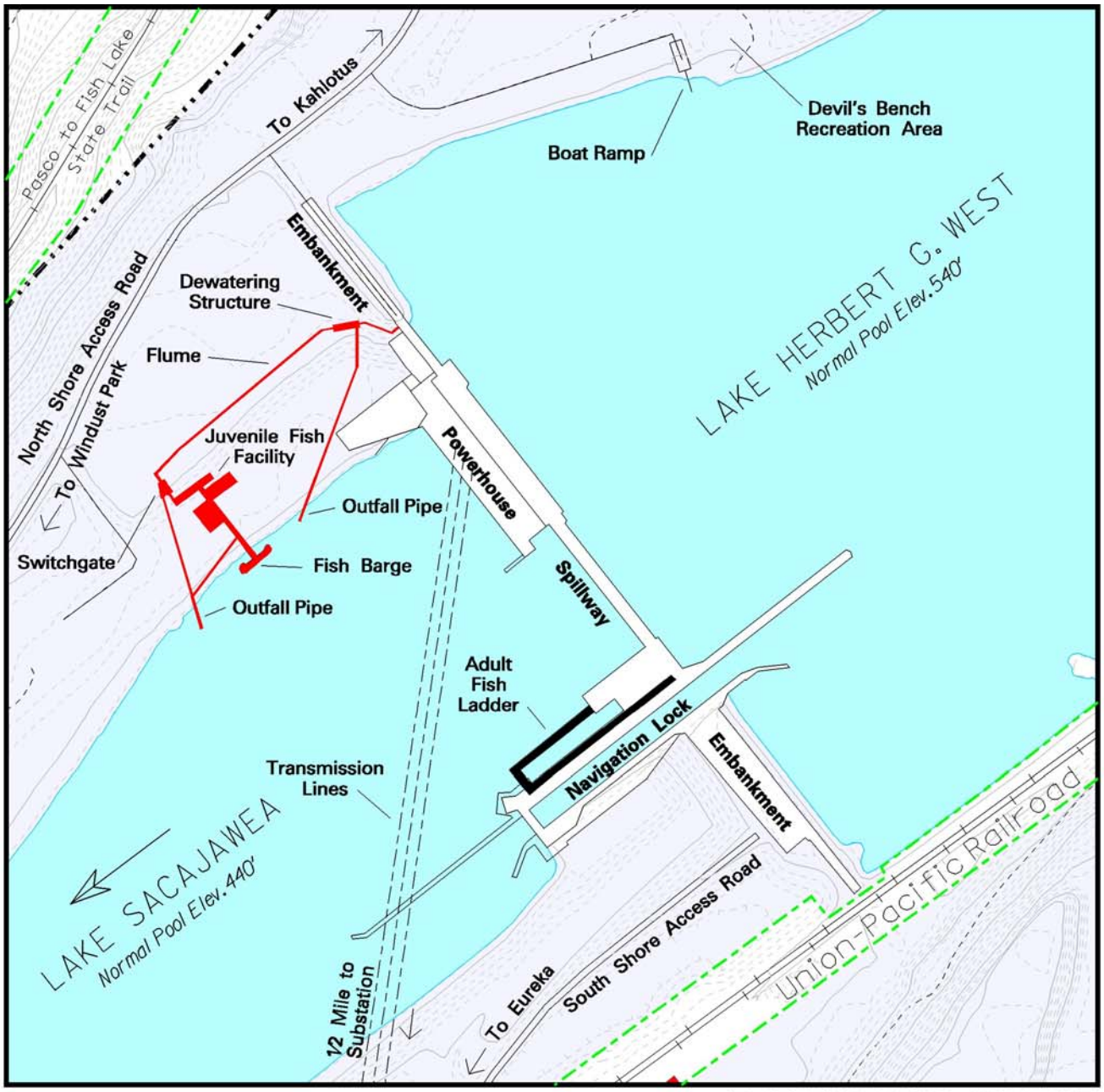
There are 4,859.6 acres of project lands surrounding Lake Bryan. These project lands include both fee and easement lands. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Currently, two areas of approximately 150 acres are leased either to the state or local ports for recreation.

There are seven developed recreation areas adjacent to Lake Bryan. These include 6 boat ramps with 13 launch lanes, 1 marina, 3 day-use facilities, and 2 campgrounds with a total of approximately 88 individual campsites. There are 18 HMUs, totaling 3,019 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. Well water is used to irrigate one HMU. There are three port facilities on Lake Bryan (Almota, Central Ferry, and Garfield), all used for grain. The port at Central Ferry also services other commodities.

2.2.3 Lower Monumental

Lower Monumental is located on the Snake River at RM 41.6 near Magallon, Washington (Figure 2-10). The dam is named after a large rock with vertical basalt columns. This rock, named Ship Rock by Lewis and Clark, was later renamed Monumental Rock. The reservoir at Lower Monumental, named Lake Herbert G. West in 1978, extends 28.7 miles upstream to Little

Figure 2-10. Looking South at Lower Monumental Facility



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Conservation Pool
USACE Lands
USACE Project Boundary
Railroad Boundary
Access Road
Service Road
10–Foot Contour Lines

METERS 75 25 0 FEET 125 250 500

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 ACRE
0.5
0.25

1 : 6,000

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–11.
SCHEMATIC OF LOWER MONUMENTAL FACILITY

Goose. Lower Monumental was placed into service in 1969. Lower Monumental has several major components (Figure 2-11). From the south (top bank) north (lower bank), they are the south non-overflow embankment, navigation lock, fish passage facilities (also located between the powerhouse and the north non-overflow embankment), spillway, powerhouse, and the north non-overflow embankment. The dam, located at the head of Lake Sacajawea, is 3,791 feet long, with an effective height of 100 feet. The normal operating range of Lake West (the reservoir) is from 537 to 540 feet NGVD29. The powerhouse is 656 feet long and houses six 135-MW generators. Next to the powerhouse is a 498-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 180 feet downstream from the spillway on the river bottom. The navigation lock at Lower Monumental is a single-lift type, 666 feet long by 86 feet wide, with a 14-foot minimum operating depth and a maximum lift of 103 feet. Next to the navigation lock is the north dam embankment, which is 968 feet long. Juvenile fish passage facilities at Lower Monumental consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are comprised of north and south shore fish ladders, a powerhouse collection system, and an auxiliary water supply system.

There are 9,143.6 acres of project lands surrounding Lake West. These project lands include both fee and easement lands. Port districts own land both on and adjacent to the project lands for industrial development. The majority of the Corps-managed lands, 7,024.0 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Approximately 1,177 acres are leased to the State of Washington for Lyons Ferry State Park.

There are six developed recreation areas adjacent to the Lake West. These include 4 boat ramps with 8 launch lanes, 1 marina, 9 day-use facilities, and 1 campground with approximately 50 individual campsites. There are 13 HMUs, totaling 4,381 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. Well water is used to irrigate one HMU. There is one port on the reservoir (Lyons Ferry). It is used for grain.

2.2.4 Ice Harbor

Ice Harbor is located on the Snake River at RM 9.7 near Levee, Washington (Figure 2-12). Major cities in the local vicinity include Kennewick and Pasco, which are located upstream of the confluence of the lower Snake and Columbia Rivers, and Richland, which is located at the confluence of the Yakima and Columbia rivers. Ice Harbor is named after a mooring spot a few miles upstream of the Snake-Columbia confluence.

Figure 2-12. Looking Northeast at Ice Harbor Facility

The reservoir at Ice Harbor, known as Lake Sacajawea, extends 31.9 miles upstream to Lower Monumental. Ice Harbor was placed into service in 1961. Ice Harbor has several major components (Figure 2-13). From the south (right bank) to north (left bank), they are the fish passage facilities (also located between the spillway and the navigation lock) powerhouse, spillway, navigation lock, and non-overflow embankment. The dam is 2,822 feet long, with an effective height of 100 feet. The normal operating range of Lake Sacajawea extends from 437 to 440 feet NGVD29. The powerhouse is 671 feet long and houses three 90-MW and three 110-MW generators. Next to the powerhouse is a 590-foot-long concrete spillway equipped with steel tainter gates. The spillway has 10 spillbays, each 50 feet wide. The tainter gates are each 50 feet wide by 52.9 feet high. A concrete-lined stilling basin extends 168 feet downstream from the spillway along the river bottom.

The navigation lock at Ice Harbor is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 624 feet long.

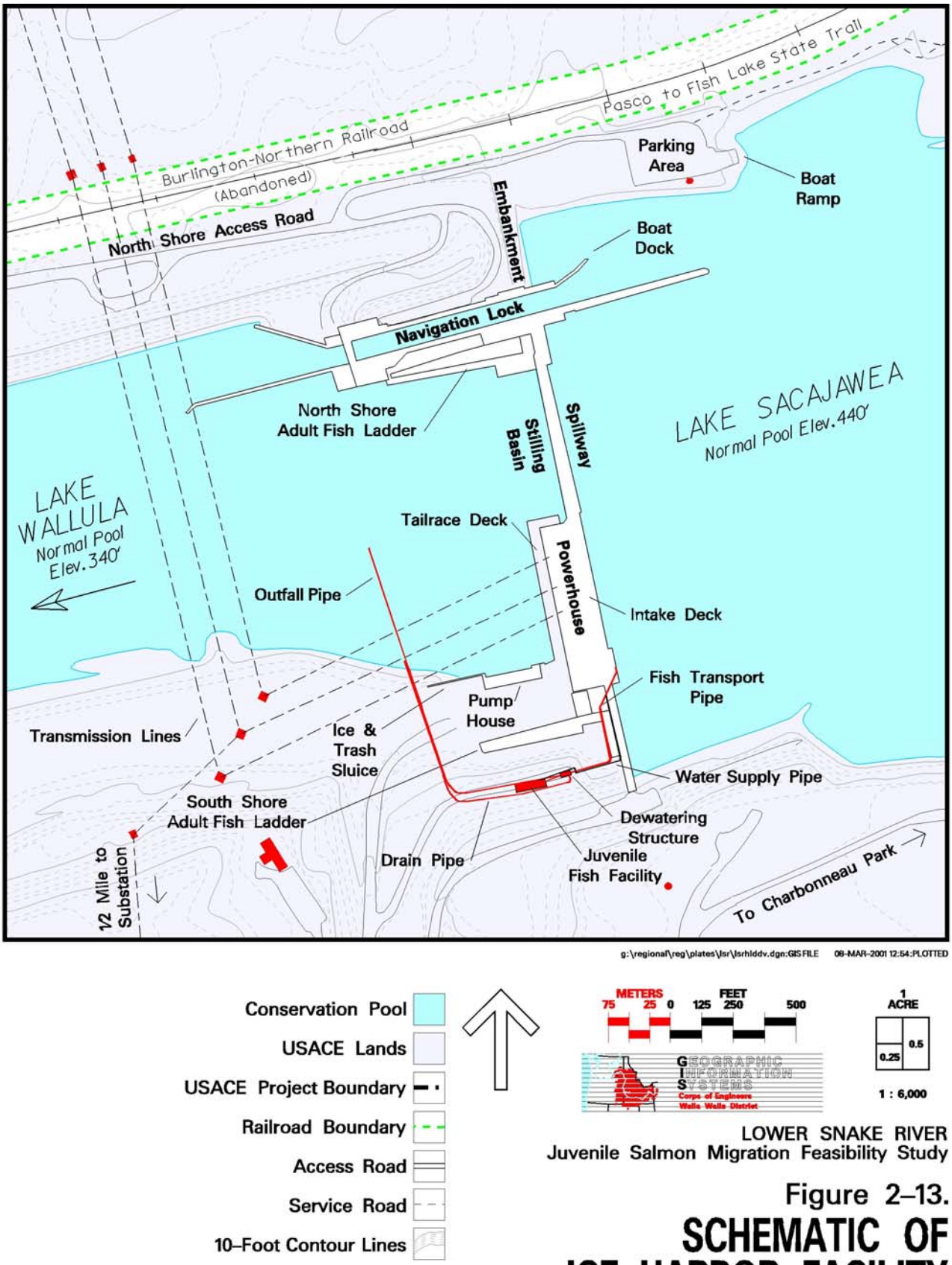
Juvenile fish passage facilities at Ice Harbor consist of a bypass system and juvenile transportation facilities. Adult fish passage facilities are made up of separate north and south shore facilities (see Table 2-2 and Sections 2.1.1, Adult Fish and 2.1.2, Juvenile Fish). The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities are comprised of a fish ladder, a powerhouse collection system, and an auxiliary water supply system.

There are 4,037.7 acres of project lands surrounding Lake Sacajawea. These lands include both fee and easement lands. The majority of the Corps-managed lands, 3,517.3 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are seven developed recreation areas adjacent to the Lake Sacajawea. These include 6 boat ramps with 10 launch lanes, 1 marina, 2 moorage facilities, and 3 campgrounds with a total of approximately 145 individual campsites. There are 14 HMUs, totaling 2,032 acres, along the reservoir. Water pumped from the pool is used to irrigate 3 of these HMUs.

There are two ports on Lake Sacajawea (Windust and Sheffler). Both are used for grain.

Approximately 37,000 acres of non-Federal land are presently irrigated with water pumped from Lake Sacajawea. Between the 14 irrigation pumping stations at the reservoir, there are about 75 pumps. The irrigated lands grow a variety of crops, including cottonwood/poplar trees, potatoes, and corn.



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–13.
SCHEMATIC OF ICE HARBOR FACILITY

Chapter 3

Plan Formulation

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3.2 Alternative 2—Maximum Transport of Juvenile Salmon
3.3 Alternative 3—Major System Improvements (Adaptive Migration)
3.4 Alternative 4—Dam Breaching
3.5 Implementation Schedule and Costs
3.6 Other Potential Actions Outside the Scope of the FR/EIS
3.7 Alternative Actions Eliminated from Further Consideration

3. Plan Formulation

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In response to National Marine Fisheries Services' (NMFS) 1995, 1998, and 2000 Biological Opinions and the results of the *Interim Status Report* (Corps, 1996a), the U.S. Army Corps of Engineers (Corps) continued evaluating various improvements to the Lower Snake River Project. These improvements are intended to improve the effectiveness of downstream migration by juvenile salmonids and upstream passage of adults. This section describes the four alternatives that are evaluated in detail (Sections 3.1 through 3.4). These alternatives include:

- Alternative 1—Existing Conditions
- Alternative 2—Maximum Transport of Juvenile Salmon
- Alternative 3—Major System Improvements (Adaptive Migration)
- Alternative 4—Dam Breaching.

This section also addresses actions that were considered, but were not evaluated in detail in this Feasibility Report/Environmental Impact Statement (FR/EIS) because

they were either outside the scope of the FR/EIS (Section 3.5) or they were eliminated from further consideration for various reasons (Section 3.6). Further details on dam breaching alternatives and major system improvements are provided in Appendix D, Natural River Drawdown Engineering, and Appendix E, Existing Systems and Major System Improvements Engineering, respectively.

The Draft FR/EIS was released in December 1999 and was based on the 1995 and 1998 Biological Opinions. NMFS' 2000 Biological Opinion, released in December 2000, extends many of the actions prescribed in the earlier opinions. However, it specifically addresses the dam breaching question by outlining a process and planning mechanism for breaching.

The RPA in NMFS' 2000 Biological Opinion establishes a schedule for determining whether to pursue breaching as a means of avoiding jeopardy. As indicated in Section 1.3.3, this process involves major reviews in 2005 and 2008 that determine if the RPA in the 2000 Biological Opinion is meeting certain performance standards. These standards are based on the stock status of listed species and the likelihood of their survival and recovery. If the 2005 and 2008 reviews indicate failure to implement the RPA of the 2000 Biological Opinion or that the prescribed actions have not been effective, authorization for dam breaching may need to be sought so that this option is available for implementation.

3.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions consists of continuing the operation of the fish passage facilities and project operations that were in place or under development at the time that this FR/EIS was initiated.

Operations under Alternative 1—Existing Conditions would continue to meet the authorized uses of the Lower Snake River Project (see Section 1.2, Purpose and Need). Figure 3-1 summarizes the activities that would continue with the existing operations (and activities for other alternatives). These operations are described in detail in Section 2.0, Affected Projects and Programs. Existing environmental conditions are described in Section 4, Affected Environment. This alternative is the base case or "no action" alternative considered in this National Environmental Policy Act (NEPA) process.

Under Alternative 1—Existing Conditions, activities prescribed in the 1995 and 1998 Biological Opinions to improve juvenile fish passage conditions would be continued. In addition to the structural changes that would be implemented (e.g., adding end-bay deflectors) and the facilities that would be developed (e.g., additional barges for transporting juvenile fish), it is assumed that flow augmentation would continue.[1]

Project operations—including all ancillary facilities such as fish hatcheries and Habitat Management Units (HMUs) under the Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan) (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions. For example, the captive broodstock program of the Comp Plan could be expanded to include all listed species, which could modify some or all hatchery operations from

[1] Flow augmentation of 427,000 acre-feet from upstream sources has been assumed for certain periods of juvenile downstream migration. However, the Idaho statute that established this flow level has expired. Negotiations concerning this flow augmentation are continuing under a separate Section 7 consultation.

producing high numbers of juvenile salmon to fewer, but higher quality, juveniles that may have a higher survival rate.

Alternative 1—Existing Conditions would include a "spread-the-risk" strategy for downstream juvenile fish passage. This strategy provides operational options which ensure that "the majority of the downstream migrants from any one stock is not transported and that uncollected migrants are exposed to (the) best possible in-river conditions" (NMFS, 1998). However, this is accomplished through existing or currently planned facilities and not major system improvements. Adult and juvenile fish passage facilities would continue to operate.

Existing operations include several other planned measures that would be used to increase fish passage survival. These include:

- **New Turbine Cams**—Cams are computer software based upon the turbine performance curves that automatically control the turbine blade angle and wicket gate openings. These cams may be modified to increase the hydraulic efficiency of the turbines. The increased hydraulic efficiency of the turbines would likely reduce fish mortality. The existing condition assumes that new or modified cams would be used on all turbines at all dams to optimize turbine efficiency.
- **New Turbine Runners**—Studies are currently underway to develop turbine runners that reduce fish injury and associated mortality for those juvenile fish passing through the turbines. It is assumed that for the existing conditions, all turbines and generators would eventually require rehabilitation and, new turbine runners would be installed at that time. This would imply that new turbine runners could be installed over the next 5 to 15 years.
- **Upgrade Lower Granite Juvenile Fish Facilities**—Certain structural modifications and upgrades would be made to this facility to more effectively handle fish. Proposed activities include:
    1. Replacing the thirty-six 254-millimeter (10 inch) orifices extending from the bulkhead slots to the juvenile fish collection gallery with thirty-six 305-millimeter (12 inch) orifices. Each orifice would be equipped with an air operated knife valve, and an air back-flush system for dislodging debris. The valves would be automated and controlled with a programmable logic control computer so they could be cycled to prevent clogging.
    2. Mining the gallery to a 2.7-meter (9 foot) width so orifice flow would not strike the far wall. The gallery is currently 1.8 meters (6 feet) wide.

Figure 3-1. Lower Snake River Juvenile Salmon Migration Feasibility Study, Alternatives Matrix

	Alternative 1 —Existing Conditions	**Alternative 2** —Maximum Transport	**Alternative 3** —Major System Improvements	**Alternative 4** —Dam Breaching
Existing System Operations				
Adult Fish Passage Systems				
Fish Ladders	√	√	√	
Pumped Attraction Water Supplies	√	√	√	
Powerhouse Fish Collection Systems	√	√	√	
Juvenile Fish Bypass and Collection Systems				
STS – IHR, LMO	√	√	√	
ESBS – LGO, LGR	√	√	√	
Collection and Transportation Facilities	√	√	√	
Trash Shear Boom	√	√	√	
Minimum Operating Pool – During Fish Migration	√	√	√	
Turbine Operations – Within 1 percent Peak Efficiency	√	√	√	
Voluntary Spill				
Current Operations	√			
Minimize Operations – IHR Only		√		
Optimize Operations			√	
No Spill				√
Flow Augmentation (Dworshak)	√	√	√	√
Flow Augmentation (Upper Snake River) – 427,000 acre feet	√	√	√	√
Dissolved Gas Abatement Measures				
Spillway Gas Control Measures (Deflectors)	√	√	√	
Spillway Gas Monitoring	√	√	√	
Continue Fish Facility Operations	√	√	√	
Continue AFEP Evaluations	√	√	√	
Power				
Current Production	√		√	
Increased Production		√		
No Production				√
Navigation				
Current Operations	√	√	√	
No Operations				√
Fish Transportation				
Spread-the-Risk	√			
Optimize Transportation			√	
Maximize Transportation		√		
No Transportation				√

3. Mining an exit channel from the dam out to daylight, and installing a non-pressurized flume system to the fish collection facility.
4. Installing a dewatering system to reduce the flow from 7.08 m^3/sec (250 cfs) to 0.85 m^3/sec (30 cfs), similar to the design at Little Goose Dam, and routing the excess water to the adult fish collection facility.
5. Installing a size separator to separate smaller (primarily salmon) from larger (primarily steelhead) smolts so smaller and larger smolts can be transported in separate truck or barge compartments.
6. Upgrading raceways and distribution flume systems at the collection facility.
7. Upgrading direct barge loading facilities.

- **New Fish Barges**—Seven additional 22,700-kg (50,000-lb) capacity barges would be constructed to allow direct loading at fish collection facilities. Direct loading would reduce the amount of fish handling and associated stress. These would replace two 10,400-kg (23,000-lb) capacity barges scheduled for retirement and would provide additional capacity. The two barges being replaced are old hulls (over 50 years old) that are approaching the end of their serviceable life.
- **Adult Fish Attraction Modifications**—The adult fish attraction water at selected dams would be modified in order to ensure an adequate water supply for the fish ladders in the event of a pump failure. This may include electrical upgrades to provide a more reliable source of electrical power to the attraction water pumps, upgrading existing pumps, adding new pumps, or adding a gravity feed system for the attraction flow.
- **Modified Fish Separators**—To improve fish separation and to reduce fish stress, delay, and mortality at existing juvenile fish facilities, the existing fish separators would be modified. New separators would be installed at Little Goose and Lower Monumental, and would be included in an upgrade of the Lower Granite juvenile fish facility.
- **Cylindrical Dewatering Screens**—Cylindrical dewatering screens would be installed at Little Goose, Lower Monumental, and Ice Harbor, and included in an upgrade of the Lower Granite juvenile fish facility. These screens reduce the amount of water routed into the fish collection facilities. They are a more effective means (compared to stationary screens) for avoiding plugging of screens and for removing trash from the inflow. This screen design may be an improvement over existing stationary screen designs.
- **Spillway Flow Deflectors/Pier Extensions**—Additional spillway flow deflectors, modifications to existing spillway flow deflectors, and pier wall extensions would be added at Lower Granite, Little Goose, and Lower Monumental. These improvements are expected to further reduce dissolved gas concentrations and, thus, provide more control of TDG levels. They would be similar to the designs for the recently installed deflections at Ice Harbor. Overall, the dissolved gas abatement structures should assist in lowering concentrations.

- **Improvements to the Extended Submerged Bar Screens**—The existing ESBSs at Lower Granite and Little Goose would be modified to improve their operability and longevity.

3.2 Alternative 2—Maximum Transport of Juvenile Salmon

All of the existing or planned structural configurations and flow augmentation of 427 thousand acre feet (KAF) from the existing conditions would be included in this alternative (Figure 3-1). This alternative is the same as the Corps' Alternative 2a that is described in Appendix E, Existing Systems/Major System Improvements Engineering.

Under Alternative 2—Maximum Transport of Juvenile Salmon, project operations—including all ancillary facilities such as fish hatcheries and HMUs under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor).

To accommodate maximum transport of juvenile salmon, measures would be used to maintain, upgrade, and significantly improve fish facilities (see Section 3.1, Alternative 1—Existing Conditions) that would focus on limiting in-river migration. For example, even though conditions for flow augmentation under the 1995, 1998, and 2000 Biological Opinions would be met, in-river migration would be minimized by limiting spill, and fish collected in facilities would be transported downstream by trucks or barges rather than bypassed below the dams. Also, there would be no need to modify spillway flow deflectors at Lower Monumental, Little Goose, or Lower Granite because voluntary spill (except at Ice Harbor) would be eliminated. As with Alternative 1—Existing Conditions, two end-bay deflectors would be added at Lower Monumental and Lower Granite (see Table 3-1). This should help to improve water quality conditions associated with elevated levels of dissolved gas.

Under Alternative 2—Maximum Transport of Juvenile Salmon, activities prescribed in the 1995 and 1998 Biological Opinions to improve juvenile fish passage conditions would be continued the same as for Alternative 1—Existing Conditions.

3.3 Alternative 3—Major System Improvements (Adaptive Migration)

Alternative 3—Major System Improvements assumes that the juvenile fishway systems would be operated under an adaptive migration strategy that balances the passage of fish between in-river and transport passage methods. This strategy addresses concerns about the risks and effectiveness associated with bypass-only and transport-only approaches. It would also allow the flexibility for implementing operational changes within a migration season, if necessary.

Alternative 3—Major System Improvements would include all of the existing or planned structural configurations from Alternative 1 and most structural configurations found under Alternative 2—Maximum Transport of Juvenile Salmon

(Figure 3-1). For example, spillway flow deflectors and pier extensions would be used to help lower TDG concentrations. In addition, Alternative 3—Major System Improvements would include major system improvements that would provide a greater ability and more options to better adjust migration approaches (i.e., either in-river or transport).

Under Alternative 3—Major System Improvements, activities prescribed in the 1995 and 1998 Biological Opinions to improve existing juvenile fish passage conditions would be continued the same as for Alternative 1—Existing Conditions. In addition, it is assumed that flow augmentation of 427 KAF would continue. Project operations—including all ancillary facilities such as fish hatcheries and HMUs under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions.

Major system improvements that are focused on more effective diversion of juvenile fish away from the turbines would be implemented under Alternative 3—Major System Improvements using SBCs (Figures 3-2a and 3-2b). Ten different SBC options were developed and evaluated for Lower Granite (see Annex B to Appendix E, Existing Systems/Major System Improvements Engineering). These 10 were narrowed down to 4 possible options, based on the results of the prototype testing and results of the evaluations. A fifth SBC option was later added.

Some of the possible surface bypass options would be used in conjunction with existing ESBSs and a new behavioral guidance system (BGS). The BGS (Figure 3-2b) is a long and deep physical structure used to guide migrating juvenile fish to the SBC. Fish collected by the SBC or ESBSs would be combined and delivered to the transportation facilities, and either trucked or barged downstream. Implementation of the SBC system with transportation would involve a high volume dewatering system which results in directing juvenile fish from a large and dispersed volume of water to a smaller volume where they can be more readily collected. A variety of options under this alternative could be implemented, depending on results of ongoing or future tests of equipment, facilities, and approaches (see Appendix E, Existing Systems/Major System Improvements Engineering).

At Lower Granite and Lower Monumental, SBC systems would be installed in front of Turbine Units 5 and 6. Surface collectors could then be used to collect fish at these two dams for downstream transport. Lower Granite is a logical location for collecting fish for transport because it is the furthest upstream dam and therefore, the first dam encountered by outmigrating juvenile fish. The SBC at Lower Monumental would allow collection of 1) fish not collected at Lower Granite, 2) fish entering the Snake River from the Tucannon River, and 3) fish released from the Lyons Ferry Hatchery.

When in transport mode, the SBC at Lower Granite and Lower Monumental would collect downstream migrating fish and pass them through a dewatering section into the surface collector, delivering them to the existing juvenile fish collection channel

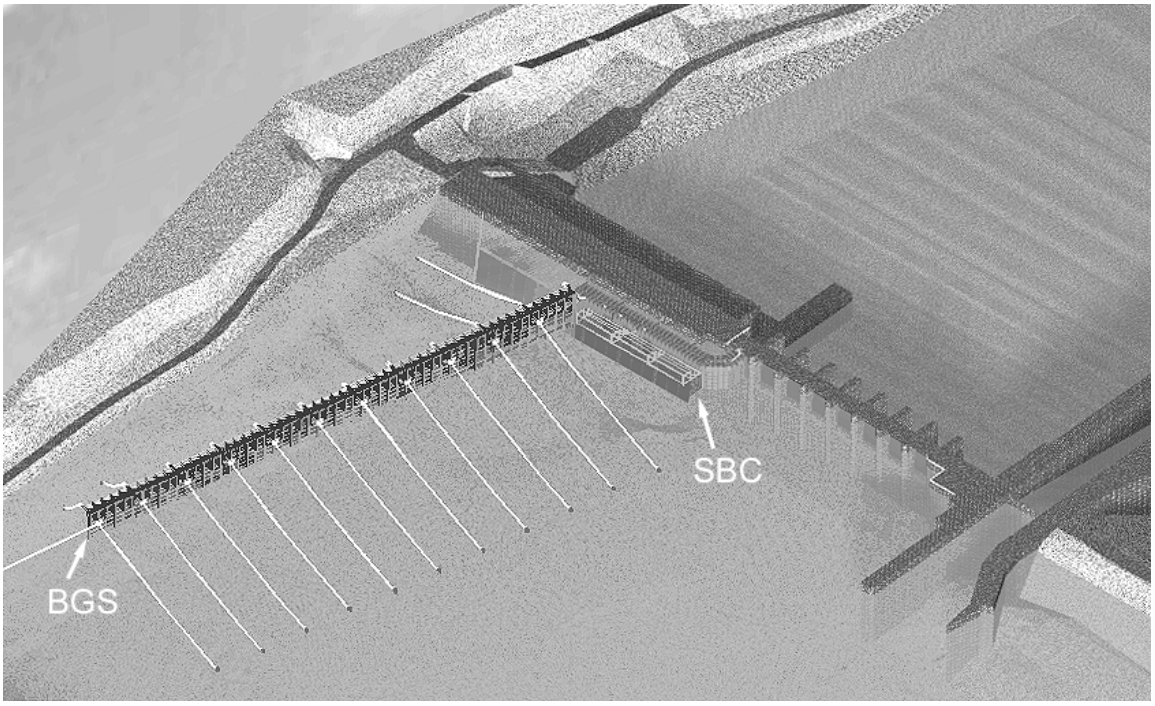


Figure 3-2a. Surface Bypass Collector Prototype System

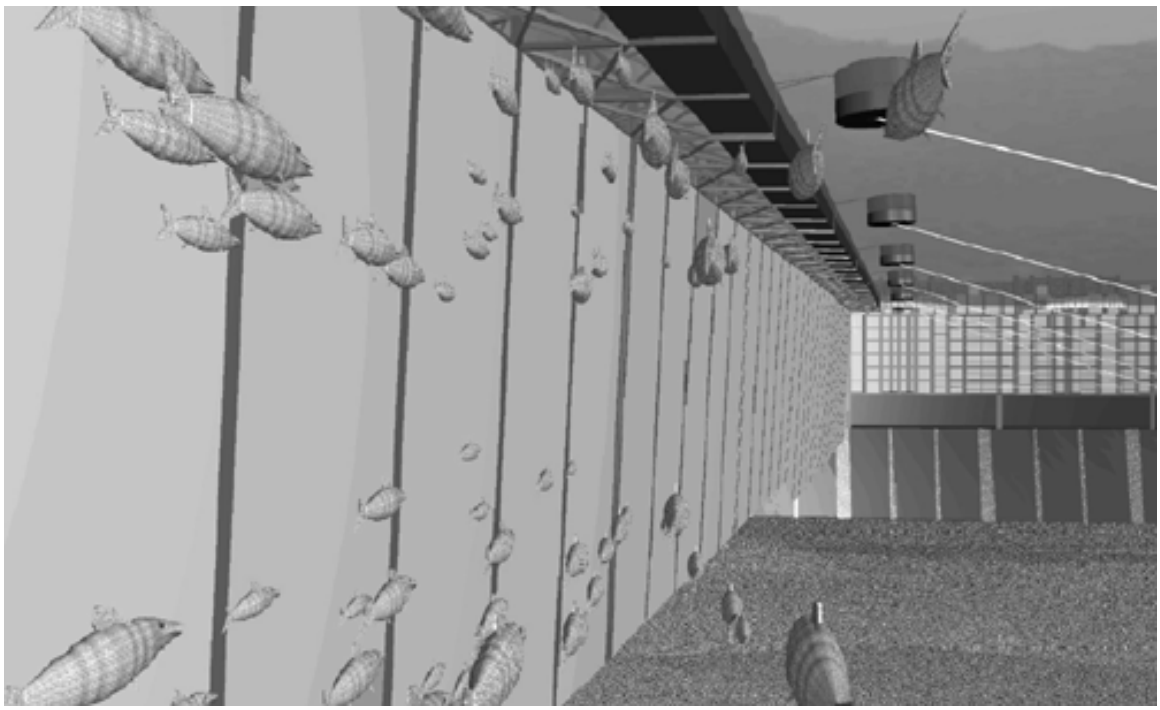


Figure 3-2b. Behavioral Guidance Structure Underwater View

within each dam. To guide fish away from Turbine Units 1 through 4, a BGS would be constructed in the forebay.

When it is desired to keep juvenile fish in the river, the surface collector would be shut off and the fish would be guided by a BGS past the SBC to removable spillway weirs (RSWs).

The RSW is a removable steel structure that is inserted in front of the existing spillbay, creating a raised overflow weir above and upstream of the existing spillway crest (see Figures 3-3a, 3-3b, and 3-3c). Figure 3-3a, which shows the Lower Granite 2001 surface bypass and RSW prototype, is presented to illustrate the RSW location relative to other dam components. No modifications, except the addition of support brackets, would be required to the existing spillway to accommodate the RSW. Because the flow over the RSW is essentially uncontrolled, the flow rate would vary depending on the forebay water elevation. Discharge would be greater when the forebay is at maximum operating pool and smaller when at the minimum operating pool.

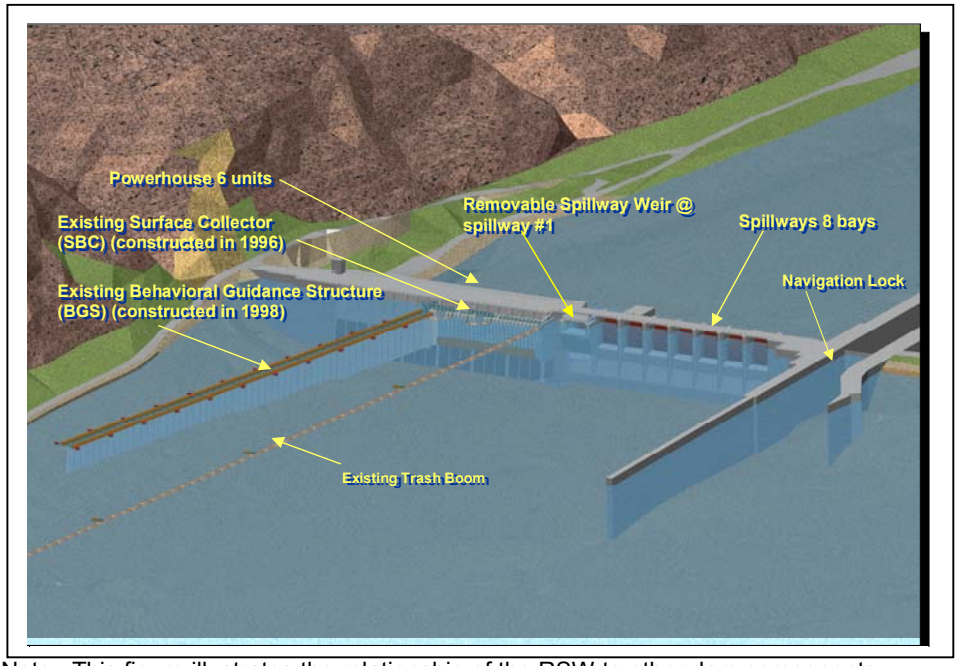
The RSW is supported vertically on hinges attached to the spillway. During high river flows, the RSW is rotated off the spillway by gradually filling flotation tanks within the RSW with water. This reduces the buoyancy of the RSW, causing it to rotate upstream. Filling continues until the RSW is lowered onto a landing pad resting on the bottom of the river (Figure 3-3d). This restores the hydraulic spill capacity. After the river flows drop to an acceptable level, the tanks are gradually filled with air, replacing the water. This causes the RSW to rotate back into position on top of the spillway.

The RSWs would provide a surface attraction flow and a less stressful method of bypassing fish than is now used for spillway passage. The best shape of the downstream portion of the RSW to provide optimum passage would have to be determined from prototype testing.

ESBS intake diversion systems would be used in conjunction with these two-unit SBC structures. At Lower Granite, the existing ESBS would be used, whereas at Lower Monumental, there would be new ESBSs to replace the existing submerged traveling screens (STSs). ESBS would be located in the turbine intakes of all six units of both powerhouses to bypass fish that pass around or under the BGS.

An SBC system termed a full-length powerhouse Occlusion Structure (see Appendix E, Existing Systems/Major System Improvements Engineering) would be installed at Little Goose. This structure would be expected to improve the performance of the ESBSs and to increase the guidance of fish away from the turbine intakes and towards the spillway. RSWs would be placed in spillbays 1 and 3 to bypass fish. Also, each turbine unit at Little Goose would have an existing ESBS in place. Fish diverted by the ESBS would be directed to the juvenile fish facilities where they would be collected for transport or returned to the river.

At Ice Harbor, a SBC system would be constructed. A BGS would extend from the interface of the powerhouse and spillway. Two RSWs would be installed, one on spillbay 1 and the other on spillbay 3. The RSWs would provide attraction flow to the spillways and would provide a method of bypassing fish over the spillway. New ESBSs would replace the existing STSs at Ice Harbor. They would be installed in the turbine intakes to offer a bypass for fish passing around or under the BGS.



Note: This figure illustrates the relationship of the RSW to other dam components.

Figure 3-3a. Overview of the Lower Granite 2001 Surface Bypass and Removable Spillway Weir Prototype

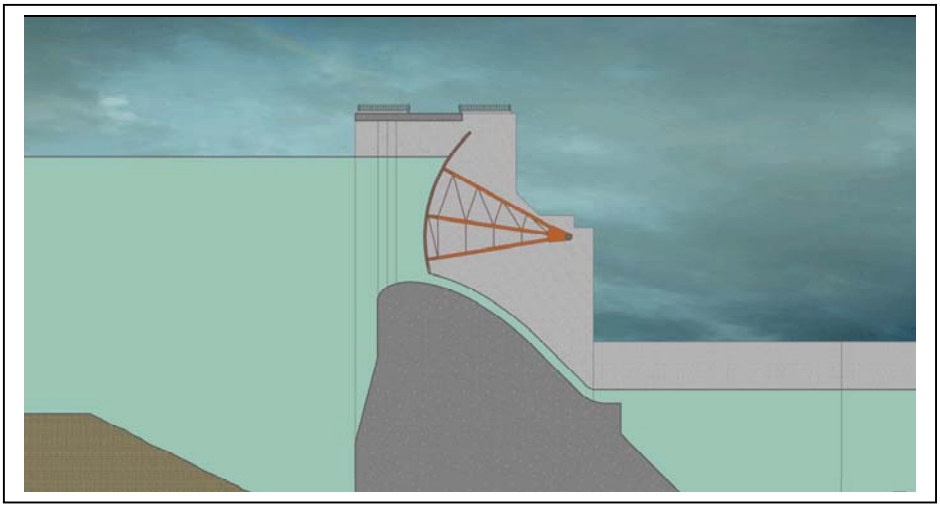


Figure 3-3b. Spillway without Removable Spillway Weir (Typical Spillway Operation) (Cross-Sectional View)

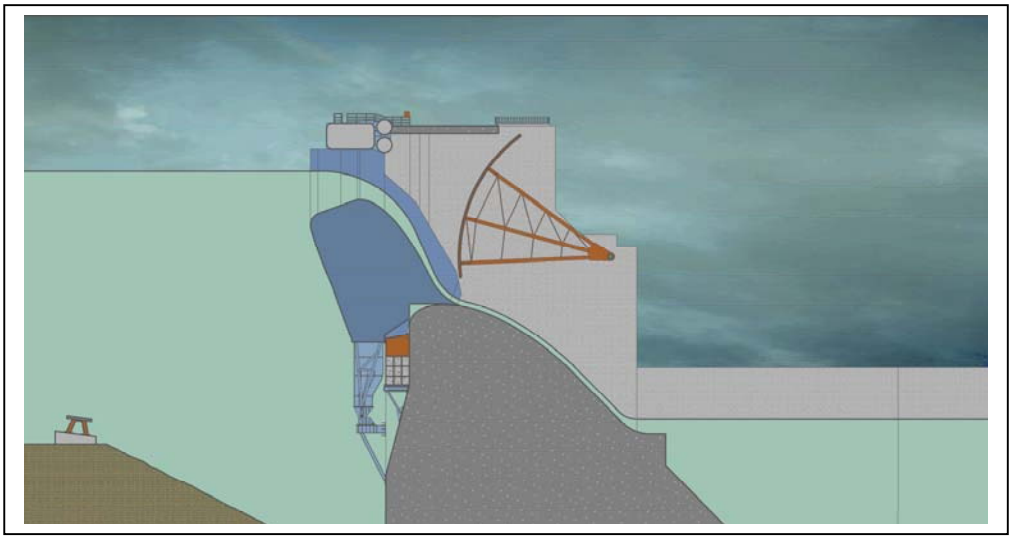


Figure 3-3c. Spillway with Removable Spillway Weir Deployed (Operating Position) (Cross-Sectional View)

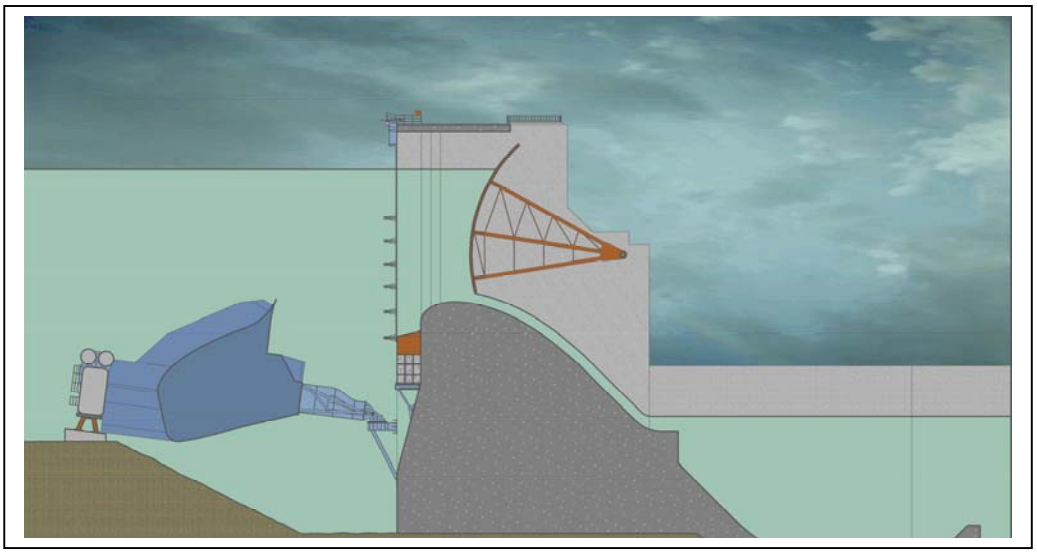


Figure 3-3d. Spillway with Removable Spillway Weir Removed (Flood Control) (Cross-Sectional View)

When operating in the bypass mode, it is anticipated that there would be a need for voluntary spill only over the RSWs at Lower Granite, Lower Monumental, and Ice Harbor. This is because the BGS proposed for these dams is expected to divert a majority of fish away from the powerhouse to the RSWs. Also, two RSWs are expected to provide adequate surface attraction to the RSWs at these dams.

When collecting and transporting fish, there would be no need for voluntary spill at Lower Granite or Lower Monumental because fish would be collected for transport. Voluntary spill over the RSWs alone is required at Little Goose and Ice Harbor in an effort to bypass fish at these dams.

Alternative 3—Major System Improvements would be implemented in two phases. The first phase would be considered "near-term actions" that involve a number of model and full scale tests of various SBC, BGS, RSW, and other structure configurations to determine their effectiveness. For example, model testing would be required to determine the ability of the occlusion structure to effectively divert fish by the spillway RSWs at Little Goose. Then the need for additional voluntary spill at Little Goose can be accessed. This would apply when the river is in bypass or transport mode. Prototype testing of other potential major improvements would also occur in this first phase. In addition, near-term actions would include implementation of existing facility improvements that require little or no additional research or evaluation.

Once the "near-term actions" have been completed and the prototype testing has demonstrated which configurations are most effective, "long-term actions" would be implemented. These actions would likely include full-scale construction and operation of major structures at each of the four dams. These "long-term actions" may not include all of the system upgrades currently included under this alternative because results from the prototype tests may alter the need for certain structures or require addition or deletion of other structures. For any significant adjustments, compliance with NEPA may also be required.

3.4 Alternative 4—Dam Breaching

The *Interim Status Report* (Corps, 1996a) considered three drawdown options: 1) seasonal, spillway crest; 2) seasonal, natural river drawdown; and 3) permanent, natural river drawdown. None of these drawdown options specifically incorporated a dam breaching scenario (see Section 1.2, Purpose and Need).

The dam breaching scenario differs from all other drawdown scenarios. Structural modifications are undertaken at the dams, allowing reservoirs to be drained, and resulting in a free-flowing river that would remain unimpounded. For example, with flows of 20,000 cubic feet per second (cfs), the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite, 114 feet at Little Goose, 108 feet at Lower Monumental, and 97 feet at Ice Harbor. Breaching of only one, two, or three dams was not considered in this FR/EIS because the removal of only one dam would eliminate major navigation in the lower Snake River and would curtail options for collecting and transporting juvenile fish. In addition, the 1995 Biological Opinion only addressed drawdown concepts for all lower Snake River reservoirs.

With dam breaching, the navigation locks would no longer be operational, and navigation for commercial and large recreation vessels would be curtailed. Similarly,

recreation opportunities, operation and maintenance of hatcheries and HMUs, and other activities associated with the modification from a reservoir environment to an unimpounded river in the lower Snake River would entail important changes in these activities (see Sections 5.10.2, 5.12, and 5.5.2 for details on specific changes). No hydropower would be produced at the four dams under this alternative. In addition, some water quality conditions such as TDG concentrations would likely be at or near natural conditions. However, other conditions such as water temperature, would still be affected by upstream conditions or releases.

For dam breaching, the primary reason for leaving portions of the project in place is that it meets the operational criteria at the lowest practical cost. However, modifications to structures would be done in such a manner that the structures could be restored to operating conditions with later modifications (Figure 3-4). With this alternative, reservoirs behind the four lower Snake River dams would be eliminated, which would result in a 140-mile near-natural river. This requires the protection of structures from near-natural river flows, and the decommissioning of equipment and structures. Secondly, construction operations would be phased so that power production, navigation, and fish migration could continue until the last possible period.

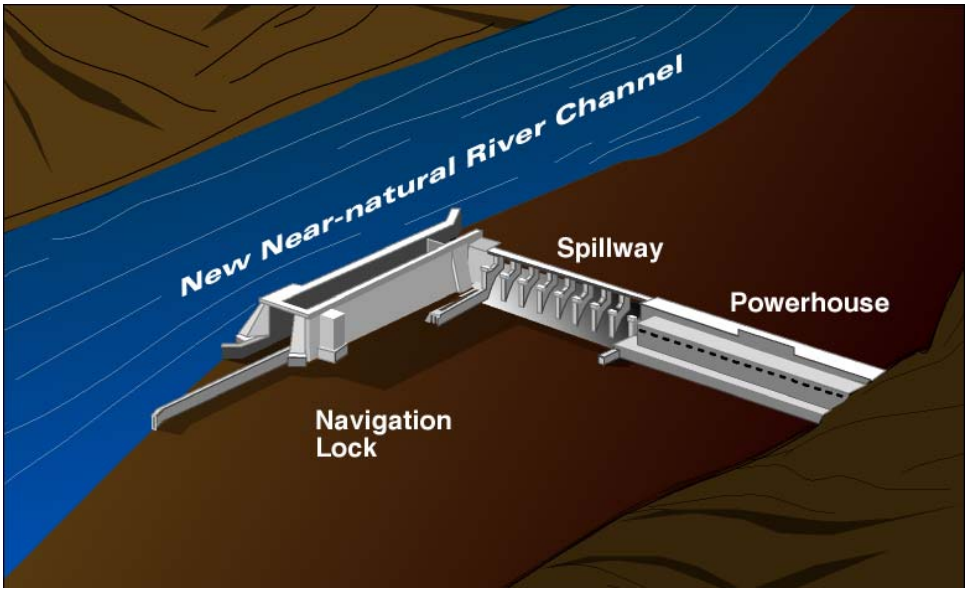


Figure 3-4. Dam Breaching

Dam breaching would involve removal of the earthen embankment section and abutment at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. Once the embankment is removed, the river would flow around the remaining structures (powerhouses, spillways, and navigation locks). Levees would be used to "shape" the river into a channel around these structures. Long-term maintenance or preservation of these powerhouses, spillways, and navigation locks would be minimal.

The following sections describe key aspects of dam breaching.

3.4.1 Reservoir Drawdown

The powerhouses and spillways would be used to lower upstream pool elevations from full pools to near existing spillway crest elevations. Below spillway crest, the current powerhouses and existing spillways would become inoperable. Additionally, based on a drawdown rate of 2 feet per day, current facilities to pass juvenile and adult fish would be inoperable within a few days to two weeks of initiating the drawdown process. This drawdown rate of 2 feet per day is based on the need to achieve drawdown in a specified timeframe to reduce the risk of embankment failure.

Because none of the four lower Snake River dams were constructed with a low-level outlet, reservoir drawdown below spillway crest is not possible without some major structural modifications. Several options were considered to evacuate the reservoirs below spillway crest, including mining through the concrete of the spillway bays or the powerhouse, excavating through the embankment section, and modifying the navigation lock to discharge low-level flows. The selected option is to modify the six units so that water can be discharged through the units at varying reservoir levels.

It is necessary to provide a discharge capacity of 60,000 cfs. The minimum base flow for the Snake River during late fall and winter is 20,000 cfs. It is estimated that each powerhouse unit (one of six) must pass up to 15,000 cfs during various reservoir stages. Since each powerhouse bay is designed so that upstream and downstream bulkheads can be installed to stop flow, construction could proceed without the construction of independent cofferdams. Construction could proceed on some activities well in advance of the drawdown operation. However, early preparations will need to balance power generation, fish mitigation, and control of dissolved gas supersaturation.

Although discharge of water through the turbine passages would allow drawdown of the majority of the reservoir, some ponding would still exist behind the earthen embankments. After draining as much water as possible through the new outlets, a section of the embankments would be removed to allow the river to run through the channel.

Reservoir drafting would be controlled. For example, at Lower Granite, drafting would be limited to 2 feet per day, requiring 58 days to draft 115 feet below full pool. The total reservoir storage, in the four reservoirs, that would be evacuated during drawdown would be about 1.67 million acre-feet (MAF).

3.4.2 Required Modifications

A number of structural modifications to the features of each dam would be necessary for a permanent drawdown. Some embankment would be removed and replaced with a channel to allow the near-natural flow of the river. Some channelization of the river in the dam reach would be necessary to create hydraulic conditions that allow upstream fish migration. In addition, facilities for passing adult fish upstream and during construction activities, as well as during the time when the reservoir is being lowered would be needed.

Criteria, assumptions, and key considerations for upstream fish passage during construction activities and for permanent drawdown were established for the feasibility evaluation. Construction activities would be orchestrated in a manner to ensure, so far as possible, that upstream passage of adult fish would not be adversely

affected. For example, it was assumed that channel velocities below 5 feet per second (ft/s) require no supplemental adult fish upstream passage facilities. Channel velocities above 5 ft/s require features in the river to produce rest areas. The higher the velocity, the more numerous and frequent the rest areas. It was also assumed that the maximum flow against which adult fish are assumed to swim upstream is 170,000 cfs. Specific options and facilities for adult fish passage during construction are described in Section 3 of Appendix D, Natural River Drawdown Engineering.

Juvenile fish would be allowed to pass downstream through the open channel that would be present after dam breaching. Collection and transport facilities for juveniles would no longer be operated following dam breaching. Construction will occur August through December, a period where downstream passage of juveniles does not occur, except for subyearling fall chinook salmon smolts that pass through October, depending upon annual flow and subsequent water temperature resulting from augmentation operations upriver (see Section 4.5.1, Anadromous Fish).

Additional criteria, assumptions, and key considerations for dam breaching included in the feasibility studies are described below:

No Catastrophic Drawdown

The evacuation of the reservoirs would be done at a maximum fixed rate of 2 feet per day. This rate is designed to minimize or avoid slope failures in the reservoirs, which could put highways and railroads out of service.

Minimal Cost

When considering various options for implementing drawdown, the lowest cost option was the primary consideration. The goal of the Feasibility Study was to identify the major activities necessary to implement a four-reservoir drawdown and to document a feasible, reasonable method to accomplish those activities.

Mitigation Measures

Numerous construction activities and post-construction mitigation measures were assumed for implementation of dam breaching and modification of existing structures in the reservoirs. Direct measures are those activities necessary to evacuate each reservoir, remove a portion of the dam structure, and establish a river channel at each dam site. An example would include maintaining conditions for upstream passage of adult fish. In addition to these activities, modifications and repairs to transportation facilities adjacent to and across the river (e.g., bridge supports would need additional protection from potential scour) would be needed. Existing access to the river for cattle watering and protection of cultural resources would need to be addressed.

Other discretionary mitigation measures were also considered because they are authorized under current and anticipated project authorization. Examples include modifications to current wildlife mitigation lands, modifications to an operating fish hatchery, and measures to provide river access and appropriate recreation facilities. These are evaluated in greater detail in the respective sections of this FR/EIS.

The process of decommissioning the project requires a number of tasks. Key modifications are discussed in detail in the following sections.

3.4.2.1 Bulkheads

To use the turbine units as low-level outlets, some modification to the intake gates would be required. Upon completion of unit modifications, discharge through the turbine passages would be initiated by raising the intake gate, or by some coordinated operation of the turbine wicket gates and draft tube bulkheads. Neither gate was designed to regulate flow, so modification or replacement would be necessary so the gates would regulate discharge. Modifications may include gate strengthening, added operators, and new rollers and seals. Such modifications would apply to all gates. Further modifications may be necessary to the draft tube bulkheads.

3.4.2.2 Turbines/Generators

Modifications to turbines and associated equipment would be necessary to allow the use of the turbine and passages to function as outlets. Modifications would need to be completed well in advance of drawdown. However, some turbine capacity must be maintained during the previous spill season in order to aid in controlling the total dissolved gas supersaturation in the river. Excessive spillway use raises total dissolved gas supersaturation to unacceptable levels. Modifications must be scheduled so that turbine use is maximized and spillway use is limited to acceptable timeframes.

The operating turbine and generator serve to dissipate the energy of a high head and allow the passage of a significant volume of water. In order to make the turbines operate at lower heads than the current operating head, numerous modifications must be made. A detailed report on the Turbine Passage Modification Plan is provided in Appendix D, Natural River Drawdown Engineering. In summary, these modifications are as follows:

- **Addition of Performance Instrumentation**—Additional instrumentation is necessary to monitor conditions of the turbine during out-of-the-ordinary operations. The instrumentation identifies developing conditions that may lead to a failure of the system and may prevent the necessary discharge of water. Early warning provided by instrumentation allows operators to react and implement contingency plans.
- **Emergency Closure Devices**—Existing emergency closure devices should be in operating condition. The use of these gates is only in the event that conditions develop that could cause failure of the water outlet process and the purpose is to isolate that turbine passage. Currently, the intake gates at each project are either raised (with the hydraulic operators disconnected) or removed for improved fish passage purposes. During a reservoir drawdown, the fish screens would be removed. The intake gates should be connected to the hydraulic operators and stored in the normal position, ready for emergency use.
- **Cooling Water System**—Additional cooling water for turbines and generators would be required to supplement the existing gravity-fed system as the head drops.
- **Trash Rack Modifications**—Investigation is necessary to assure that the trashrack structures are adequate for debris loads over the range of head pressures to which they will be subject. Some strengthening has been assumed

to be necessary for drawdown conditions. A significant effort will be required to keep the trash racks clear of debris during drawdown.

- **Draft Tube Bulkheads**—When more than one dam is drawn down at once, the tailwater of the upstream project will drop significantly. This drop in tailwater will cause serious cavitation problems for the turbines. Approaches for addressing these problems are provided in Appendix D, Natural River Drawdown Engineering. Each dam only has one set of draft tube bulkheads, so additional bulkheads for the remaining five units would need to be purchased.
- **Turbine Blade Removal**—Up to three turbines at each project would require removal of the turbine blades to operate as bladeless runners. This would allow maximum discharge of water through the turbine passages at low heads. Removal is expected to be done several months in advance of drawdown by cutting the blades and removing them through the intake slot or out through the draft tube.
- **Operation**—Operation below the speed no load (SNL) condition is possible, but would require direct manual operation. It is not recommended without more critical evaluation. The increased risks and uncertainties of operating below SNL make this a potentially more dangerous operation.
- **Contingency Plans**—If equipment fails to operate as expected during the reservoir evacuation, contingency plans must be in place in order to continue the drawdown process and complete the embankment breach. Typical contingent operations might be operating turbine units manually at or below SNL status, breaching the embankment cofferdams at higher heads, and/or using a modified intake gate for regulated flow through the turbine passages.

3.4.2.3 Channel Preparation

Some operations related to channel excavation could be completed in advance of embankment excavation. The processing and stockpiling of riprap could also be done in advance. While some riprap could be salvaged for the embankment shells, additional riprap would be needed for protection against higher velocity and wider range of river flows. Riprap protection would be necessary adjacent to the navigation locks, adjacent to the spillway structures, and for the new levees.

3.4.2.4 Embankment Removal

Embankment removal would be expected to require a three-stage operation. The reservoir would be drawn down to spillway crest, while concurrent excavation of the upper embankment would be performed. Further drawdown would be done using the modified powerhouse units. Concurrent excavation of the embankment would continue at an accelerated rate. It may be that the powerhouse outlet configuration results in some reservoir impoundment when at its lowest level. Depending on the reservoir elevation, a controlled breach of the embankment may be necessary to provide final drawdown.

3.4.2.5 River Channelization

River channelization is expected to be relatively minimal. Final channel shaping would be done by dragline from the shore. Channelization would be necessary in the reservoir to capture the river, and divert it around the powerhouse and spillway structures. Channelization in the form of new levee structures would extend upstream

some distance. Without these measures, areas may pond water, threatening water quality and creating fish migration difficulties.

3.4.2.6 Changes to Other Facilities

Numerous modifications would be necessary to ancillary structures (see Appendix D, Natural River Drawdown Engineering, for details). These modifications would include:

- Bridge pier protection
- Railroad and highway embankment protection
- Protection of drainage culverts and pipe outfalls along each reservoir
- Railroad and roadway damage repair
- Modifications to water supply, adult fish ladder, and operations at the Lyons Ferry fish hatchery
- Modifications to HMUs
- Reservoir revegetation
- Modifications to cattle watering facilities
- Modifications for recreation access
- Cultural resources protection
- Once breaching begins, the dams would no longer produce power. Provisions to modify station service power feeds would be necessary to draw power from other sources. Independent power systems may be necessary if other sources are unavailable (see Section 5.9, Electric Power)
- The relocation of roads, railroads, visitor facilities, and other facilities would be required to construct the new channels and bypass structures and to accommodate drawdown
- Flow augmentation would continue under the 2000 Biological Opinion levels and the Comp Plan would be re-evaluated.

3.4.3 Lower Snake River Compensation Plan

The Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan) was authorized to mitigate for fish and wildlife losses caused by the construction and operation of the four lower Snake River dams. Breaching of the dams would result in cessation of operations and return of the river to near-natural or unimpounded conditions in this reach. Therefore, the conditions that resulted in the need for the Comp Plan and its mitigation requirements would no longer exist. The Comp Plan would be re-evaluated.

Specific measures such as operation of existing fish hatcheries, wildlife habitat management units, and access are likely to be discontinued or modified, likely over a transition period that would allow post-breaching conditions to stabilize. For example, operation and maintenance of HMUs and fish hatcheries may be discontinued whereas the operations of some remaining hatcheries would be modified to captive broodstock facilities that would be used to rebuild fish runs. The Lyons Ferry Hatchery may need to be maintained because the fall chinook salmon in this hatchery are included in the Snake River fall chinook evolutionarily significant unit

(ESU). It is also likely that any new measures needed to mitigate the effects of breaching on fish and wildlife would be considered.

3.5 Implementation Schedule and Costs

3.5.1 Alternatives 1 and 2

Table 3-1 includes costs for any new construction, implementing the anadromous fish evaluation program, lock and dam operations and routine maintenance, major rehabilitation of turbines, fish hatchery operation and maintenance, and BOR annual requirements for each alternative. The table also includes schedules for new construction, the anadromous fish evaluation program, and major turbine rehabilitation. These alternatives have actions that would likely take between 5 and 40 years to implement. Alternatives 1 and 2 have a 5-year-long construction schedule. All four alternatives are similar in the amount of time for research and development.

3.5.2 Alternative 3—Major System Improvements (Adaptive Migration)

Some of the proposed systems under Alternative 3, such as the RSW, SBC, and BGS, present more challenging technical issues than the other non-breach alternatives. Accordingly, Alternative 3 has a 10-year-long construction schedule. This schedule includes most of the near-term costs included under the first two alternatives, which require little or no additional study or research and could be implemented within 5 years after the ROD and this FR/EIS provide NEPA compliance for implementation. The long-term actions generally require additional evaluation, prototype development, and testing; therefore, they take more time to put into place. Near-term and long-term improvements included under Alternative 3—Major System Improvements (Adaptive Migration) are summarized below:

Near-term Improvements

- Complete installation of spillway flow deflector at Lower Monumental and Little Goose
- Upgrade auxiliary fish ladder water supply systems at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite
- Modify extended submerged bar screens at Little Goose and Lower Granite
- Use additional barges for transport with upgraded mooring facilities at Lower Granite.

Long-term Improvements

- Install new juvenile facility at Lower Granite
- Install new cylindrical dewatering screens at all dams
- Replace submerged traveling screens (STSs) with ESBSs at Ice Harbor and Lower Monumental
- Install new wet separators at Lower Monumental and Little Goose
- Install turbine improvements (as powerhouses are rehabilitated)
- Install RSWs with or without BGS at all four dams

Table 3-1. Implementation Costs and Schedules

Alternative	New Construction Costs ($ million)	Construction Schedule (Duration– Years)	AFEP Annual Costs ($ million)	AFEP Schedule (Duration – Years)	Major Rehabilitation of Turbines ($ million)	Major Rehabilitation of Turbines Schedule (Duration – Years)	Lock and Dam Routine O&M and Minor Repair Annual Costs ($million)	Fish Hatcheries O&M and Minor Repair Annual Costs ($ million)	BOR Annual Costs ($ million)
1 Existing Conditions	89.3	5	5.3	27	193.6	41	36.5	14.5	2.4
2 Maximum Transport of Juvenile Salmon	67.9	5	3.6	27	193.6	41	36.5	14.5	2.4
3 Major System Improvements	389.6	10	9.5	27	193.6	41	37.2	14.5	2.4
4. Dam Breaching[1,2/]	911.1	9	2.5	27	na	na	4.9	14.5	2.3

Notes: AFEP = Anadromous Fish Evaluation Program
O & M = Operation and Maintenance
MW-hr = Megawatts per hour
BOR = Bureau of Reclamation

The duration of these costs varies by cost category and alternative. Therefore, all costs are amortized over a 100-year period for comparability.

1/ Detailed implementation costs are presented for Alternative 4—Dam Breaching in Appendix D, Natural River Drawdown Engineering, Annex X, Table 1. The new construction cost total presented in this table ($911.1 million) is higher than the construction and acquisition cost total presented in Appendix D, Natural River Drawdown Engineering, Annex X, Table 1 ($858.9 million) because it includes fish and wildlife mitigation and cultural resources mitigation costs of $52.2 million. These costs are included in the operation and maintenance cost category in Appendix D, Natural River Drawdown Engineering, Annex X, Table 1.

2/ The actions associated with the non-breach alternatives can be implemented more quickly than Alternative 4—Dam Breaching, even with the recognition that the long-term improvements associated with Alternative 3—Major System Improvements could take up to 10 years to fully implement. This is due, in part, to the fact that these actions do not require Congressional authorization. Potential issues surrounding implementation duration are discussed further in Section 6.4.32.

Source: Appendix E, Existing Systems and Major System Improvement Engineering, Tables ES-1 and ES-2.
Appendix D, Natural River Drawdown Engineering, Annex X, Table 1.

- Install two-unit powerhouse surface bypass with or without dewatering system at Lower Monumental and Lower Granite
- Build full-length powerhouse occlusion structure at Little Goose.

It is important to note that while the implementation time for the construction schedule under Alternative 3 is 10 years, which is 1 year longer than the construction schedule for Alternative 4—Dam Breaching, actions associated with dam breaching are actually expected to take longer than 10 years to fully implement. Alternative 4—Dam Breaching would involve Congressional authorization and, potentially, other processes that would draw out the completion date. Potential issues surrounding implementation duration are discussed further in Section 6.4.32.

3.5.3 Alternative 4—Dam Breaching

Assuming that funds and resources are available when required, it is estimated that, from the date authority is granted and funds are appropriated, it would take about 9 years to fully implement Alternative 4—Dam Breaching. In addition, if more study or research identifies any unforeseen technical problems, additional time may be required to obtain acceptable solutions.

Dam breaching activities would take at least 4 full years to complete after an estimated 5-year period necessary for preparation of a detailed design report and assessment of contracts.

Removal of all four lower Snake River dams can be sequenced in several ways. The proposed method selected (see Appendix D, Natural River Drawdown Engineering) is to sequence the work so that Lower Granite and Little Goose Dams are breached during the fifth year of the construction period. Lower Monumental and Ice Harbor Dams would be breached during the sixth year of the construction period. Several other variations are possible; however, this method provides a realistic phasing of design and construction activities.

A feasibility-level cost estimate was developed for Alternative 4—Dam Breaching (see Appendix D, Natural River Drawdown Engineering). The estimate includes costs for construction, real estate, cultural resources, engineering and design, construction management, and project management. Construction costs were prepared using the Micro Computer-Aided Cost Engineering System (MCACES) software. The estimate is based on a work breakdown structure (WBS) that was developed to seven levels, as follows: project, feature, subfeature, element, bid item, assemblies, and detail.

The major assumptions used in preparing the estimate are as follows:

- Drawdown of the reservoirs and breaching of the dams will occur at a rate of two dams per year.
- Fish passage around the projects will be maintained during construction. The Lyons Ferry Fish Hatchery will remain operating as near to current capacity as possible.
- The rock sources identified will have enough material available.

- In-water work will be allowed to occur during normal fish window closures. Some in-water work must occur outside the normal fish window closures.

Other assumptions are documented in the detailed estimate found in Appendix D, Natural River Drawdown Engineering.

The total cost of this drawdown implementation action is $911.1 million. This cost includes required monitoring activities, operation and maintenance costs, and other related costs.

Previous estimates of cost have ranged from a high of approximately $5 billion to a low of approximately $600 million. The high cost features of earlier concepts have been eliminated and replaced with features more appropriate considering the available construction methods. The previous low estimates were revised as more details were developed for stabilization, modification, or mitigation measures.

3.5.4 Average Annual Cost Comparison

This section presents a summary of the total and average annual implementation costs for all four alternatives. Construction, interest during construction, Anadromous Fish Evaluation Program, and operation, maintenance, repair, replacement, and rehabilitation (O, M, R, R & R) costs are displayed in average annual equivalent terms, taking into account the 100-year period of analysis and adjusted to base year 2005 in Table 3-2. Average annual costs were calculated using three discount rates: the Corps' rate of 6.875 percent, the BPA rate of 4.75 percent, and 0.0 percent, at the request of the five Tribes represented by the Columbia River Inter Tribal Fisheries Commission (CRITFC).

Average annual costs vary widely depending upon which discount rate is used, but the ranking of the alternatives remains constant. Alternative 2—Maximum Transport of Juvenile Salmon, is the lowest cost alternative with a lower cost than the base case. Alternative 1—Existing Conditions, and Alternative 3—Major System Improvements, are the next lowest cost alternatives, while Alternative 4—Dam Breaching, is the highest cost alternative, under all discount rates.

3.6 Other Potential Actions Outside the Scope of the FR/EIS

The purpose of this FR/EIS is to evaluate measures that may increase the survival of juvenile anadromous fish as they migrate past the four lower Snake River dams. Numerous other studies by the Corps, other Federal agencies, states, and tribes are also being conducted in the Snake River System and elsewhere in the Columbia River Basin to address salmonid species that are either at risk or listed under ESA. This FR/EIS addresses, in detail, alternatives that could be implemented at the four lower Snake River dams; it does not directly address all other actions being considered in the Columbia River System (which are being addressed in other forums—see Section 1.4.5) to conserve and restore ESA-listed salmon runs. However, it does consider these other actions as part of the cumulative impacts analysis, discussed in resource subsections throughout Section 5, and in Section 5.16, Cumulative Effects.

Table 3-2. Summary of Implementation Costs (1998 dollars) ($1,000s)

Discount Rate /Alternative	Construction and Acquisition Cost ($)[1/]	Interest During Construction Cost ($)[2/]	Total Investment Cost ($)	Average Annual Investment Cost ($)	Average Annual AFEP Cost ($)[3/]	Average Annual O,M,R,R&R Cost ($)[4/]	Average Annual Implementation Cost ($)
6.875 Percent							
Alternative 1	89,260	8,730	97,990	6,750	5,670	3,110	15,530
Alternative 2	67,900	6,790	74,690	5,140	3,820	3,110	12,070
Alternative 3	308,120	42,970	351,090	24,170	10,220	4,020	38,410
Alternative 4	759,100	50,440	809,540	55,730	2,650	5,940	64,320
4.75 Percent							
Alternative 1	89,240	5,970	95,210	4,570	4,500	2,880	11,950
Alternative 2	67,900	4,640	72,540	3,480	3,030	2,880	9,390
Alternative 3	330,630	30,610	361,240	17,330	8,100	3,720	29,150
Alternative 4	800,220	35,690	835,910	40,090	2,100	5,250	47,440
0.0 Percent							
Alternative 1	89,260	0	89,260	890	1,370	2,480	4,740
Alternative 2	67,900	0	67,900	680	920	2,480	4,080
Alternative 3	389,650	0	389,650	3,900	2,470	3,300	9,670
Alternative 4	911,120	0	911,120	9,110	640	3,340	13,090

1/ Construction costs include those for fish-improvement projects and/or to breach the dams. Construction costs associated with Alternative 4—Dam Breaching include mitigation costs, such as wildlife mitigation and cultural resources protection.

2/ Interest during construction reflects compound interest, at the applicable borrowing rate, on construction costs incurred during the period of installation.

3/ Anadromous fish evaluation program.

4/ O, M, R, R&R costs include those associated with the new fish improvement projects (e.g., purchase of water from BOR and the O&M costs associated with the screen bypass system proposed under Alternative 3, Major System Improvements).

Source: U.S. Army Corps of Engineers (Walla Walla District, Portland District), BPA and BST Associates

Measures are also being considered at McNary, John Day, The Dalles, and Bonneville Dams to improve the effectiveness of juvenile salmon migration. These measures include additional transportation, flow deflectors, collection facilities, and spill modifications. All of these measures are in the feasibility testing phase, are under study, or have been proposed. Therefore, they are not addressed in detail in this FR/EIS. They are, however, addressed in discussions of cumulative effects in resource subsections throughout Section 5, and in Section 5.16, Cumulative Effects. The actions at these lower Columbia River dams will or have been specifically addressed in detail in other NEPA documents.

3.7 Alternative Actions Eliminated from Further Consideration

A wide variety of actions and options were identified, examined, and discussed in Phases I and II of the Corps System Configuration Study (see Section 1.1, Feasibility Study Process) (Corps, 1994). In the *Interim Status Report* (Corps, 1996a), these actions or options are specifically addressed. Many of these were eliminated for a

number of reasons, such as: 1) significant biological and uncertainty concerns, 2) benefits of the action were less than other proposed actions, 3) potentially adverse effects to both adult and juvenile fish, 4) unacceptable impacts to turbines or other fish bypass components, and 5) potentially detrimental impacts to other resources, such as cultural.

Alternative actions that were not eliminated during the System Configuration Study received further preliminary detailed evaluation and analysis for this Feasibility Study (see Appendix J, Plan Formulation). As part of this evaluation process, the four alternatives (Sections 3.1 to 3.4) were selected for full evaluation while the others were eliminated for one or more of the following reasons: 1) not meeting the purpose and need of this FR/EIS; 2) the probability of success of implementation of the action was considered low or unlikely, or 3) the action would be addressed in other forums or through other NEPA analyses. The following provides general descriptions of the actions eliminated from detailed analysis. As specifically noted, the descriptions generally coincide with those alternatives evaluated in Appendix E, Existing Systems/Major System Improvements Engineering) and Section 6 of this FR/EIS.

- **In-river Migration Option with Voluntary Spill under Existing Conditions (this option was evaluated by the Corps as Option A-1a—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This option assumes that the existing or currently planned juvenile fishway systems would be operated to maximize in-river fish passage and that voluntary spill would be used to bypass fish through the spillways. Since juvenile fish would remain in the river, and voluntary spill would be used to attract the fish to the spillway, additional structures to implement dissolved gas abatement would be needed (see Appendix E, Existing Systems/Major System Improvements Engineering for details).

  This option does not follow an adaptive migration strategy because no fish would be transported. Therefore, it would not meet the objectives of the NMFS 1995, 1998, or 2000 Biological Opinions. In addition, in-river migration only would result in a lower direct survival of juveniles through the lower Snake River and the entire migratory corridor than a combination of in-river and transportation measures. Based on this, it was eliminated from further consideration.

- **Maximized Transport at the Four Lower Snake River Facilities Without Voluntary Spill (with major SBC development at all four lower Snake River dams; this action was not specifically evaluated by PATH, but is the Corps' Option A-2b—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  Under this alternative, the number of fish collected—Existing Systems/Major System Improvements Engineering and delivered to the existing or upgraded transportation facilities located at each project would be maximized. Full length powerhouse SBCs would be provided at Lower Granite, Little Goose, and Lower Monumental. These would be used in conjunction with ESBSs located in the turbine intakes. Fish collected by both bypass structures would

be combined and delivered to the transportation facilities, and either trucked or barged downstream.

The upper two dams (Lower Granite and Little Goose) currently have ESBSs installed in the turbine intakes. These would continue to be used. However, the intakes at Lower Monumental are currently outfitted with STSs. These would be removed and replaced with ESBSs to increase the screen diversion efficiency, and further reduce the number of fish passing through the turbines.

At Ice Harbor, the turbine intakes are also currently outfitted with STSs. As at Lower Monumental, these would be removed and replaced with ESBSs to increase the diversion efficiency of the screening system. However, no SBCs would be installed at Ice Harbor.

If the combination of the SBC and the ESBS systems function as anticipated at Lower Granite (the major system improvements alternative), there should be very few migrating fish left in the river at the lower three dams (see Section 3.3, Alternative 3—Major System Improvements). In addition, few fish enter the Snake River between Lower Monumental and Ice Harbor. Therefore, construction of SBCs at all dams would not appear to be justified, and this option was eliminated from further consideration. In addition, the intent of this option is to maximize transport, which does not incorporate an adaptive migration strategy. Therefore, it does not meet the objectives of the 1995, 1998, and 2000 NMFS Biological Opinions.

- **Maximized Transport at the Four Lower Snake River Facilities with Voluntary Spill at Ice Harbor (this is similar to the Corps' Option A-2c—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This option assumes that the juvenile fishway systems would be operated to maximize fish transportation and that voluntary spill would be needed only at Ice Harbor to aid in bypassing fish over the spillways.

  The juvenile fish passage strategies for this option are the same as under the previous option. However, there are significant differences in designs and project operations between the two. Also, the costs for this option are considerably lower than for the previous one. The primary difference is that an SBC would only be developed at Lower Granite. Only ESBSs would be used at the other three dams. This option does not incorporate an adaptive migration strategy and does not meet the objectives of the 1995, 1998, and 2000 NMFS Biological Opinions. Therefore, it was eliminated from further consideration.

- **In-river Migration Option (no transportation, no drawdown, SBCs at all dams, and flow augmentation under the 1995 Biological Opinion) Plus an Additional 1.0 MAF Flow Augmentation (this action was evaluated by the Corps as Alternative A-6a)**

  With this action, spill would be maximized to the extent possible to bypass additional fish over the spillways. There would be no transportation of juvenile fish and in-river migration would be maximized. Augmentation flows would be increased by an additional 1.0 MAF. Therefore, the total augmentation flow would be 1,427 MAF.

Juvenile fish would be passed directly downstream to the tailrace. To maximize diversion away from the turbines, ESBS intake diversion systems would be used in conjunction with the SBCs at all four dams to divert fish which might pass under the SBC and into the turbine intakes. Lower Granite and Little Goose already have ESBS systems, and these would continue to be used in conjunction with the new SBCs. The STS systems at Lower Monumental and Ice Harbor would be removed and replaced with new ESBS systems.

The Corps has an interest in flow augmentation from upstream sources and how it would affect operations and juvenile fish passage in the lower Snake River. As a result, the Corps asked BOR for assistance in developing further information on flow augmentation, particularly regarding the feasibility and potential impacts of providing the 1.0 MAF additional flow augmentation. The current findings of BOR's studies are presented in the *Snake River Flow Augmentation Impact Analysis* (BOR, 1999). The report concludes additional flow augmentation would involve high costs and multiple implementation issues. Section 7 consultation with the BOR and Idaho Power on the flow issue is continuing under a separate review process.

Additionally, PATH did a preliminary screening analysis of this alternative, designated as Alternative A-6, which found with "most realistic" assumptions that it performed at only 80 to 100 percent of the survival and recovery criteria that PATH Alternative A-2 did. Therefore, it was unlikely this alternative would perform any better than alternatives considered fully and was not included for detailed assessment.

- **In-river Migration with No Flow Augmentation (This is the same as Corps Option 6b—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This alternative was eliminated from detailed analysis because it was not recommended in the 1995 and 1998 Biological Opinions and no flow augmentation would occur. In addition, adaptive migration would not be an objective of this option and, therefore, flexibility for implementing passage options would be limited.

  PATH performed a preliminary screening analysis alternative (designated as Alternative A-6') with very similar characteristics to this alternative, but with the inclusion of SBCs at all Snake River dams to bypass fish. Even with the addition of SBCs, which should enhance dam passage survival relative to current bypass systems, the PATH preliminary analysis found that this alternative performed worse than PATH Alternative A-2 relative to the NMFS survival and recovery criteria. Therefore, considering its poor performance and NMFS' lack of recommendation in its 1995 and 1998 Biological Opinions to study this alternative, this alternative was not carried forward to full alternative analysis.

- **In-river Migration (major system improvements and flow augmentation under the 1995 Biological Opinion; this is similar to the Corps' Option A-6d—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This option assumes that juvenile fishway systems would be operated to maximize in-river fish passage. This option is similar to the previous option, except it assumes 427 KAF from upstream storage and not 1,427 KAF. It also includes different SBC components to pass fish (see Appendix E, Existing Systems/Major System Improvements Engineering).

  This option also assumes that there would be no voluntary spill except at Little Goose. Adaptive migration would not be an objective of this option and, therefore, flexibility for implementing passage options would be limited.

- **Dam Removal (for PATH analysis, this action is equivalent to A-3)**

  Dam removal would include the same actions as described for dam breaching, but would also include removal of all structures (e.g., spillways, powerhouses, navigation locks) at each facility. In addition, long-term maintenance of site structures or preservation of equipment would be eliminated. This alternative was not considered in detail because dam breaching would achieve the same results at a lower cost. In addition, the option of reestablishing the function of the dams in the future would be eliminated. Dam removal as an alternative would result in no increase in fish survival or recovery compared to the dam breaching without removal. Therefore, this alternative was eliminated from further consideration.

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Chapter 4

Affected Environment

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4.2 Geology and Soils
4.3 Air Quality
4.4 Water Resources
4.5 Aquatic Resources
4.6 Terrestrial Resources
4.7 Cultural Resources
4.8 Native American Indians
4.9 Transportation
4.10 Electric Power
4.11 Water Supply
4.12 Land Ownership and Use
4.13 Recreation and Tourism
4.14 Social Resources
4.15 Aesthetics

4. Affected Environment

4.1 General Setting

4. Affected Environment 4.1-1
4.1 General Setting 4.1-1
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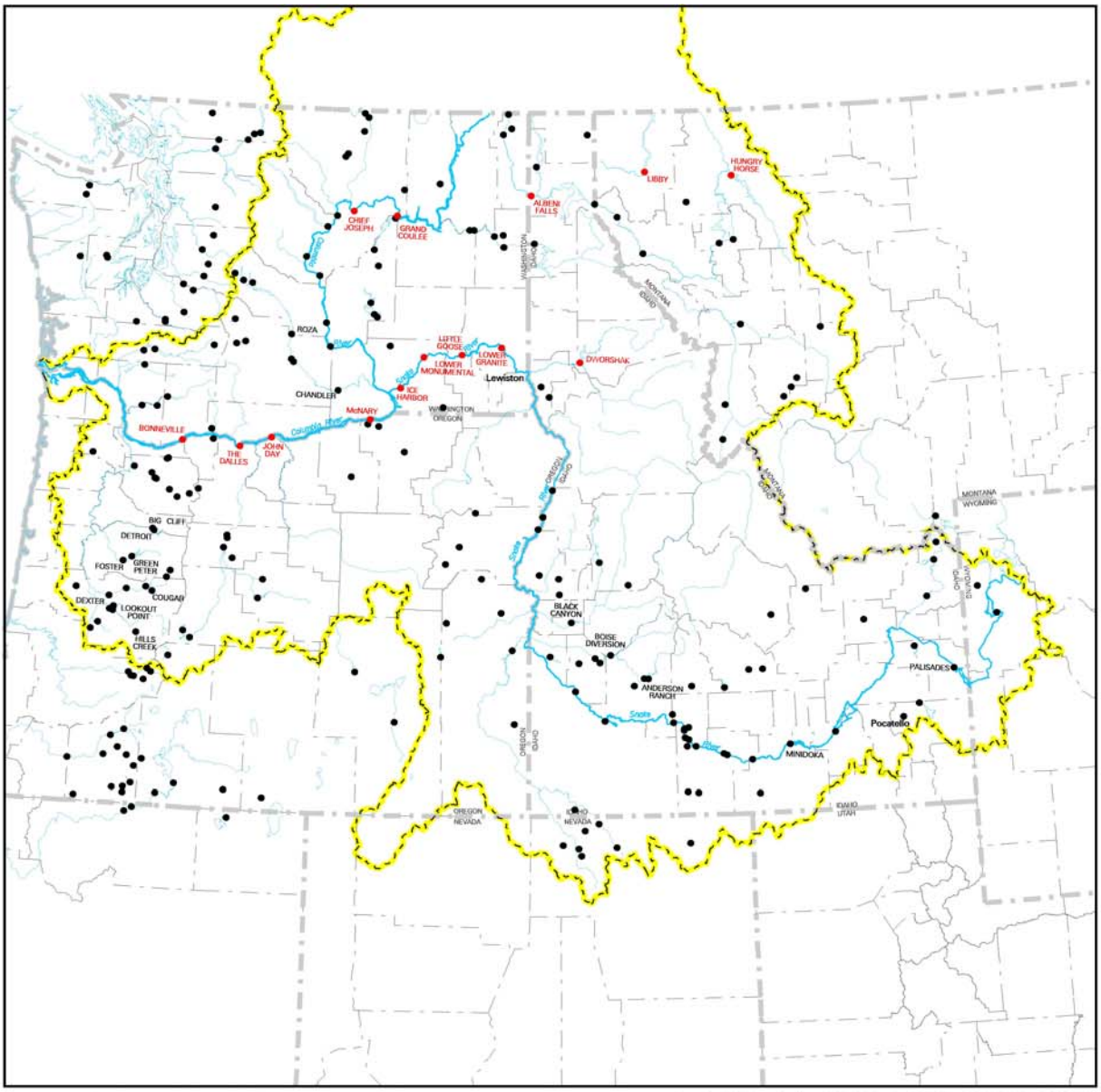
4.1.1 Physical Environment

The Snake River is the principal tributary of the Columbia River. Originating in northwestern Wyoming, it winds its way 1,078 miles to its confluence with the Columbia River near Pasco, Washington. Tributaries to the Snake River include the Salmon, Clearwater, Boise, Owyhee, Grande Ronde, and Palouse. The Snake River originates in Yellowstone National Park. From there it flows south into Idaho and west across the broad Snake River Plain of southern Idaho to the Oregon-Idaho border. Here it turns north, forming part of the boundary between Idaho, Oregon, and Washington and flowing through Hells Canyon, a mile-deep canyon cut through the Seven Devils Mountain Range. Near Lewiston, Idaho, the Snake River is joined by the Clearwater River and turns west to join the Columbia River near Pasco, Washington. Approximately 140 miles upstream of Lower Granite Dam, Idaho Power Company operates the Hells Canyon Complex, a series of three dams on the Snake River.

The four lower Snake River dams—Lower Granite, Little Goose, Lower Monumental, and Ice Harbor—are located along the lower 140 miles of the river extending west from Lewiston, Idaho (Figure 4.1-1). The Palouse and Tucannon rivers are the major tributaries below Lewiston. Both of these tributary rivers enter the lower Snake River behind Lower Monumental Dam. Only 5 percent of the Snake River's total drainage area is located downstream of its confluence with the Clearwater River.

The Snake River Basin encompasses a 109,000-square-mile area shared by several states including Wyoming, Oregon, Idaho, and Washington. Several complex systems of mountain ranges, with intervening valleys and plains, lie within the Snake River Basin. Much of the southern part of the basin is included within the Columbia



Special Note: Dams may not all be operational or currently in use.

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REGIONAL DAMS

Federal Columbia River Power System (FCRPS)

Other Federal, State, & Private

BOUNDARIES

Columbia River Basin

State

County

KM 100 50 0 MILES 50 100

1,000,000 ACRES

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 : 76,032,000

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.1–1.

REGIONAL DAMS

Plateau Province, a semiarid expanse formed by successive flows of basaltic lava. A rugged area of mountain ridges and troughs, with deeply incised stream channels, lies north of this plateau. Elevations in the basin range from 13,766 feet above National Geodetic Vertical Datum (NGVD29) at Grand Teton Mountain in Wyoming to approximately 330 feet NGVD29 at the lower Snake River's confluence with the Columbia River.

The climate of the lower Snake River Basin is greatly influenced by prevailing westerly winds and the Cascade and Rocky Mountain ranges. The Rocky Mountains shield this section of Washington from the more severe winter storms that move southward across Canada, while the Cascade Range forms a barrier to the easterly movement of moist air from the Pacific Ocean.

Dam development in the Columbia River Basin began in the 1800s. Mainstem dam development began with Rock Island Dam (a non-Federal project) on the Columbia River in 1933 and continued through 1975 with the completion of Lower Granite on the Snake River. Bonneville Dam was the first Federal dam on the mainstem. It was completed in 1938. The major period of construction on the mainstem Columbia and Snake rivers was from the 1950s through the 1970s.

Federal agencies have built 30 major dams with hydropower facilities on the Columbia and its tributaries. Overall, there are some 255 Federal and non-Federal projects that have been constructed in the basin.

There are 14 major Federal dams on the mainstem Columbia River and lower Snake River. Project features include dams and reservoirs, navigation channels and locks, hydroelectric powerplants, high-voltage power lines and substations, fish ladders and bypass facilities, irrigation diversions and pumps, parks and recreation facilities, boat launches, lands that are dedicated to the projects, and areas set aside for wildlife habitat. The Corps operates 12 of the 14 projects. The remaining two projects, Grand Coulee and Hungry Horse, are operated by the U.S. Bureau of Reclamation (BOR). The Corps and BOR develop multiple purpose operating requirements for their projects and, within these limits, Bonneville Power Administration (BPA) schedules and distributes the power.

Other major dams on the mainstem Columbia or Snake rivers have been built by non-Federal operators. For example, after Rock Island Dam was built, four more dams were constructed on the middle Columbia River in Washington during the 1950s and 1960s by three different public utility districts (PUDs). These projects are operated under licenses from the Federal Energy Regulatory Commission (FERC). Two of the projects (Wampum and Priest Rapids) are operated by Grant County PUD, two (Rock Island and Rocky Reach) by Chelan County PUD, and one (Wells) by Douglas County PUD.

Three major non-Federal projects are operated on the middle Snake River upstream from the four Corps dams on the lower Snake River. Idaho Power Company operates these three dams under FERC licenses. Collectively, the three projects are known as the Hells Canyon Complex and include Hells Canyon, Oxbow, and Brownlee Dams. In addition to the non-Federal dams, a number of dams in the Canadian portion of the Columbia River play a key role in the overall system operation and coordination. The

Columbia River Treaty between the United States and Canada provides for coordination of both power production and flood control from these projects.

4.1.2 Human Environment

The Snake River Basin has a rich and diverse landscape with areas of scenic beauty characterized by mountain ranges, plateaus, and large river valleys. The forests and mountains in the Pacific Northwest, in general, have abundant and diverse aquatic, terrestial, and wildlife resources, and many outstanding natural and scenic features. Water-related settings range from wilderness mountain lakes and streams to urban waterfront parks. Land use in the Snake River Basin is strongly influenced by a variety of Federal, state and private land ownership, water availability, and land productivity. Land use in the basin includes tremendous amounts of agricultural land in cropland. Large areas of publicly-owned land provide a significant proportion of the region's natural, recreational, and scenic resources.

Population growth in the region continues to be primarily in urban areas, such as the Tri-Cities and Spokane, Washington; and Boise, Nampa, and Caldwell, Idaho. The remaining areas are sparsely populated because large tracts of land are devoted to agriculture, forestry, and livestock grazing. The basin population is culturally diverse. Native Americans are a widespread cultural group with direct ties to the Snake River System spanning many generations. Persons of Hispanic origin comprise a rapidly growing portion of the population in areas surrounding the lower Snake River. There are also a variety of active community or industry based groups in the basin area, including groups representing river transporters, irrigators, the aluminum industry, commercial fisheries, sports fisheries, farming communities, and environmental interests.

The regional economy has experienced some transition over the past decade or so, evolving from being primarily resource-based to a more diverse economy, with growing trade and service sectors. The Snake River continues to provide a variety of resource uses, including transportation, electric power generation, recreation, and irrigation. The lower Snake River transportation system consists of navigation channels and locks, port facilities, and shipping operations. This system provides a key transportation link to the eastern interior region of the lower Columbia River Basin. Grain harvested in eastern Washington, throughout Idaho, and as far away as North Dakota is transported on the lower Snake River by barge. The majority of these shipments are shipped to ports on the deep-draft portion of the lower Columbia River for export. Power generated by the four lower Snake River dams serves residential, commercial, agricultural, and industrial loads. Recreational opportunities at developed sites along the lower Snake River reservoirs include camping and picnicking, swimming, boating, fishing, and windsurfing. Approximately 37,000 acres of cropland are irrigated from Ice Harbor Reservoir. Municipalities draw water from the lower Snake River reservoirs for their water supplies. Water is also withdrawn to irrigate vegetation for wildlife and is used for some commercial uses or as a source of outfall for municipal and industrial effluents.

The harvest of Columbia River and Snake River anadromous fish has been a important human activity throughout history. Native American, non-native

commercial, and sport anadromous fisheries have all experienced large declines in harvest levels from before the turn of the century. Incomes generated by salmon harvest have varied accordingly, but continue to be strong elements of some local economies in Oregon and Washington, and for the treaty tribes.

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4.2 Geology and Soils

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4.2.1 Introduction

This section presents background information on the regional geology of the lower Snake River and, in more detail, on the shoreline geology of the reservoirs affected by the alternatives. Areas with specific geologic hazards (e.g., landslides along reservoir shorelines) or surficial deposits (loess) susceptible to impact by the alternatives are also described. Emphasis is placed upon the existing and historical conditions of the geologic materials.

4.2.2 Regional Geology

The Columbia Plateau is drained by two principal rivers, the Snake River in the south, and the Columbia River in the north and west portions of the plateau. The source of the Columbia River is in the Columbia Mountains in British Columbia. The source of the Snake River is in Yellowstone National Park in northwestern Wyoming. From Wyoming, it flows across the southern part of Idaho to the Oregon-Idaho border. Here it turns north, flowing through Hells Canyon, a mile-deep canyon cut through the Seven Devils Mountain Range. At Lewiston, Idaho, the Snake River is joined by the Clearwater River, and it abruptly turns west along the base of a fault scarp entering the Columbia Plateau. After following the scarp for 10 miles, it swings northwestward on the first segment of a large radius arc. The river has entrenched itself in the plateau surface to a depth of 2,000 feet. The larger tributary streams entering the Snake River between Lewiston, Idaho and its mouth are the Palouse River and Tucannon River. Both of these tributary rivers enter the Snake River behind Lower Monumental Dam.

The predominant rock type of the Columbia Plateau is a thick sequence of Miocene flood basalts collectively named the Columbia River Basalt Group (CRBG). The Miocene epoch is a division of geologic time that represents the earth history between 5 and 24 million years before present (BP). However, the Snake River drainage contains rocks of many different geologic time periods, from PreCambrian (over 570 million years BP) to Recent. Rock types range from limestones and shales to metamorphic rocks. The basalt

lava flows of the CRBG were extruded through a series of north-trending fissures now preserved as dikes, principally in the southeast corner of Washington and the northeast corner of Oregon. The deposits spread out across the plateau as a series of basalt flows ranging in thickness from a few feet to more than 300 feet. Between the series of basalt flows, clastic and volcanic sediments were deposited along the plateau margins and in subbasins. Much like today, the original surface on which the basalt flowed was highly irregular as the area was surrounded by the Rocky Mountains, Blue Mountains, and Cascade Mountains. The basalt flows settled in lower regions abutting the flanks of the highlands to the east and north. The basalt flows arch upward to the crest of the Blue Mountains in the south. The cumulative thickness of the lava flows in the Pasco Basin is greater than 10,000 feet (Hooper and Swanson, 1987).

The CRBG is overlain by Pliocene (2 to 5 million years BP) and Pleistocene (10,000 years BP) sedimentary deposits. These deposits range from coarse to fine, dirty gravels derived from weathering of the Blue Mountains, to fine silty lake bed sediments which were deposited in local basins formed during the Pliocene.

One of the major geologic events that had a significant influence on the shaping of the current landscape in the lower Snake River area of the Columbia Plateau was the periodic breaching of the ancient glacial Lake Missoula during the Pleistocene. This ancient glacial lake was formed near the terminus of the continental ice sheets in northern Idaho and western Montana. During these catastrophic events, floodwaters cascaded across the Columbia Plateau surface, stripping soil and gouging large linear grooves into the bedrock, forming coulees, and depositing large, bouldery gravel bars along major stream drainages and in basins.

The catastrophic floods eroded the river valleys and produced large deposits of river sediments (Baker et al., 1987). These river deposits are found today on scattered terraces along river valleys. The flood erosion also produced steep slopes that have undergone some retreat, producing steep, coarse-grained talus slopes along the bedrock cliffs. Post glacial river incision has reworked some of the older river deposits, producing lower elevation and younger alluvial terraces that are distributed along the rivers. Since impoundment of the lower Snake and Columbia rivers, some smaller tributary streams and rivers have deposited alluvial fans where they enter the reservoirs; others are completely drowned, forming small embayments. All of the Pleistocene and contemporary river and alluvial deposits consist of gravels and sands with minor amounts of silts and clays.

During the Pleistocene and into the post-glacial period, winds eroded exposed fine grained sediments. These silt-sized sediments, known as loess, have been deposited over large areas. These deposits are most common on the upland surfaces of the Columbia Basalt Plain in a region known as the Palouse (Busacca et al., 1985). These materials occur only to a minor extent around the perimeter of the lower Snake River reservoirs. Near Ice Harbor Dam, there is a large wind-derived sand deposit (Miklancic, 1989) and small areas of other sand deposits exist along some reservoirs.

4.2.3 Regional Soils

The soils along the lower Snake River can be primarily divided into three types: upland soils along the hillslopes and canyons, alluvial soils along the river, and bench soils

along the ridgetops and terraces above the river. The upland soils are primarily shallow to very deep silty loam soils formed from loess deposits and residuum from basalt. These soils tend to have a high-to-severe erosion hazard due to rapid runoff along the steep slopes of the canyon. The bench-type soils tend to be sandy loam developed from glacial outwash, loess, volcanic ash, and basalt. These bench-type soils have slow runoff characteristics and slight erosion hazards because they tend to be on less steep slopes. Alluvial soils are found in the valley bottom and are excessively drained and range from cobbley coarse sand underlain by stratified cobbles, boulders, gravels, and sand. These alluvial soils were more subject to periodic flooding prior to river impoundment.

Many of the Snake River Plateau soils are light and highly erodible with low rainfall limiting the ability of vegetative cover to reestablish, once removed. Wind erosion is prevalent, especially during the spring and fall, when high winds and dry soil conditions create dust storms. The severity of these dust storms is exacerbated by dryland agricultural practices that expose the soil during spring cultivation and fall harvesting.

4.2.4 Erosion and Sedimentation

The lower Snake River downstream of Lewiston, Idaho annually transports approximately 3 to 4 million cubic yards of new sediments which have been eroded from its drainage basin. Approximately 100 to 150 million cubic yards of sediment have been deposited upstream of the four lower Snake River dams since Ice Harbor became operational in the early 1960s (Corps, 1998a).

Since the construction of dams and the creation of slackwater reservoirs, there has been little sediment transport downstream of Lower Granite Dam. Sedimentation within the lower Snake River reservoirs is dominated by small streams and rivers which drain into the reservoirs, and by wave-eroded materials. The heavier sediments, gravels, and sands can no longer be transported beyond the length of each reservoir. Lighter sediments, silts, and clays move through the spillways, fishways, and powerhouses. River erosion is concentrated within a narrow band between high and low pool levels along the upper reservoir shorelines.

Landslides of various types occur along the reservoir shorelines. These landslides are generally within the surface layer sediments, especially those that are somewhat poorly drained because of an admixture of finer grained sediment.

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4.3 Air Quality

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The air quality of the lower Snake River Basin generally meets standards established under the Clean Air Act (CAA). Sources of air pollution in the region include area sources such as agricultural fields that are susceptible to wind erosion, and point sources such as industrial emission stacks. This section discusses air quality regulations, sources of air pollution in the lower Snake River Basin, and climatic factors that may affect air quality. The information provided is taken from Technical Appendix P, Air Quality, and the Lower Snake River Biological Drawdown Test EIS (Corps and NMFS, 1994).

4.3.1 Air Quality Regulations

4.3.1.1 Regulated Air Pollutants

The CAA requires the U.S. Environmental Protection Agency (EPA) to set ambient air quality standards (AAQSs) to protect the public health and welfare. Standards to protect public health (primary standards) must provide for the most sensitive individuals and allow a margin of safety, without regard to the cost of achieving the standards. When a health standard does not protect public property or resources (public welfare), a secondary standard may be established which is more restrictive than the primary standard, but which takes into account other factors including cost and technical feasibility to achieve the standard. Air quality standards have been established for carbon monoxide (CO), lead (Pb), particulate matter with aerodynamic diameters less than 10 micrometers (PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Geographic areas with measured pollutant concentrations greater than the AAQSs are referred to as nonattainment areas.

The EPA has delegated several air quality regulatory responsibilities to state and local agencies. The state and local responsibilities include enforcing national and state AAQSs, ensuring human health protection from toxic air pollutants (TAPs), and mitigating nuisances caused by windblown dust. In Washington, the State Department of

Ecology (Ecology) enforces AAQSs and regulates emissions of TAPs. Ecology also regulates emissions from large combustion sources such as power plants, and reviews new sources of air emissions. Local air pollution authorities regulate fugitive emissions, which are emissions from sources other than industrial vents and stacks (e.g., windblown dust). Local air control programs also regulate particulate matter by placing restrictions on woodsmoke, open burning, industrial operations, and other activities.

4.3.1.2 Greenhouse Gases

Emissions of greenhouse gases (GHGs) are addressed by the U.S. Climate Change Action Plan (CCAP), introduced in 1993, which seeks to reduce GHG emissions in the United States to their 1990 levels by 2000. Under the CCAP, individual states play a critical role in reducing GHG emissions. Washington State's CCAP, created in partnership with the EPA, sets the goal to stabilize GHG emissions through an 18 million ton reduction from "business as usual" by 2010. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFC), partially halogenated fluorocarbons (HCFC), and O_3. Increased concentrations of GHGs enhance the atmosphere's ability to retain heat.

4.3.2 Sources of Air Pollution

The air quality in the lower Snake River region generally continues to meet the AAQSs. Components of the air quality environment include emission sources, ambient air pollutant concentrations (as measured by a sampling network), and climatic effects that govern the generation of fugitive dust and the behavior of emitted industrial emissions.

Potential sources of particulates within the region include area sources (e.g., dirt or gravel roads and plowed fields) and industrial point sources (e.g., manufacturing plants). The area sources are subject to wind erosion that results in blowing dust. Throughout the arid and semi-arid portions of eastern Washington, wind erosion is the primary cause of dust emissions. Windblown emissions are often associated with dryland farming, but are also produced by irrigated agriculture and nonagricultural sources such as exposed reservoir shorelines.

According to the BOR (1989), area sources are far more important than point sources in eastern Washington because of the prevalence of wind erosion. Wind erosion is greatest during the spring and fall when high winds and dry soil conditions create dust storms of varying severity. Highway and road closures are sometimes necessary because of reduced visibility. The severity of dust storms can be exacerbated by dryland agricultural practices, which expose the soil during spring cultivation and fall harvesting.

Annual total suspended particulate readings at Pasco, Washington (based on a 12-month moving geometric mean concentration) ranged from 45 to 65 micrograms per cubic meter ($\mu g/m^3$) during the mid-1980s and in some years exceeded the Washington State annual standard of 60 $\mu g/m^3$. Over the same period, there were 2 to 4 days per year when particulate concentrations exceeded the 150 $\mu g/m^3$ standard for a 24-hour period (BOR, 1989).

While the above conditions and measurements apply specifically to eastern Washington and the Pasco area, they are likely to be representative of all the lower Snake River

reservoirs. Extensive agricultural areas around or near the lower Snake River reservoirs could contribute to fugitive emissions.

The primary source of gaseous criteria air pollutants, TAPs, and GHGs in the lower Snake River Basin is industrial emissions. Typical manufacturing plant emissions include soot and fine wood particles. Major stationary emission sources—emission rates greater than 100 tons per year (TPY)—within 31 miles of the four lower Snake River dams are located in Benton, Franklin, Walla Walla, and Whitman counties. Table 4.3-1 lists emissions data for local major sources in these counties, for the most recent reporting year available (EPA, 2000b).

Table 4.3-1. Major Air Emission Sources within the Lower Snake River Region

	Source		Emissions (TPY)			
County/State	**City**	**Facility**	**NO_2**	**PM_{10}**	**SO_2**	**VOC**
Benton/WA	Plymouth	Northwest Pipeline	532			
	Benton City	A & B Asphalt		177		
	Kennewick	Harvest States Corp.	2,246	126		
		Unocal Agricultural Products				
	Richland	Acme Materials Construction		104		
		U.S. Energy Department	283		457	
Franklin/WA	Pasco	Tidewater Terminal				1,427
		Chevron Northeast Terminal				215
Walla Walla/WA	Starbuck	Pacific Gas Transmission	330			
	Wallula	Pacific Gas Transmission	326			
		Boise Cascade Wallula	1,080	348	1,995	913
	Walla Walla	Crown Cork & Seal				297
Whitman/WA	Pullman	Washington State University	240		191	
Nez Perce/ID	Lewiston	Potlatch Corp.	133			

Sources: EPA, 2000b.
Notes: TPY=tons per year. Metric tons per year = TPY*0.907.

Air quality is a particular concern around thermal power plants, which commonly emit CO, CO_2, NO_x, particulate matter (PM), and SO_2 as combustion by-products. All recent additions to Northwest thermal plant capacity have been natural gas-fired combined cycle combustion turbines. These plants use the least-polluting carbon fuel in highly efficient engines, in which chemical emissions can be effectively controlled.

4.3.3 Ambient Air Pollutant Concentrations

The air quality in Benton, Franklin, and Whitman counties (Table 4.3-1) achieve all state and national AAQSs, based on information from the nearest air pollution monitoring stations. The monitoring stations are located close to major air emissions sources. Therefore, the monitoring data are not representative of air quality at the project locations. There are few industrial sources in the areas of the four dams. Therefore, PM_{10} is the only pollutant of concern for the region.

A small area encompassing Wallula, Washington is a PM_{10} nonattainment area (Table 4.3-1). Wallula is about 11 miles south of Ice Harbor Dam. The air quality problem associated with the Wallula nonattainment area appears to be related to industrial emissions and fugitive dust.

4.3.4 Climatic Factors

Air quality is influenced by climatic factors including precipitation, temperature, and wind conditions. In the case of windblown dust, the greatest potential for occurrence coincides with periods of low relative humidity, extended sunshine, and warm to hot temperatures. Dry, loose soils and sediments become airborne during high wind events. Surface particles are much less mobile if the ground is wet or frozen. In the case of industrial emission point sources such as thermal powerplants, maximum air pollutant concentrations are a consequence of low wind speeds and very stable atmospheric conditions. The final height of a plume emitted from a stack is a function of the effects of momentum and buoyancy. Greater plume rise is usually achieved with colder ambient temperatures.

Climatic conditions in the lower Snake River area are characterized by large seasonal temperature differences, low precipitation, and relatively minimal cloud cover. Valley bottoms along the Snake River record some of the highest summer temperatures in the region, and they tend to stay slightly warmer than surrounding upland areas in the winter.

Precipitation is typically concentrated in the late fall, winter, and early spring, with more arid conditions prevailing from late spring through the summer. The reservoirs on the middle and lower Snake River generally experience measurable precipitation on 90 to 120 days per year (Jackson and Kimerling, 1993).

The prevailing wind direction in southeastern Washington is from the southwest in both winter and summer. Average wind speeds throughout the basin are generally in the range of 7 to 8 miles per hour. Some locations have considerably higher wind speeds (Jackson and Kimerling, 1993).

Infrequent July and August thunderstorms, which usually drop only small amounts of rain, are sometimes accompanied by strong wind gusts. Winter weather conditions often produce strong winds in the region. Local winds in the reservoir areas are often channeled parallel to the shoreline by the river valleys. Local topography can also act as a funnel that increases wind speeds. A daily cycle of changing up-valley and down-valley local wind directions can be common, particularly in mountain areas.

Average wind speeds and peak gust speeds recorded at selected meteorological monitoring stations in the basin are relatively high. These characteristics represent significant potential for windblown dust if soil or sediments are exposed. Much of the interior plateau area near the Columbia and Snake rivers is dominated by fine-grained loessal soils that are particularly susceptible to wind erosion (Jackson and Kimerling, 1993).

4.4 Water Resources

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4.4.1 Hydrology

4.4.1.1 Climate

The climate of the lower Snake River study area is greatly influenced by prevailing westerly winds and the Cascade and Rocky Mountain ranges. Most of the air masses and weather systems crossing the area are influenced by these winds. Dry continental air masses occasionally enter the region from the north or east. This air from the continent results in low humidity and high temperatures during the summer, while in the winter the weather is clear, cold, and dry. Climate data for Lewiston, Idaho and Ice Harbor Dam are presented in Table 4.4-1.

Precipitation generally increases in an easterly direction across the lower Snake River canyon. Average annual precipitation ranges from approximately 11 inches in the lower elevations near the western edge of the study area to 23 inches in the higher elevations near the Idaho border. Average annual snowfall ranges from 25 inches in western Whitman County to 35 inches in the eastern part of the canyon. A chinook wind or rain on a snow cover sometimes results in rapid melting, heavy runoff, and flooding along the larger streams (Donaldson, 1980). Precipitation is light during the summer and average summer high temperatures range from 80 to 90°F.

Table 4.4-1. Climate Data for the Lower Snake River Study Area

	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Average (inches)	Average Snowfall (inches)	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Average (inches)	Average Snowfall (inches)
January	39.1	26.4	1.24	5.8	41.1	27.1	1.21	3.0
February	46.2	30.7	0.91	2.6	48.5	30.4	0.98	1.1
March	53.6	34.3	1.06	1.4	57.4	34.6	0.99	0.1
April	62.1	39.6	1.20	0.1	65.4	40.7	0.76	0
May	70.8	46.4	1.49	0	73.5	47.5	0.94	0
June	78.7	53.1	1.40	0	81.5	54.1	0.72	0
July	88.8	58.7	0.64	0	89.2	59.6	0.24	0
August	87.9	58.1	0.71	0	88.4	59.1	0.46	0
September	77.7	50.2	0.78	0	79.7	50.7	0.48	0
October	62.9	40.8	1.00	0.1	66.5	41.0	0.81	0
November	47.9	33.5	1.20	1.7	51.3	34.4	1.43	0.2
December	40.5	28.5	1.15	4.1	41.7	28.5	1.38	1.9
Annual Average	**63.0**	**41.7**	**12.78**	**15.8**	**65.3**	**42.3**	**10.40**	**6.4**

Source: Western Regional Climate Center (www.wrcc.dri.edu)

4.4.1.2 Description and Hydrology of Drainage Area

The Snake River is the principal tributary of the Columbia River and winds its way 1,078 miles to the confluence with the Columbia River near Pasco, Washington. The major tributaries to the lower Snake River are the Clearwater, Palouse, and Tucannon Rivers. The Clearwater River, the largest tributary to the lower Snake River segment, historically contributes about 39 percent of the combined flow in the lower Snake River reach (Corps, 1995b). Flows from the Clearwater, along with recent releases from Dworshak Dam, make up close to 50 percent of the lower Snake River flows during periods of low flow. The Palouse and Tucannon Rivers drain into Lake Sacajawea behind Lower Monumental Dam and generally make up less than 1.5 percent of the Snake River flow.

The Snake River drainage basin covers an area of more than 109,000 square miles (Table 4.4-2). Approximately 9.6 million acre-feet (MAF) of water from numerous artificial reservoirs and partially controlled lakes in the Snake River Basin have a substantial effect on the flow characteristics of the lower Snake River. Dworshak Reservoir on the Clearwater River in Idaho has the greatest usable storage capacity with approximately 2 MAF. The mean annual flow at Ice Harbor is more than 51,000 cubic feet per second (51 kcfs), corresponding to a volume of about 37 MAF. Minimum and maximum flows vary considerably as indicated in the summary hydrograph at Ice Harbor for the 1995 years through 1997 (Figure 4.4-1). Average mean daily flows are at minimum from the mid-summer (mid-July) to the early fall (mid-October). Average mean daily flows are at maximum from mid-May to mid-June due to the spring snow runoff. A description of low, average, and high flow years (1994, 1995, 1997 respectively) are described in Appendix F, Hydrology/Hydraulics and Sedimentation.

Table 4.4-2. Snake River Drainage Characteristics

Drainage Area Location	Period of Record	Mean Annual Runoff Drainage Area (sq. mi.)	Mean Flow (cfs)	MAF
Snake River at Brownlee Dam	1928-1989[1/]	72,590	19,210	14
Salmon River at Whitebird	1919-1989[2/]	13,550	11,250	8
Clearwater River at Spalding	1925-1989[2/]	9,570	15,320	11
Snake River at Lower Granite Dam	1928-1989[1/]	103,500	50,730	37
Snake River at Ice Harbor Dam	1928-1989[1/]	108,500	51,050	37

1/ BPA, Seasonal Volumes and Statistics, Columbia River Basin
2/ U.S. Geological Survey, Water Resources Data, Idaho

4.4.1.3 Historical Flows Prior to Impoundment

Prior to the impoundment of the lower Snake River and much of the Snake River drainage (before 1900), water levels were uncontrolled and fluctuated naturally as the river's discharge varied throughout the year. The difference in vertical distance measured at gauging stations near Clarkston and Riparia reflect the natural water level fluctuations of the river. Natural water level fluctuations varied between 20 feet and 30 feet above summer base flows.

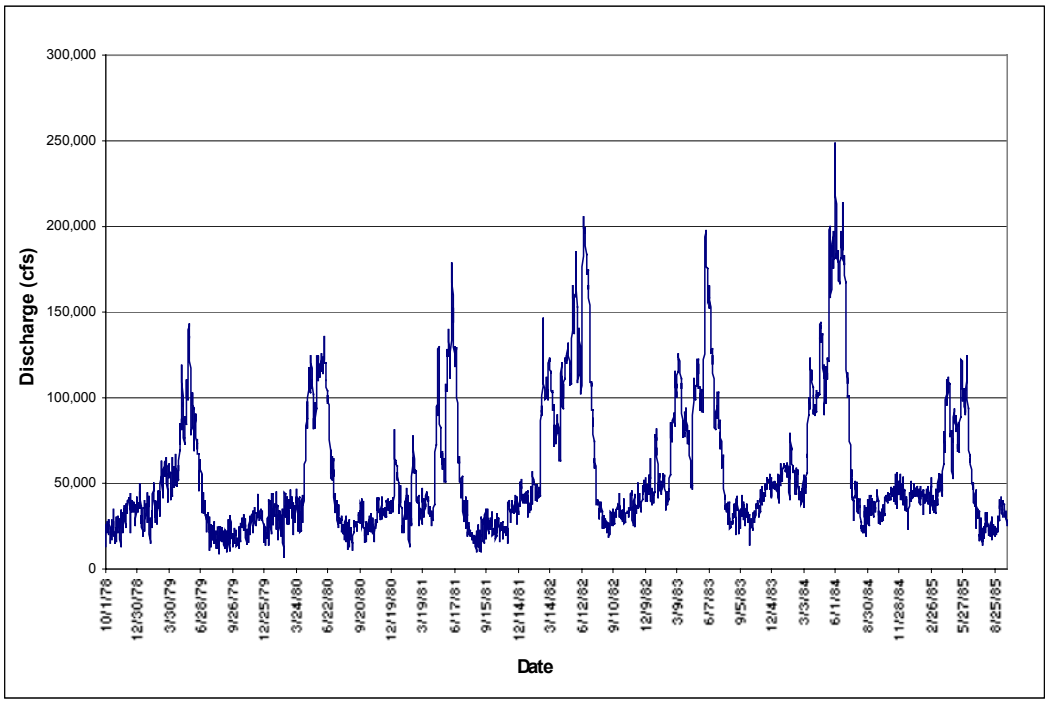


Figure 4.4-1. Average Daily Flows for Ice Harbor Dam, 10/1/78 to 10/1/85

4.4.2 Water Quality

The lower Snake River watershed encompasses a 109,000-square-mile area shared by Wyoming, Oregon, Idaho, and Washington. The major tributaries to the Snake River include the Salmon, Clearwater, Boise, Owyhee, Grande Ronde, Palouse, and Tucannon. Each state has its own water quality standards, and management and monitoring programs. The waterways in each state are also regulated by several Federal, state, tribal, and local agencies, each having responsibilities for water rights, allocation, flows, and operation of the system.

The following sections describe the water quality parameters of concern in the reach from the mouth of the Snake River to the Washington-Idaho-Oregon border (River Mile [RM] 176.1). Table 4.4-3 provides the water quality standards for each parameter of concern in this reach of the Snake River. In addition, the table indicates which of these parameters are listed as water quality limited under Section 303(d) of the Clean Water Act. The 303(d) list identifies parameters that exceed the water quality standards. This list is prepared every four years by each state to identify its polluted waters. These parameters include: stream water temperature; sediment-related water parameters such as suspended sediment and turbidity; total dissolved gas (TDG), dissolved oxygen (DO), pH; and nutrients such as nitrates and phosphates.

A detailed description of water quality monitoring and data are provided for each parameter of concern. A map of the water quality monitoring stations is displayed in Figure 4.4-2.

4.4.2.1 Activities in the Lower Snake River Affecting Water Quality

Dams and Hydropower

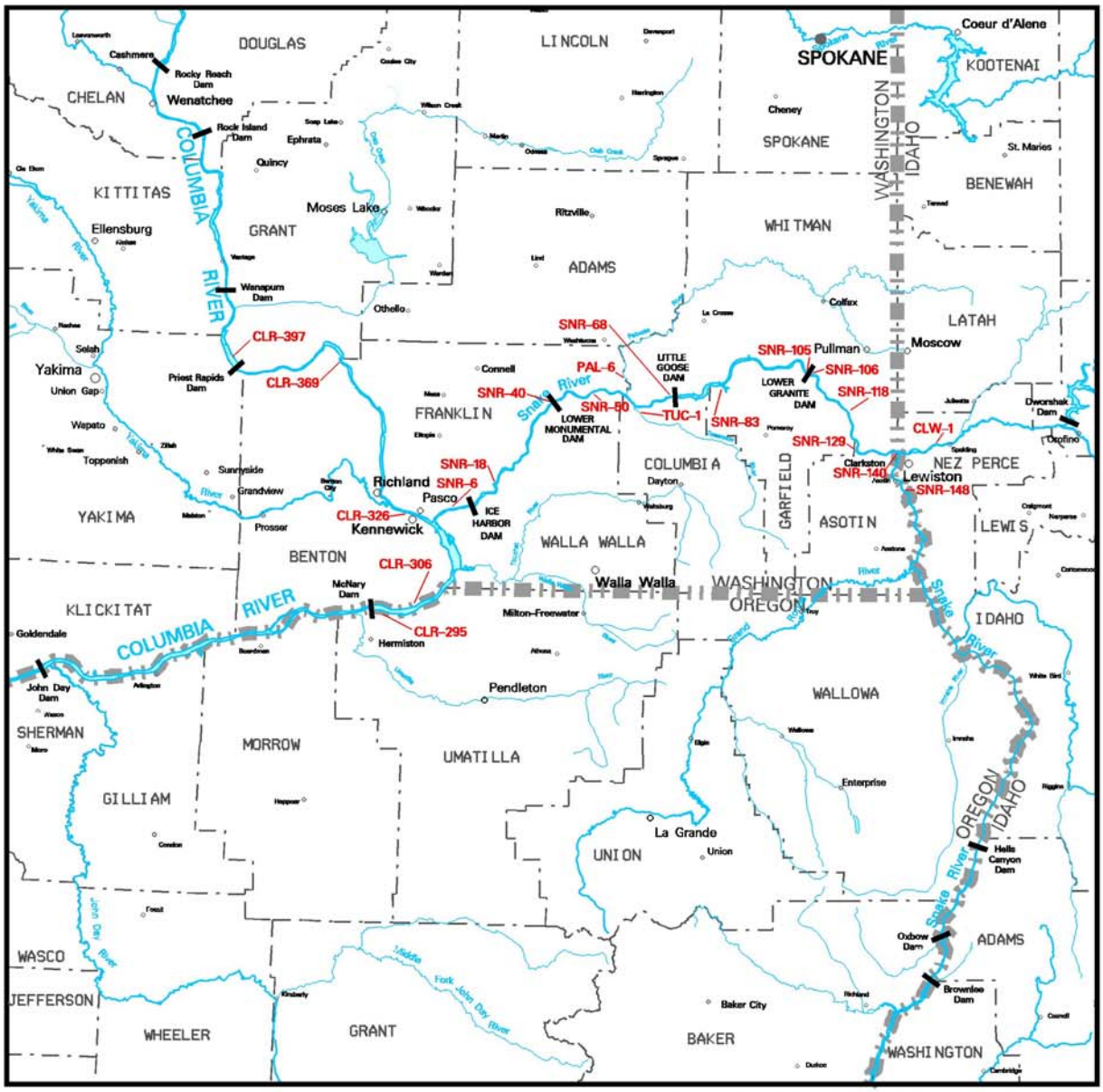
Two of the project uses of dams constructed on the lower Snake River are navigation and hydropower. The dams impound water and reduce river velocity. As a result, sediment settles on the bottom of the reservoir or remains suspended in the reservoir's water column, affecting turbidity and concentrations of contaminants in the reservoir or downstream. Sediment transport downstream of dams is affected because natural sediment movement is interrupted by the dams.

Dam operations could result in downstream scouring, increased total dissolved gas (TDG) supersaturation, decreased DO in deeper water, increased turbidity, and re-suspension of contaminated fine sediments. Upstream impacts may include decreased water volumes and flows, decreased DO concentrations, increased pollutant concentrations, and altered mixing of outfall discharges.

Water released through spillways can cause gas bubble disease or trauma in fish through production of TDG supersaturation. Gas bubble disease can kill fish and may cause behavioral disorders. Heating (solar and geological) can also increase TDG concentrations in water. Fish tolerance to elevated gas pressure varies with fish species, life history stage, water temperature, hardness, depth, and length of exposure. Details are presented in Section 4.4.2.3.

Reservoirs may also affect water temperature. After a stream is impounded, more surface area contributes to heat transfer through solar radiation, precipitation, evaporation, and wind. A discussion of the physical processes involved in heat transfer is provided in Section 4.4.2.3. At the microclimate level and depending upon local conditions and mesoscale meteorological elements, new lakes may have some influence over weather and climate.

Creation of large deep-storage reservoirs normally causes stratification or layers of water with different physical and chemical properties. The lower Snake River dams are run-of-river dams defined by their rate of water replacement or retention and do not stratify during any season of the year like storage reservoirs. The lower Snake River reservoirs may "grade" (Bennett et al., 1997) in temperature by a few degrees with increasing depth only when a higher volume of cold water released from a deep storage reservoir is augmented into a low inflow during summer and early fall (such as from Dworshak augmentation addressed in Bennett et al., 1997). The higher density of the colder water forms a wedge that is submerged below the warmer layer down to about 20 feet of depth in Lower Granite reservoir for a few miles downriver from the confluence input zone with the Clearwater River.



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.4–2.
WATER QUALITY SAMPLING SITES

Table 4.4-3. Washington Water Quality Standards for Parameters of Concern and 303(d) Listings in the Lower Snake River

Water Quality Parameter	Washington State Standard (Class A, Excellent) WAC 173-201A-030(2)	303(d) List
Total Dissolved Gas	Shall not exceed 110% of saturation at any point of sample collection. [1/]	Yes
Dissolved Oxygen	Shall exceed 8.0 mg/l.	No
PH	Shall be within 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 unit.	No
Temperature	Shall not exceed 68°F due to human activities.[1/]	Yes
Turbidity	Shall not exceed 5 NTUs over background when the background level is 50 NTUs or less, nor increase more than 10% of background when the background level is 50 NTUs or more.	No
Fecal Coliform	Shall both not exceed a geometric mean of 100 colonies/100 ml, and not have more than 10% of all samples obtained for the geometric mean value exceeding 200 colonies/100 ml.	No
DDT (and metabolites)	Acute[2/]: Shall not exceed instantaneous concentration of 1.1 µg/l at any time.	No
	Chronic[3/]: Shall not exceed concentration of 0.001 µg/l as any 24-hour average.	No
Mercury	Acute[2/]: Shall not exceed a 1-hour concentration of 2.1 µg/l at any time.	No
	Chronic[3/]: Shall not exceed a 4-day average concentration of 0.012 µg/l more than once every 3 years on average.	No
Glyphosate	EPA Maximum Contaminant Level goal is 0.7 mg/l (40 CFR Ch. 1 (7-1-99 Edition).	No
Dioxin	EPA Maximum Contaminant Level goal is 0.00000003 mg/l (40 CFR Ch. 1 (7-1-99 Edition).	No
Manganese	Concentrations greater than 150 µg/L impart an undesirable taste and browns laundry (EPA, 1976).	No

1/ WAC 173-201A-130 Specific Classifications – Freshwater Special Condition for Snake River from mouth to Washington-Idaho-Oregon border (RM 176.1). WAC 173-201A-060(4)b-special fish passage exception for sections of the Snake and Columbia Rivers.

2/ "Acute conditions": changes in the physical, chemical, or biologic environment which are expected or demonstrated to result in injury or death to an organism as a result of short-term exposure to the substance or detrimental environmental condition (WAC 173-201A-020, p. 1).

3/ "Chronic conditions": changes in the physical, chemical, or biologic environment which are expected or demonstrated to result in injury or death to an organism as a result of repeated or constant exposure over an extended period of time to a substance or detrimental environmental condition (WAC 173-201A-020, p. 1).

mg/l = milligrams per liter, NTU = Nephelometric Turbidity Unit, ml = milliliter, µg/l = micrograms per liter

Flow releases from reservoirs are regulated by a series of operating rule curves designed to ensure that the dams perform their authorized functions. Actual releases, however, depend on runoff conditions. Generally, more water is stored and released during a high flow year than during a low flow year, resulting in different impacts to water quality in reservoirs and areas downstream from the dams. More flows also mean higher potential for spill. As most of the dams on the Snake and Columbia rivers are stair-step impoundments, the water moving downstream does not circulate sufficiently to rid itself of gas entrainment at the upstream dams. As a result, dissolved gas supersaturation created by spill at one dam will often stay at or above that initial saturation as the water flows downstream.

Agriculture

The lower Snake River provides irrigation water for approximately 37,000 acres of farmlands, primarily from the Ice Harbor Reservoir. Water diverted for irrigation evaporates or transpires, seeps into the ground, or runs off the ends of fields, eventually returning to the river or tributaries as potential point or non-point pollution.

Livestock grazing adjacent to the Snake River can have an adverse impact on water quality of the reservoirs and tributaries to the lower Snake River. Grazing adjacent to streams can destroy riparian habitat and vegetation necessary to shade streams and prevent erosion. Heavily grazed watersheds usually exhibit less holding capacity; this can result in increased runoff velocities. Increased runoff velocities can result in excessive erosion and sedimentation of streams.

Navigation and Transport

Transportation on the lower Snake River has been vital to the economy of the area. Wheat growers and many industries along the river depend on it to transport their products to market. Many large vessels and barges travel up and down the river daily, requiring channels deep enough for them to navigate (see Section 4.9, Transportation).

Dredging to maintain navigation channels affects the hydrology of the river channel and disturbs the channel bottom. It can increase the velocity of the current and the movement of suspended sediments which can scour the bottom and shoreline. Dredging also disturbs sediments that may contain toxic substances that can be harmful to plants and animals. Before dredging, the Corps typically tests for the presence of contaminants.

The possibility of accidental chemical spills from trucks and trains running parallel to the river exists. Barges and other vessels can have accidental spills of chemicals also. Most are small spills of gasoline, diesel, or oil but the potential for larger spills exists. Because of the size and velocity of the river, containment is very difficult. Depending on the type of material spilled and the location, sections of the river could be adversely affected for many years.

Timber and Wood Product Industry

A large wood product facility is located on the Clearwater River, upstream of the confluence with the Snake River. Releases from this facility are permitted and regulated by various resource agencies.

4.4.2.2 Water Quality Parameters and Standards

The EPA and Idaho, Washington, and Oregon have established surface water criteria or water quality standards for the Snake River. This discussion focuses on the state standards because they are the same or more stringent than the Federal criteria. Because the codes, rules, and regulations for these state standards are voluminous, only selected highlights of the standards are presented in this document. Washington, Idaho, and Oregon have established a policy of anti-degradation and beneficial uses for their surface waters, which precludes the discharge or introduction of any toxic or hazardous materials that result in significant deleterious effects. Idaho's beneficial uses are domestic and agricultural water supply, cold water and warm water biota, salmonid spawning, primary and secondary contact recreation, and special resource water. All except warm water biota have been designated as beneficial for the Snake River downstream of Brownlee Reservoir and the north fork of the Clearwater River, and at Dworshak Reservoir.

Washington has a four-level water quality classification system that ranges from AA (extraordinary) to C (fair). The State of Washington has classified the lower Snake River as Class A (excellent). Beneficial uses are water supply (domestic, agricultural, and industrial); stock watering; fish and shellfish rearing, spawning, and harvesting; wildlife habitat; recreation (primary contact); and commerce and navigation. Oregon water quality standards would only apply to possible downstream impacts in the Columbia River such as McNary pool, a portion of which is in Oregon.

The water quality parameters that will be discussed in this section are significant for aquatic ecology and its relationship with the beneficial uses of water resources. These parameters include DO, temperature, suspended sediments, turbidity, pH, and nutrients such as nitrogen and phosphorous. The Washington water quality standards and 303(d) listings are displayed in Table 4.4-3. The following sections provide general information and water quality standards for each of the parameters.

Total Dissolved Gases

Total dissolved gas supersaturation can be found in natural river conditions; however, it is currently being caused when water passes through a dam's spillway and carries trapped air deep into the waters of the plunge pool or "stilling basin" where increased hydrostatic pressure dissolves the air into the water. At depth, this dissolved gas is supersaturated compared to the conditions at the water's surface. If the supersaturated water is brought to the surface, the dissolved gas will either come out of solution and equilibrate with atmospheric conditions, or it will form bubbles. Dissolved gas supersaturation can lead to a physiological condition in aquatic biota known as gas bubble trauma (GBT) or gas bubble disease (GBD).

In general, the major signs of GBT that can cause death or high levels of physiological stress in fish include:

- Bubble formation in the cardiovascular system, causing blockage of blood flow, respiratory gas exchange, and death (Stroud et al., 1975; Weitkamp and Katz, 1980; Fidler, 1988 and 1998a).

- Over-inflation and possible rupture of the swim bladder in some species of juvenile (or small) fish, leading to death or problems of over buoyancy (Shirahata, 1966; Jensen, 1980; Fidler, 1988; Shrimpton et al., 1990a and b).
- Extracorporeal bubble formation in gill lamella of large fish or in the buccal cavity of small fish, leading to blockage of respiratory water flow and death by asphyxiation (Fidler, 1988; Jensen, 1988).
- Sub-dermal emphysema on body surfaces, including the lining of the mouth. Emphysema of the epithelial tissue of the mouth may also contribute to the blockage of respiratory water flow and death by asphyxiation (Fidler, 1988; White et al., 1991).

Other signs of GBT in fish include exophthalmia and ocular lesions (Blahm et al., 1975; Bouck, 1980; Speare, 1990); bubbles in the intestinal tract (Cornacchia and Colt, 1984); loss of swimming ability (Schiewe, 1974); altered blood chemistry (Newcomb, 1976); and reduced growth (Jensen, 1988; Krise et al., 1990), all of which may compromise the survival of fish exposed to dissolved gas supersaturation over extended periods. The GBT may also increase the susceptibility of aquatic organisms to other stressful factors such as bacterial, viral, and fungal infections (Meekin and Turner, 1974; Nebeker et al., 1976; Weitkamp and Katz, 1980; White et al., 1991). All signs of GBT weaken fish, especially juvenile life stages, thereby increasing their susceptibility to predation (White et al., 1991). Consequently, GBT mortality can result from a variety of both direct and indirect effects caused by dissolved gas supersaturation.

Dissolved gas supersaturation can affect all aquatic organisms, including fish, invertebrates, and plants. This may lead to alterations in the food chain structure of an aquatic ecosystem. For example, GBT may increase or decrease the availability of a food source for a particular species (White et al., 1991). This may result in the redistributed populations of species either increasing in abundance through colonization or becoming locally extinct (Brammer, 1991). Changes such as this may affect the whole aquatic ecosystem structure. Additional information on the physiological response and biological consequences of GBT can be found in Appendix C, Water Quality, Section 3.2.4.3.

Because the dams have slowed the velocity, reduced the turbulence, and shortened the free-flowing sections of the river, the river cannot always equilibrate the excess dissolved gas between the dams, and the supersaturation condition can persist for extended distances. This is especially true during periods of high flow and continuous spill.

For Washington, Idaho, and Oregon, a total dissolved gas standard of 110 percent saturation at ambient atmospheric pressure is the maximum concentration for total dissolved gas. However, in Washington, Ecology has currently waived the state standard for the four lower Snake River dams and has set an upper limit of 115 percent saturation in the forebays and 120 percent saturation in the tailwater. If the measured concentrations exceed these values based on a daily average of the 12 highest hourly measurements, then the spill release is curtailed to meet the limits. These dissolved gas criteria do not apply when the stream flow exceeds the 7-day, 10-year frequency flood.

The lower Snake River between the Clearwater River and Columbia River, has been placed on the Washington 303(d) list as water quality impaired for dissolved gas.

Dissolved Oxygen

DO refers to the concentration of oxygen dissolved in water. Adequate DO concentrations are important for supporting fish, invertebrates, and other aquatic life. Salmon and trout are particularly sensitive to reduced DO.

Oxygen is the key element in many chemical processes in water. Through oxidation and reduction reactions, the concentration of oxygen influences the concentration of many dissolved substances in water. These chemical processes include the decomposition of organic matter, the cycling of nutrients, and the transformation and transport of toxic substances within the water column and between the sediments and the water column. The biochemical processes of photosynthesis and respiration by living organisms provide a means by which the aquatic community can regulate the amount of oxygen in the aquatic environment, within limits. Most organisms cannot survive with too little oxygen while the solubility of oxygen generally limits the maximum amount that can be dissolved in water under most conditions.

The capacity of water to hold oxygen in solution is inversely proportional to temperature. For example, higher stream temperatures result in lower DO concentrations. Supersaturation of water with oxygen does occur during periods of intense photosynthetic activity and as a result of dissolution of oxygen under high hydrostatic pressure in the plunge pools of high head dams (Bowie et al., 1985). Both of these special situations occur, at times, in the lower Snake River.

The primary sources of DO to river and reservoir systems include reaeration from the atmosphere at the water surface and production of oxygen as a byproduct of photosynthesis. Reaeration in rivers is generally caused by turbulence at the surface of fast moving water, such as falls or rapids. Reaeration in reservoir reaches is typically a result of wind causing waves and turbulence at the surface.

DO concentrations can vary along the length and width of river and reservoir systems, with depth, and with time. Longitudinal variability in DO concentrations can be related to areas of sediment oxygen demand, stands of attached benthic algae or macrophytes, differences in reaeration rates related to channel morphometry, the presence of blooms of phytoplankton or the presence of large numbers of respiring organisms in localized areas. The presence of dams has the ability to change the lateral DO distribution because it has the ability to dramatically alter flow patterns. Spilling water over the top of a dam has the potential to significantly raise the DO concentration downstream, while passing water through turbines may have little influence on the DO concentration downstream.

Generally, DO does not vary vertically in riverine environments because they are typically well mixed. However, in reservoirs, the potential exists for DO depletion at depth. This typically occurs when water is isolated from reaeration at depth through thermal or density stratification. Biological and sediment oxygen demands also remove oxygen from these deep layers of the water column. The potential for oxygen depletion at depth is higher in slow, deep, biologically productive reservoirs.

DO dynamics vary over temporal time scales ranging from seasonal to hourly. Seasonal variability in DO concentrations in a system is typically related to water temperature in northern temperate climates. During the winter, reduced water temperatures and subsequent increased solubility of oxygen result in higher DO concentrations. In the summer, increased water temperatures have the opposite effect, resulting in lower DO concentrations. Increased water temperatures accelerate the decomposition of organic substances resulting in higher oxygen consumption during periods when water is warmer.

Minimum DO standards vary for each state. Idaho has specific criteria below existing dams. From June 15 to October 15, these criteria require at least 6.0 milligrams per liter (mg/l; 30-day mean), 4.7 mg/l (7-day minimum), 3.5 mg/l (instantaneous minimum), and 6 mg/l or 90 percent of saturation (whichever is greater) for salmonid spawning uses. In Washington, the DO for Class A waters must exceed 8.0 mg/l. Oregon specifies at least 90 percent saturation for its portions of the Columbia River.

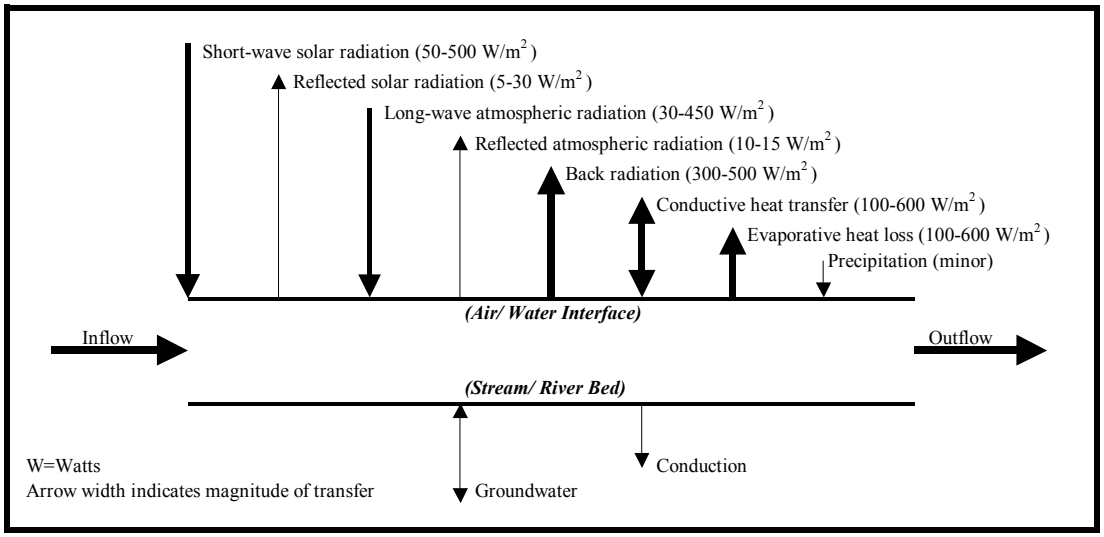
Temperature

Temperature plays an integral role in the biological productivity of streams. Aquatic organisms are highly sensitive to water temperatures. Salmonids and some amphibians appear to be the most sensitive to water temperatures and are used as indicator species regarding water temperature and water quality. Water temperature is one of the more critical parameters affecting fish migration behavior during the April through September adult and juvenile salmonid migration periods. The optimal temperature range during the summer juvenile and adult migration period is generally recognized to be between 10 to 20 °C (45 to 68 °F) (BPA, 1995).

Temperature represents one of the most important characteristics of river water. It affects other physical properties, such as DO, and also influences the chemical and biological reactions that take place in aquatic systems (Calow and Petts, 1992). Transfers of heat energy fundamentally determine the temperature of a river or reservoir. Energy inputs are short-wave solar radiation and long-wave atmospheric radiation, condensation and precipitation, conduction, and through advection of heat from groundwater, upstream, and tributary inflows. Heat energy is lost from the system through reflection of solar and atmospheric radiation, back radiation from the water surface, evaporation, and as the heat content of water leaving a reach. These processes, along with ranges of values for those that occur at the air-water interface, are illustrated in Figure 4.4-3.

Short-wave radiation is that segment of the solar input that is not absorbed by the atmosphere (i.e., it is mainly visible light). A portion of this light, typically less than 10 percent, is reflected but varies with the solar angle (Rinaldi et al., 1979). The remaining short-wave radiation penetrates the water surface and provides the major natural source of heat to most water bodies.

A second source of heat gain and loss is long-wave radiation. Solar radiation absorbed by the clouds and atmosphere is in turn reflected at longer wavelengths. Atmospheric long-wave radiation is often the greatest source of heat at the water surface on cloudy days. About 3 percent of the long-wave radiation is reflected, and the rest is available



Source: Adapted from Martin and McCutcheon, 1999

Figure 4.4-3. Major Sources of Heat Loss and Gain to a River System

for heating. However, this input contributes only to surface warming, and the heat must be transferred into the main body of the river by wind or water induced turbulence.

Energy can also be exchanged between the river and the atmosphere through heat conduction and convection. The convection of air is primarily forced by the wind. Therefore, the flux of sensible heat through the water surface depends not only on the air and water temperature, but also on wind velocity. Evaporation, rainfall and heat exchange with the riverbed are other minor heat transfer processes.

Idaho specifies temperature criteria in relation to specific use categories. The most restrictive use criterion is for salmonid spawning, with maximum water temperatures set at 55°F (12.8°C) with daily averages no greater than 48.2°F (9.0°C) from the mouth of the Clearwater River (RM 0) to the Potlatch River confluence (RM 15). This reach is designated as a "Special Resource Water." Snake River standards from the Clearwater River confluence (RM 139) to Asotin, Washington (RM 147) are also restricted. The maximum instantaneous water temperature is set at 72°F (22°C) with daily averages no greater than 66°F (< 19°C).

In general, Washington water quality standards for Class A streams stipulate that temperature shall not exceed 64.4°F (18°C) due to human activities (Washington Administrative Code [WAC] 173-201A-030(2)). Special conditions have been approved for the Snake River from the mouth to RM 176.1 under Special Classifications WAC 173-201A-130(98), in which temperature shall not exceed 68°F (20°C) due to human activities. In the Snake River above the Clearwater River (RM 139.3), no increase over 0.54°F (0.3°C) caused by human activity can occur from a single source, or no increases over 2°F (1.1°C) from all activities when the stream is over 68°F (20°C). In the lower Snake River below the Clearwater River, when natural conditions exceed 68°F (20°C), no temperature increase will be allowed that will raise water temperature by more than 0.54°F (0.3°C). In addition, no temperature increase in the lower Snake River

should exceed t=34/(T+9)°C where t = change in temperature and T = background temperature. The lower Snake River has been placed on the Washington State 303(d) list as water quality impaired for temperature. Oregon also does not allow water temperature increases in the Columbia River, outside of an assigned mixing zone, when the stream water temperature is at or above 68°F (20°C).

Sediment

Two of the most common water quality parameters measured and monitored for sediment are suspended sediment and turbidity. Both are related to sediment delivery and transport in hydrologic systems. Streams that exceed the water quality objectives for sediment-related water quality objectives would have high suspended-sediment delivery rates and/or turbidity.

Suspended sediment is the portion of the sediment load that moves in suspension within the water column. The grain size of suspended sediment is generally less than one millimeter in diameter while particles greater than one millimeter are generally transported as bedload. However, the motion of individual sediment particles is under the interaction of two opposing forces, the applied force due to the hydrodynamics of the moving water column and the resisting force due to the particles' submerged weight. Thus, during high peak flows (e.g., storm events) particles greater than one millimeter can be transported as suspended sediment due to the increased kinetic energy of the water column (Sullivan et al., 1987).

Turbidity refers to the amount of light scattered or absorbed by a fluid. In streams, turbidity is usually a result of suspended particles of silts and clays, but also organic compounds, plankton, and microorganisms. Turbidity is measured in nephelometric turbidity units (NTUs). Although turbidity in a stream is highly variable and the relationship between turbidity and suspended sediment must be determined at each site, turbidity is regarded as the single most sensitive measure of land use on streams, mainly because relatively small changes in suspended sediment can cause a large change in turbidity.

Idaho and Washington specify that turbidity shall not exceed 5 NTUs over background levels when the background level is 50 NTUs or less, nor increase more than 10 percent when background is more than 50 NTUs. Oregon specifies that no more than a 10 percent increase over background is allowed. The turbidity in the lower Snake River has followed the same trends as the suspended sediment.

pH

As an index of the hydrogen ion concentration, pH is measured on a scale of 0 to 14. A value of 7 indicates a neutral condition; values less than 7 indicate acidic conditions; and values greater than 7 indicate alkaline conditions in water. The presence of carbonates, hydroxides, and bicarbonates decreases the acidity of water, while the presence of free mineral acids and carbonic acids increases its acidity. Acid mine drainage and industrial wastes that have not been neutralized may significantly lower the pH of water. A pH range from 6.5 to 8.3 pH units is acceptable in drinking water. For the protection of the aquatic environment, and for aesthetic and recreational use, the pH should be between

6.5 and 9 pH units. Washington, Idaho, and Oregon all require a pH within the range of 6.5 to 8.5 pH units with a human-caused variation less than 0.5 pH unit.

Nutrients—Nitrogen and Phosphorus

Nitrogen and phosphorus are two elements that are important to plant growth such as primary production and possibly secondary production. The nitrogen to phosphorus ratio or balance in solution in the water determines the primary productivity of water bodies (WA DNR, 1997).

Nitrate is the predominant form in unpolluted water and ammonia may exist as an intermediate breakdown product of organic nitrogen, fertilizers, and animal wastes. Both ammonia and nitrate are readily taken up by aquatic biota, so an increase in nitrate concentrations upstream tends to diminish rapidly downstream. The primary concern with nitrates is that increased biological activity due to increased concentrations of nitrogen can deplete DO, which may adversely affect fish and other aquatic organisms (MacDonald et al., 1991).

Phosphorous can be separated into two fractions, dissolved and particulate. Dissolved phosphorous is found almost exclusively in the form of phosphate ions and these bind readily with other chemicals. The three main classes of phosphate compounds are orthophosphates, condensed phosphates, and organically bound phosphates. In general, only orthophosphates are readily available for biotic uptake. In aquatic systems, phosphorous is usually a limiting nutrient. However, phosphorous increases in aquatic systems may increase primary production. Increased primary production due to nutrient enrichment can impair designated uses of water. Adverse effects can include changes in water chemistry, DO levels, less recreational use, and a decline in aesthetic values.

According to Washington State Water Quality Standards, total phosphorous inputs above 0.02 mg/l and 0.035 mg/l are considered to be critical thresholds in terms of preventing excessive algal growth when ambient trophic conditions are considered to be in the lower and upper mesotrophic categories, respectively. Oligotrophic conditions represent high quality waters with good water clarity and low algal production, and eutrophic conditions represent high nutrient levels, excessive algal growth, and poor water clarity. Mesotrophic conditions are somewhere in the middle and typically represent moderate levels of algal production, water clarity, and light transparency.

Dioxins and Furans

Tetrachlorinated dibenzo dioxins (TCDD) and tetrachlorinated dibenzo furans (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; Eisler, 1986). The most significant sources are pulp mills, municipal waste incinerators, and fires involving polychlorinated biphenyl (PCB)-contaminated oil (Palmer et al., 1988). Other potential sources of deposition includes open burning of household waste in barrels (Lemieux et al., 2000). The EPA (1993) considers dioxin-like compounds to be carcinogens.

The TCDDs and TCDFs have low solubility in water and when discharged to aquatic environments, their primary fate is sorption to the sediments and accumulation in biota

(Johnson et al., 1991). Because of this, concentrations in fish can exceed environmental concentrations by factors as high or greater than 5,000 times (Maybee et al., 1991; EPA, 1984; Opperhuizen and Sijm, 1990). Bioconcentrations are probably greatest for species that live in contact with sediments or are part of the food webs linked to sediments (Cooke, 1987; Kuel et al., 1987). Half-lives of TCDD and TCDF in aquatic sediments exceed 1 year and could be as high as 10 years for some congeners (Callahan et al., 1979; Eisler, 1986; CCREM, 1987).

Washington water quality limits for dioxins are provided in Table 4.4-3. Ecology uses the standard of 0.07 ppt 2,3,7,8-tetrachlorodibenzo-p-dioxin (2378-TCDD) in fish as a violation of state surface water quality standards (Johnson et al., 1991), and the EPA bioconcentration factor for 2378-TCDD is a factor of 5,000 (EPA, 1986).

Other Contaminants

Table 4.4-3 lists the Washington water quality standards for several other contaminants including glyphosate, metals, and dichloro-diphenyl-trichloroethane (DDT). The water quality data available for these contaminants is presented in Section 4.4.2.3.

4.4.2.3 Water Quality Monitoring Programs and Historical Data

Water quality studies and monitoring have been ongoing for many years in the lower Snake River by the Corps, U.S. Geological Survey (USGS), Ecology, and private entities, such as Potlatch. Studies and monitoring are conducted to establish status and trends, and to assess watersheds. A review of recent data and long-term data was performed for the Snake River. The data available for each water quality parameter of concern are summarized in the following sections.

Long Term

The Corps monitors the water quality at four reservoirs. Routine parameters include flow, temperature, conductivity, nutrients, DO, pH, and dissolved gas. Sediment sampling is conducted in selected locations to assess sediment contaminants of concern. The Corps also conducts some biological monitoring in its reservoirs and some groundwater quality monitoring. Eight long-term monitoring stations are located on the Snake River at Burbank, WA; Ice Harbor, WA; Lower Monumental, WA; Little Goose, WA; Lower Granite, WA (RM 107); Lower Granite, WA (RM 120); Anatone, WA; and Weiser, ID and Spaulding, ID on the Clearwater River (Figure 4.4-2). Monitoring dates used in this study range from 1975 to 1998.

The EPA and individual states conducted ambient water quality monitoring to assess compliance status and trends. Ecology sampled up to 10 samples per year in 1997 for the parameters of concern. USGS samples similar water quality parameters about once a year at two long-term monitoring stations on the lower Snake River (Anatone [RM 167] and Burbank [RM 2.2]) and one on the Clearwater River at Spaulding, ID (RM 11). The University of Washington and the University of Idaho (UI) analyzed pre-impoundment water quality at the Lower Granite Dam area from 1970 to 1972. Limited data was collected on various toxics including heavy metals, pesticides, and other organic compounds.

Recent Data

In 1994, the Corps initiated an extensive sampling program throughout the lower Snake River basin with the assistance of research teams from Washington State University (WSU), National Marine Fisheries Service (NMFS), and the University of Idaho (UI). The primary goal of this sampling program was to provide a more complete synopsis of the existing limnological and biological productivity conditions above, below, and throughout the lower Snake River reach and to assess the effects, if any, that the various dams have on water quality. Sampling was conducted both in the impoundments and in the "free-flowing" reaches and major tributaries. Sampling was also conducted in the Columbia River above and below the Snake River confluence. Initially, in 1994 and 1995, data were collected on a monthly or bi-weekly basis within the Lower Snake River System. The sampling frequency was increased in 1997 to bi-weekly monitoring through the growing season in both the lower Snake River and portions of the Columbia River. An extensive suite of parameters was sampled during these investigations, including many of the same conventional parameters used in the long-term monitoring studies such as pH, alkalinity, conductivity, dissolved oxygen, nutrients, total suspended solid (TSS), and turbidity. Various anions and cations were also monitored including chloride, silica, sulfate, calcium, magnesium, sodium, and potassium. In addition, biochemical oxygen demand was also measured at selected locations, as well as various biological parameters including chlorophyll *a*, phytoplankton, zooplankton, attached benthic algae, and other primary productivity indicators. The Corps also conducts extensive sampling throughout the Columbia River Basin to monitor total dissolved gas concentrations. For example, monitoring has been conducted in the tailraces since 1992 and in the forebays since the early 1980s of each of the four dams on the lower Snake River. Reports on dissolved gas concentrations are automatically updated every hour during the critical flow season (April 1 through September 15). A reduced number of stations are monitored during the remainder of the year.

In 1997, sediment samples from the four lower Snake River reservoirs were also analyzed for a number of chemical parameters, designated as the nutrient group (although not all of the parameters are true nutrients). The sediments were analyzed for: ammonia, total Kjeldahl nitrogen (TKN), nitrogen as nitrate/nitrite, total organic nitrogen, total organic matter, pH, phosphorus bicarbonate and sulfate.

A range of hydrological conditions was encountered during the recent sampling program, including a relatively dry year in 1994 [ranging from 11 thousand cubic feet per second (kcfs) to 93 kcfs and ranked near the lowest 10 percent of annual flows]; an average year in 1995 (ranging from approximately 15 kcfs to 149 kcfs); and a wet year in 1997 (ranging from approximately 15 kcfs to 225 kcfs), based on historical streamflow data. The comparison of water quality conditions collected during a range of hydrologic conditions will assist in estimating how future conditions might be different, if at all, under various hydrologic conditions.

Total Dissolved Gases

Water passing through the spillways of the dams entrains air bubbles as it passes under the gates, flows over the spillway, and plunges into the stilling basin. Hydrostatic pressure forces the air bubbles into solution, thus raising TDG concentration in the water. As a convenience, dissolved gas pressures may be expressed as a percentage of

barometric pressure (percentage of saturation). The TDG supersaturation is often mislabeled as "nitrogen supersaturation" because air is composed mostly of nitrogen, and nitrogen was believed to be the only gas that caused problems. While nitrogen does speed the problems of GBT, all of the dissolved gases in air participate in the process.

Variables that may determine dissolved gas concentrations on run-of-river dams include: 1) the total amount of spill; 2) the amount of spill per spillway bay; 3) the presence and effectiveness of spillway deflectors; 4) dissolved gas concentrations in the forebay; 5) water temperature; and; 6) the depth of the stilling basin relative to the tailwater elevation (i.e., the depth of spill plunge). While relationships among all of these variables have been hypothesized (Roesner and Norton, 1971), the significance of several variables is unknown at this point. However, it is known that spill volume and tailwater elevation are very significant factors and, therefore, are important in determining operational strategies.

The operation of a powerhouse allows reductions in the amount of spill and may reduce TDG concentrations by diluting the higher dissolved gases created by spillway operations. However, as spill volumes increase, the dissolved gas concentrations downstream consistently increase. As the river flow passes each of the lower Snake and Columbia river dams, sequential spill will cause the concentration of dissolved gas in the river to be incrementally and cumulatively increased. The problem is exacerbated by the fact that dissolved gas concentrations in water entering Lower Granite Lake are already elevated and typically range from 105 to 110 percent due to releases from the middle Snake River dams and Dworshak Dam (Corps, 1996c).

Several measures have been implemented within the project area to improve the downstream migration and survivability of juvenile salmonids. Among these measures are voluntary spillway releases, installation of flow deflectors, and other spillway modifications (Appendix C, Water Quality). These measures are briefly summarized below.

Voluntary Spillway Release. To improve conditions for downstream salmon migration and their survivability, the Corps has been releasing water from the eight lower Columbia and lower Snake River facilities as requested by NMFS. The Corps maximizes spill up to 120 percent TDG under temporary waivers granted by the Washington Department of Ecology. These special spillway releases have been ongoing since 1994 and typically occur during the migration season from March through August. The volume of released water consists of up to 80 percent of the total river discharge. The specific requirements for the water releases for fish passage are spelled out in the NMFS 1998 Supplemental Biological Opinion (NMFS 1998 Biological Opinion). The start and end dates of this voluntary spill were recommended by the Technical Management Team (TMT) based on seasonal monitoring information. Planning dates for the spring spill are April 3 to June 20 in the lower Snake River. Within the facility area, a planned summer spill between June 21 and August 31 is only required at the Ice Harbor Dam. Spill periods are for 24 hours a day at Ice Harbor, and from 6 pm to 6 am at Lower Monumental, Little Goose, and Lower Granite.

The NMFS 1998 Biological Opinion also recommends spring spill at all three Snake River collector facilities (Lower Monumental, Little Goose, and Lower Granite) outside of the time windows mentioned above, "when seasonal average flows are projected to

meet or exceed 85 kcfs." In addition, the NMFS 1998 Biological Opinion recommends spilling directly up to spill discharge caps that correspond to 120 percent TDG below the spilling facilities. The spill discharge caps set to not exceed 120 percent TDG at the tailwater monitoring stations in 1998 were 45 kcfs at Lower Granite, 60 kcfs at Little Goose (though TDG readings led to a 48 kcfs cap), 40 kcfs at Lower Monumental, and 75 kcfs at Ice Harbor (Corps, 1998b). However, the NMFS 1998 Biological Opinion spill caps for Lower Granite and Little Goose seem to be reversed, as Lower Granite spill cap is 60 kcfs and Little Goose is 45 kcfs. The spill cap at Ice Harbor increased to 100 kcfs in early 1999 resulting from the addition of spillway flow deflectors on end bays. In-season adjustments to the spill caps are made based on actual TDG readings below the facilities.

Spillway Flow Deflectors. The spillway flow deflectors on the lower Snake River facilities are submerged flip-lips jutting out from the spillway faces, which force spilled water to skim over the surface of the tailwaters instead of plunging deep into the stilling basin. By minimizing the plunging of water into the stilling basin, the production of TDG supersaturation is also minimized.

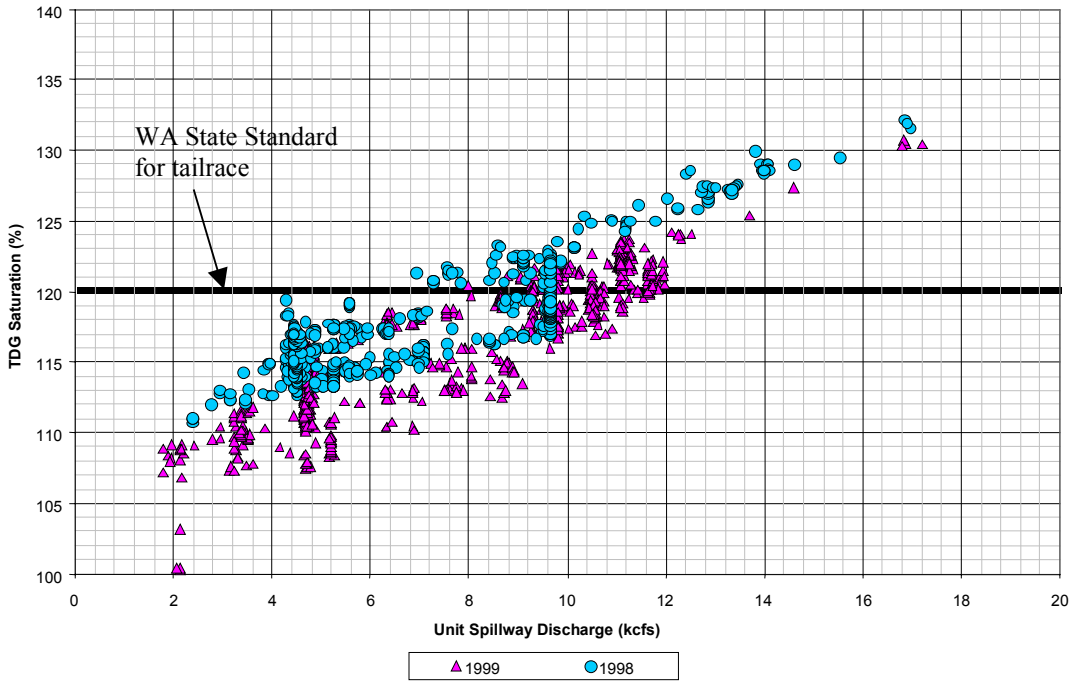
Spillway flow deflectors are installed in all eight spillway bays at Lower Granite, all ten spillway bays at Ice Harbor, and six of eight bays at Little Goose and Lower Monumental. The spillway deflectors have reduced TDG (see Figures 4.4-4 and 4.4-5 for Ice Harbor). However, saturation concentrations above 100 percent and upwards to 130 percent are still being recorded during high flow events (Appendix C, Water Quality).

Spillway Deflector Modifications. Modifications to spillway deflectors have been implemented as a means of further reducing TDG concentrations in the lower Snake River. Among the modifications used are pier extensions, which were added to the flow deflectors at Ice Harbor Lock and Dam. These pier extensions extend the downstream face of the existing piers flush to the downstream edge of the flow deflector and prevent the sidewall flow from directly impacting the flow deflector and plunging into the basin. The extension forces the expansion of sidewall flow to occur further out away from the deflector, where the flow becomes intercepted by the much more dominant deflected surface flow, preventing it from plunging into the basin.

Dissolved Gas Abatement Study (DGAS). The DGAS is a part of the Columbia River Fish Mitigation Program. The DGAS is in response to the NMFS 1995 Biological Opinion on Operation of the Federal Columbia River Power System. The goal of the DGAS is to identify means to reduce TDG at the eight Corps facilities on the Lower Snake and Columbia Rivers to the extent economically, technically, and biologically feasible. To date, gas abatement alternatives have been identified and evaluated for potential application at the eight study facilities. Additionally, numerical modeling tools have been developed to help evaluate the complex issues related to gas abatement through more than 300 miles of river. The draft DGAS evaluates the alternatives and potential implementation scenarios using the numerical modeling tools (Appendix C, Water Quality).

Source: Appendix C, Water Quality

Figure 4.4-4. Total Dissolved Gas Measured Below Ice Harbor Dam, 1996 to 1998



Note: No deflectors in 1996, 4 of 10 installed in 1997, 8 of 10 installed in 1998.

Source: Appendix C, Water Quality

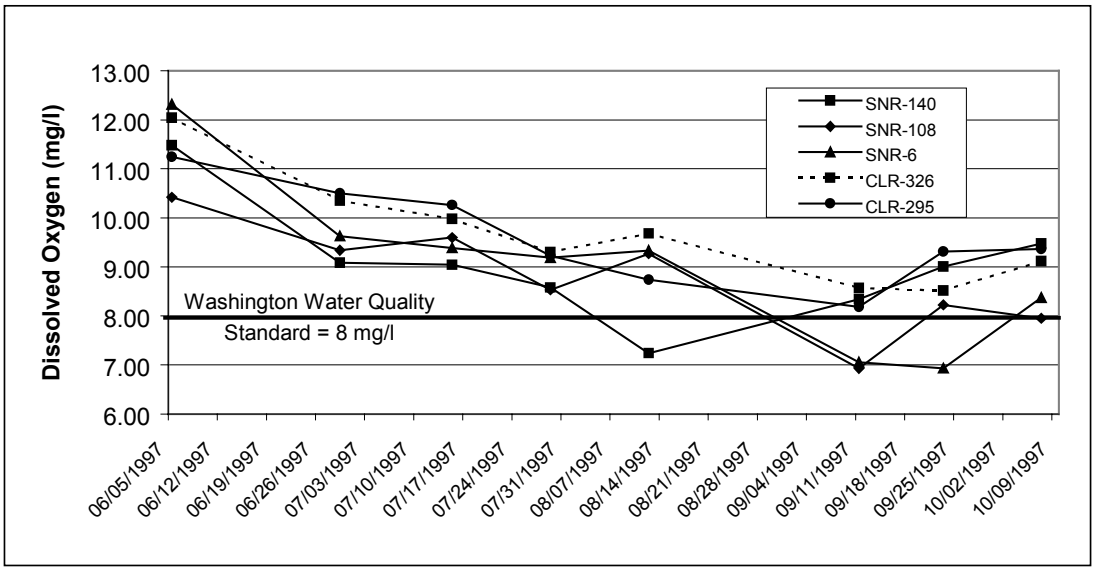
Figure 4.4-5. Total Dissolved Gas Measured Below Ice Harbor Dam, 1998 to 1999

Dissolved Oxygen

The following DO data sources were reviewed as part of this study:

- 1969 to 1971 and 1975 to 1977 data collected by researchers at WSU and UI under contract with the Corps. Sampling stations ranged from RM 6 below Ice Harbor Dam to RM 154 on the Snake River and up to RM 9 on the Clearwater River. Most of the data were collected during the summer and fall although monitoring did continue through the 1976 to 1977 winter.
- The next major set of reservoir dissolved oxygen data were collected between 1994 to 1998. The 1994 to 1996 data were collected by the State of Washington Water Research Center (WRC), while the 1997 to 1998 study was a collaborative effort between the WRC and the Corps. The monitoring stations visited varied slightly from year to year, but encompassed the ones established in previous investigations to maintain consistency. Most of the measurements were taken between May and October on a biweekly or monthly schedule, although monthly sampling did continue through the winter of 1994/1995.
- NMFS collected near-shore oxygen data as part of a 1994 to 1995 study in the Lower Granite reservoir. Three locations were monitored on a biweekly to monthly schedule.
- The Corps also collects dissolved oxygen data as part of their overall water quality monitoring program. Their primary focus has been on fixed stations above and below the four lower Snake River dams and in the Clearwater River up to the Dworshak reservoir. Oxygen data are available from early 1995 to the present at many of the stations. Data are not available from all stations year-round, with the primary data gaps occurring during the winter months. However, these stations are the only ones within the system that provide hourly information.
- The USGS has collected oxygen data at their gauging stations, although the intensity and frequency has varied. Composite sampling was completed at RM 2.2 from 1977 to 1990 on a monthly to quarterly basis. Monthly monitoring was also completed at RM 9.7 from 1967 to 1972 (with the exception of the 1970 and 1971 water years); at RM 106.5 from July 1975 to July 1977; at RM 132.9 between the latter part of 1971 and mid 1972; and finally at the Anatone, Washington, gaging station during the 1976 to 1980 water years. The WDOE has several long-term monitoring stations throughout the state, and one of them is located at RM 139.2. Monthly data are available from December 1990 to the present. Prior to that, monthly to quarterly data were collected between late 1963 to late 1969 with the exception of 1966 and 1967.

The highest DO concentrations are typically observed during spring runoff and decline with increasing temperature. Figure 4.4-6 shows the DO data for several stations along the Snake River in 1997. The values represent DO concentrations averaged over the entire water column. During the early spill season, April through mid-July, DO concentrations are maintained by entrainment of air over spillways.



Notes: SNR – Snake River Mile Designation
CLR – Columbia River Mile Designation
Source: Appendix C, Water Quality

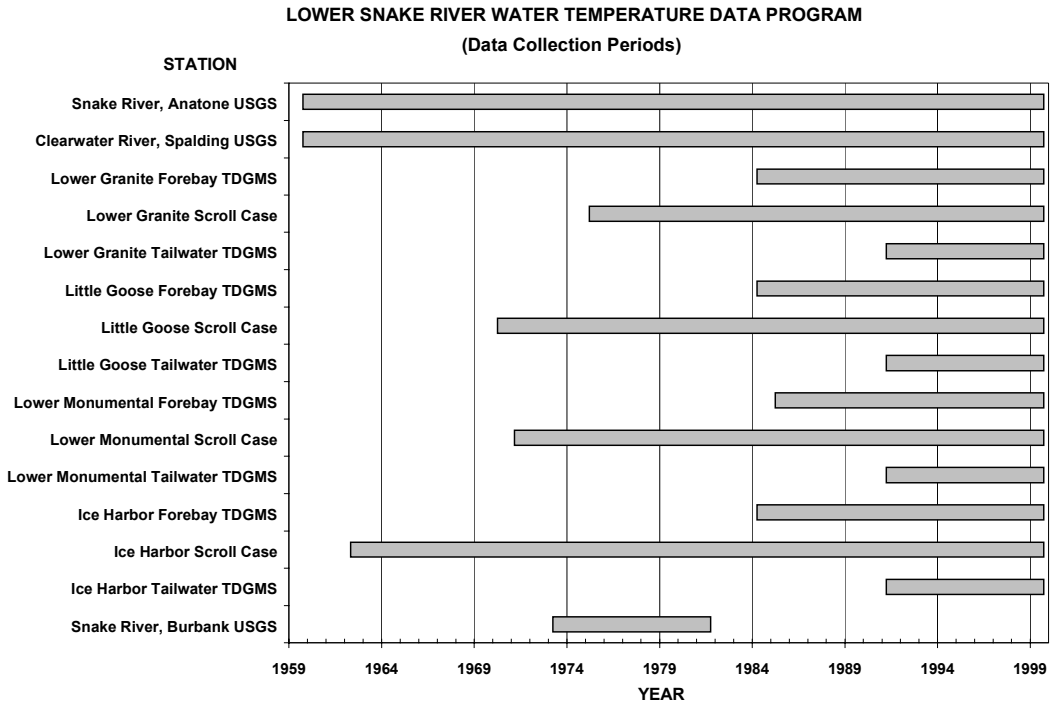
Figure 4.4-6. Dissolved Oxygen for Select Stations in 1997

The data show that DO concentrations in the Snake River are too low only during the summer low flow period when biological oxygen demand depletes oxygen near the bottom in deep water. USGS data for 1977 show a high degree of vertical fluctuation at RM 83, RM 108, and RM 18 sites during August. Concentrations at the bottom of the water column at RM 108 were as low as 2.4 mg/l, but rose to 8.3 mg/l near the surface. Low DO makes the deep areas of the reservoirs uninhabitable for fish, preventing access to cooler groundwater upwellings. This could affect the ability of fish to tolerate and avoid high temperature waters.

September is generally the month when the DO profiles resumed a more uniform profile if deviations occurred during the summer. Decreasing water temperature during October, along with increased mixing, increase oxygen concentrations to DO measured during the springtime levels.

Temperature

Data used for evaluation of temperature in the lower Snake River came from several sources detailed in Appendix C, Water Quality. Figure 4.4-7 displays the water temperature data sites and period of records available just above, below, and within the study reach. Water temperatures were evaluated and compared above, below, and within the reservoir system. The results of the evaluation are presented in the following sections.



Note: Above chart does not indicate periods of missing data.
Chart gives representative periods of recorded data.

TDGMS = Total Dissolved Gas Monitoring Station
USGS = U. S. Geological Survey

Source: Appendix C, Water Quality

Figure 4.4-7. Lower Snake River Water Temperature Data Collection Periods

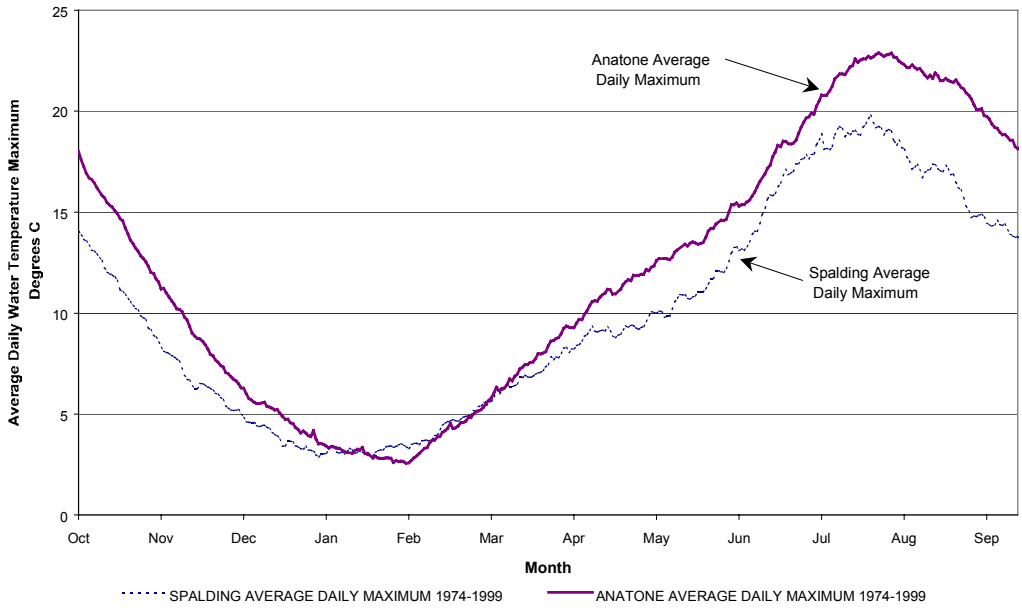
Water Temperatures Above the Lower Snake Reservoir System

Water temperature data in the lower Snake River upstream of the study reach have been collected through routine monitoring programs since 1959. Construction of the lower Snake River reservoir facilities began in 1956 at the Ice Harbor damsite. To support construction and future facility data requirements, the USGS began collecting water temperature data at the following gauging stations:

- The river gauging station near Anatone, Washington (Snake River RM 167.2 approximately 8 miles east of Anatone)
- The river gauging station near Clarkston, Washington (Snake River RM 134)
- The river gauging station near Spalding, Idaho (Clearwater River RM 11.6, approximately 11 miles above Lewiston, Idaho).

The quality of this data are controlled by the USGS using their standards, and the record is considered to be very good and representative of the river at these locations. The Snake River station near Clarkston was discontinued in 1964; therefore, only the Anatone and Spalding station data were used in this evaluation. By 1974, upstream reservoir development above Lewiston, Idaho, was completed on both the Snake and Clearwater Rivers and the upstream reservoirs were being operated under their normal operating criteria (as defined before special reservoir operations began for threatened and endangered fish species).

Therefore, where possible for this evaluation, data graphs were plotted beginning in 1974 to best represent the current level of upstream reservoir development. Figure 4.4-8 displays an average of the daily maximum water temperature data values collected at the Anatone and Spalding stations for the period 1974 through 1999. As shown by the graph, the Anatone station summer water temperatures are typically higher than the Spalding station temperatures by approximately 2 to 5°C. An average of the maximum daily water temperatures at the Spalding station do not normally exceed 20°C, while an average of the maximum daily temperatures at Anatone normally reaches 23°C each year and exceeds 20°C for a period of approximately 60 days each summer.



Source: Appendix C, Water Quality

Figure 4.4-8. Average Daily Maximum Water Temperature for Spalding and Anatone (1974 to 1999)

Table 4.4-4 compares the number of days each year (1972 through 1999) that daily maximum water temperatures at the Anatone and Spalding stations have exceeded 20°C. Anatone water temperatures exceeded 20°C during the summer each year the data were available for the 1972 through 1999 period, and the exceedance each year averaged approximately 60 days. The Spalding water temperatures exceeded 20°C most of the summers by an average of only a 15-day duration. Note that the Spalding records include releases for temperature control from Dworshak Reservoir, lowering the daily averages of the record. Since implementation of the Dworshak summer flow augmentation and temperature release regulation in 1995, temperatures exceeding 20°C at the Spalding site have averaged approximately 5 days duration per year. The overall mid-July through September water temperatures appear to be reduced by approximately 2 to 5°C.

Table 4.4-4. Maximum Water Temperatures

Year	Snake River near Anatone, Wa.		Clearwater River at Spalding, Id.	
	Days over 20 Degrees C	Days Missing	Days over 20 Degrees C	Days Missing
1972	49	16	6	0
1973	57	0	25	0
1974	34	0	0	0
1975	+	97	10	27
1976	43	0	8	0
1977	60	0	16	0
1978	35	0	22	0
1979	79	0	1	0
1980	51	0	9	0
1981	72	0	6	0
1982	47	0	2	0
1983	47	0	0	16
1984	---	137	+	44
1985	---	137	13	0
1986	80	19	17	0
1987	83	0	39	0
1988	76	0	26	0
1989	71	7	16	0
1990	88	0	52	0
1991	68	0	36	0
1992	64	2	41	3
1993	39	0	+	109
1994	88	0	22	0
1995	66	0	5	0
1996	60	0	0	0
1997	63	0	13	0
1998	82	0	8	0
1999	61	0	0	0

NOTES:

Days Missing based on the period of 1 June to 15 October (137 total days)

Missing days may skew the maximum temperature and number of days over 20 degrees C

--- Data missing for indicated periods

\+ Insufficient Record

Source: Appendix C, Water Quality

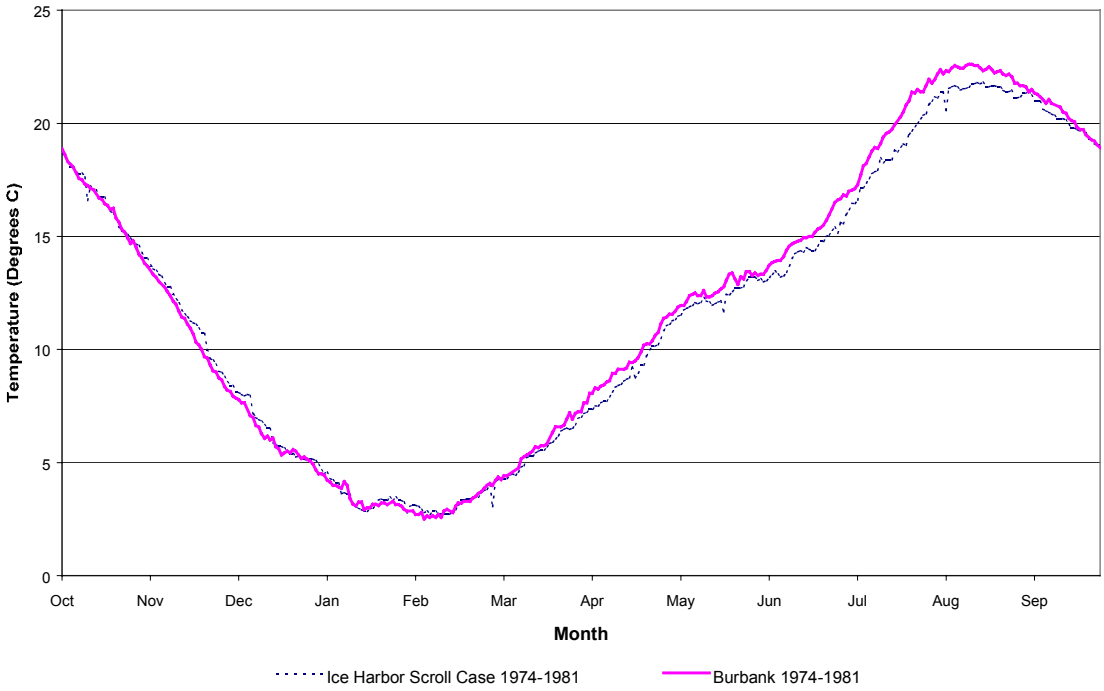
Water Temperatures Below the Lower Snake Reservoir System

Available water temperature station data considered to represent temperature conditions below Ice Harbor Dam are:

- Snake River at Burbank (1973 to 1981). This station was located on the Snake River at RM 2.2 near Burbank, Washington, and approximately 7 miles below Ice Harbor Dam. Data were collected by the USGS.
- The total dissolved gas monitoring station (TDGMS) (1991 to present). This station is located on the north bank of the Snake River approximately 2.9 miles downstream from Ice Harbor Dam. The depth of the probe is approximately 10 feet. Data are collected by the Corps.
- Ice Harbor Dam scroll case temperature gage (1961 to present). This gage is located on the Unit #1 cooling system water supply pipe, located at the south end of the dam. The inlet of the pipe is located at a depth of approximately 100 feet. Data are collected by the Corps.

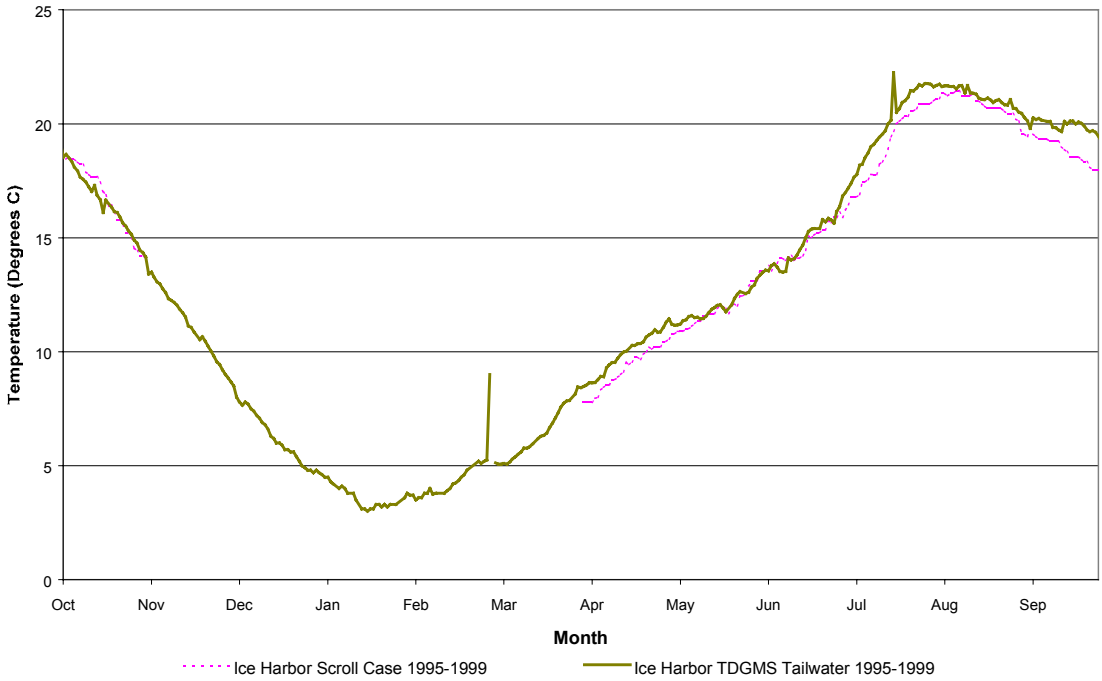
After reviewing the data and the record lengths for these stations, the Burbank site data and Ice Harbor Dam scroll case data from 1973 through 1981 (water years 1974 through 1981) were used to evaluate water temperature conditions below the Snake River reservoir system before the use of the current flow augmentation and temperature control regulation at Dworshak. Available Ice Harbor scroll case data and Ice Harbor tailwater TDGMS data (1995 through 1999) were used to evaluate conditions after the Dworshak regulation for augmentation and temperature control. Figure 4.4-9 displays an average of the maximum daily values for the Burbank station and the average daily values for the Ice Harbor scroll case gage. Figure 4.4-10 displays an average of the maximum daily values for the Ice Harbor TDGMS tailwater station and the scroll case gage. Figure 4.4-11 shows average daily differences between the maximum and minimum values for the Ice Harbor TDGMS tailwater station and the Burbank station.

An average of the daily maximum summer temperatures of the scroll case gage appears to be 1 to 3 °C cooler than the Burbank station and 0 to 2 °C cooler than the TDGMS tailwater station. However, the data sets are consistent and the scroll case data has minimal variations from the other data sets. The average number of days each year that the scroll case temperatures exceeded 20 °C is 45 versus 60 for the Burbank station and 35 versus 56 for the Ice Harbor TDGMS tailwater site. It does not appear that there is a big difference in the exceedance days between the Burbank station and the TDGMS tailwater station even though they are different periods of record. It is unclear why there is a 10-day decrease in the scroll case days of exceedance - 45 days for the 1973 through 1981 period down to 35 days for the 1995 through 1999 period. One possible explanation is the amount of cool water releases augmented from Dworshak Reservoir during late summer and early fall beginning around 1992.



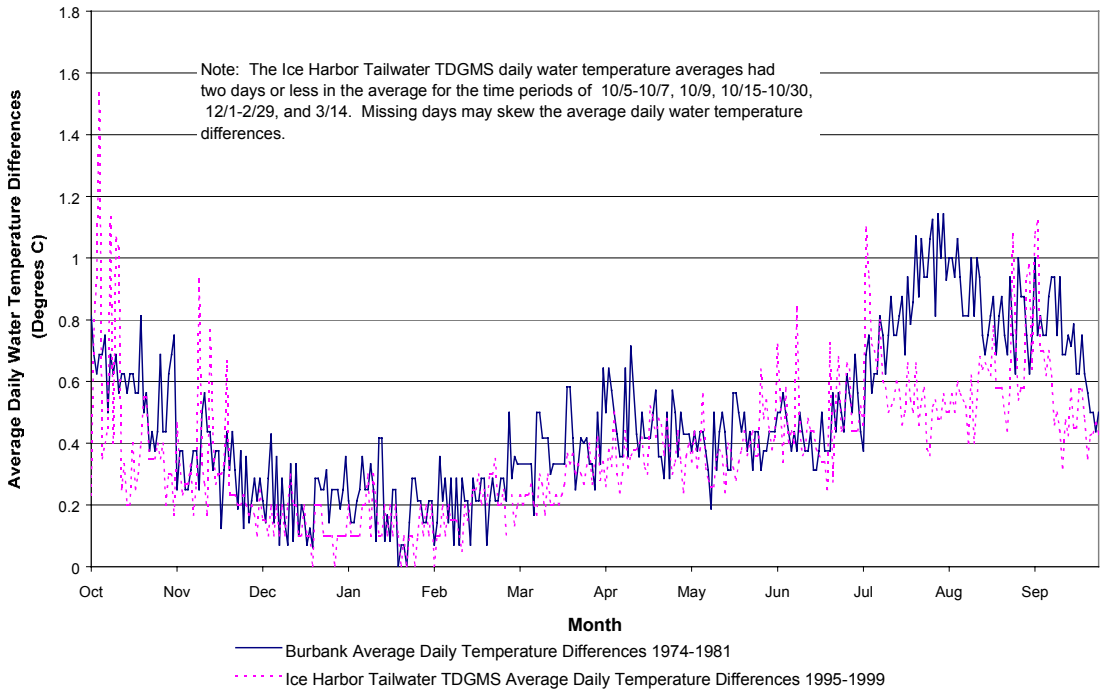
Source: Appendix C, Water Quality

Figure 4.4-9. Average Maximum Water Temperatures in Degrees Celsius—1974 to 1981



Source: Appendix C, Water Quality

Figure 4.4-10. Average Maximum Water Temperatures in Degrees Celsius—1995 to 1999



Source: Appendix C, Water Quality

Figure 4.4-11. Average Daily Water Temperature Differences (Between Daily Maximum and Daily Minimum) at Burbank and Ice Harbor Dam

The Ice Harbor scroll case data appears to be colder than either the Burbank data or the Ice Harbor TDGMS data as indicated by summarizing the data through an average graphical plot and a temperature exceedance summary. This leads to questions of how well the data may represent well-mixed river temperature conditions. Perhaps it does not represent an average river temperature, but rather only represents one temperature point location at a depth of approximately 100 feet within the Ice Harbor reservoir pool.

A comparison of the average daily fluctuation between maximum and minimum water temperatures shows that there is an approximate variation in the daily maximum and minimum water temperatures at the Burbank station of 0.4 to 1.2 °C each day during the summer and approximately a 0.3 to 0.8 °C variation in the Ice Harbor tailwater TDGMS station.

Water Temperature Comparison Above and Below the Lower Snake Reservoir System

Water temperature conditions above the Snake River reservoir system were compared to conditions below the reservoir system using available data stations summarized in the two previous sections. The Anatone, Burbank, and the Ice Harbor TDGMS data do not indicate that summer temperatures (peak and duration) below the reservoir system are substantially different than the summer temperatures (peak and duration) of the Snake River above the reservoir system at the Anatone station. However, the Anatone, Burbank, and the Ice Harbor TDGMS data do appear to show that the timing of the warming and cooling between the upper reach and lower reach may be different. It

appears that the upper reach (Anatone station) temperatures may warm earlier in the spring and summer and cool earlier in the fall and winter than the lower reach (Burbank and Ice Harbor TDGMS tailwater) temperatures. The data show an average summer temperature fluctuation difference between an average of the daily maximum and minimum water temperature data of 0.8 to 1.4 °C for the upstream and 0.4 to 1.0 °C for downstream reaches.

Water Temperatures within the Lower Snake Reservoir System

Water temperature data collected within the lower Snake River reservoir system primarily consist of TDGMS temperature data for each of the four reservoir facilities at both a forebay and tailwater site and at a temperature gage on the scroll case cooling water pipe for each facility. These data have been collected by the Corps and are published in the Corps Annual Fish Passage Report for each year. The Corps and others have collected temperature profile data for several locations within the reservoir system. Table 4.4-5 summarizes the number of days in 1995 through 1999 that summer temperatures exceed 20 °C for the TDGMS forebay and tailwater stations and scroll case gages at each facility. The data from this period should best represent the current operational conditions being used for the reservoir regulation (this would include upstream flow augmentation, upstream temperature control, and voluntary spill at the facilities being used for fish passage). This period is also when the TDGMS data had the highest degree of quality control and consistency of station operation.

Table 4.4-5. Water Temperatures at Corps Dams

Year	Ice Harbor Days over 20 °C					Lower Monumental Days over 20 °C					Little Goose Days over 20 °C					Lower Granite Days over 20 °C				
	Scroll Case	TDGMS Tailwater	Days Missing	TDGMS Forebay	Days Missing	Scroll Case	TDGMS Tailwater	Days Missing	TDGMS Forebay	Days Missing	Scroll Case	TDGMS Tailwater	Days Missing	TDGMS Forebay	Days Missing	Scroll Case	TDGMS Tailwater	Days Missing	TDGMS Forebay	Days Missing
1995	18	48	0	82	4>	23	53	1	77	4	26	54	0	49	27	0	38	3	61	0
1996	41	48	0	33	6	41	38	0	49	1	53	47	13>	54	0	23	35	0	39	0
1997	44	57	0	67	0	28	51	0	66	0	57	21	20>	49	17>	26	11	24	56	0
1998	52	84	0	85	0	75	84	0	88	0	82	65	13>	86	2	36	64	3	89	0
1999	22	42	0	47	0	29	29	0	45	0	45	13	0	42	0	0	2	0	55	0

NOTES:

TDGMS - Total Dissolved Gas Monitoring Station

Days Missing - Days missing that could be in excess of 68 °F (20 °C) for the record ending September 30
> - Indicates days missing that could exceed 68 °F (20 °C) end of data to September 30

Source: Appendix C, Water Quality

Additional graphs and data are provided in Appendix C, Water Quality. In summary, summer forebay temperatures at the dams were almost consistently warmer than either the tailwater or scroll case data. The summer tailwater temperatures at the dams were almost consistently warmer than the scroll case temperature data.

Lower Monumental reservoir temperatures appear to be lower than the Little Goose reservoir temperatures in the summer. The Palouse and Tucannon Rivers flow into the Lower Monumental reservoir pool and may be affecting temperatures within the reservoir.

Water temperature profile data for various sites within the reservoir system demonstrate that the water temperatures can certainly vary substantially or almost not at all within the

reservoir pools depending on location, time of year, flow levels, and particular reservoir operations.

Based on the scroll case data, it would appear that the special flow augmentation and temperature control operations at Dworshak may be changing the density gradient at some locations within the reservoirs and may be affecting the number of days each summer that water temperatures exceed 20 °C at the facility scroll case gages. This is most noticeable at Lower Granite Dam. The flow augmentation from Dworshak Dam is effective in reducing water temperatures in the Lower Granite reservoir and is most beneficial to rearing fall chinook when the cooling effects keep shoreline temperatures between 14 to 16°C.

Sediment

Approximately 100 to 150 million cubic yards of sediment have been deposited upstream of the four lower Snake River dams since Ice Harbor became operational in the early 1960s (Table 4.4-6). Under current conditions, Lower Granite is capturing an average sediment load of approximately 3 to 4 million cubic yards per year that is carried by the lower Snake River.

Table 4.4-6. Distribution of Sediment Carried by the Lower Snake River and Deposited in McNary and the Lower Snake River Project from 1953 through 1998

Dam	Date in Service	Time Period for Sediment Impoundment	Estimated Volume of Impounded Sediment[1/]
McNary	1953	1953 – 1961 (9 years)	27 – 36
Ice Harbor	1962	1962 – 1968 (7 years)	21 – 28
Lower Monumental	1969	1969 – 1970 (1 year)	3 – 4
Little Goose	1970	1971 – 1975 (5 years)	15 – 20
Lower Granite	1975	1975 – 1998 (24 years)	72 – 96
Total, McNary and LSRP		**46 Years**	**138 – 184**
Total, LSRP Only		**37 Years**	**111 – 148**

1/ measured in million cubic yards
Source: Appendix F, Hydrology/Hydraulics and Sedimentation

To assess the potential impacts from sediment transport associated with the drawdown alternative, a study of existing sediment conditions was initiated by the Corps in 1997 (Appendix C, Water Quality). The study was a two-phase effort and encompassed the collection of sediment samples from all four reservoirs. During the first phase (Phase 1), sediment samples were collected and analyzed to determine the grain size of the materials. During the second phase (Phase 2), additional sediment samples were collected from selected locations and submitted for chemical analyses. Phase 2 of the study involved collection of sediment core samples from the areas identified in Phase 1 as having the highest percentage of fine particles. At each of the sediment sampling locations, river water samples were also collected. The river water samples were collected to perform elutriate tests and to determine existing water quality conditions.

The sediment samples were analyzed for a variety of parameters including metals, semivolatiles, herbicides, pesticides, organics, mercury, and nutrients. Elutriates were

prepared for ambient pH. The results were used for the sediment evaluation to estimate impacts to water quality. A summary of the methodology used to analyze existing sediment quality is presented in Appendix C, Water Quality.

The results of the 1997 field investigations on sediment performed by the Corps are supplemented by data collected by others within the Columbia River drainage basin. The majority of these studies are linked directly to the Corps dredging authorities and hydropower facilities, and these predominantly focus on the Snake and Clearwater confluence area. These include the 1990 and 1997 Corps sediment surveys for dredging and individual documents supporting 40 Code of Federal Regulations 230, Section 404 (b) (1) evaluations for specific dredge operations. These are all referenced as supporting sources of information for the development of the Dredged Material Evaluation Framework (DMEF) for the Mid-Columbia and Snake River Management Areas (Appendix C, Water Quality).

The results of the sediment analysis are summarized below for each parameter and described in detail in Appendix C, Water Quality, Section 3.3 Sediment Quality.

Sediment Particle Size

The Corps, Walla Walla District, sediment study of the lower Snake River and Clearwater River confluence (Corps, 2000) sampled 53 sites for particle size with an emphasis on depositional areas. Some mid-channel and lock approach areas from Lower Granite and Little Goose Dams were also included in the sampling. The average particle size distribution for all sites in percent were fines (silt and clay) 17.14 percent, sand 74.20 percent and gravel 7.76 percent in the confluence samples (Table 4.4-7). Particle size was very dependent on locations of the sampling sites. The lock approach sites comprised 1- to 6-inch cobbles exclusively. This was expected due to the velocities measured by an acoustic doppler profiler (ADP) during spill events. Generally, a sample location near the confluence that was more than 75 meters from the shoreline contained less than 1 percent fines.

Since the 1980s, there have been concerns about dioxin/furan contamination of the Washington portion of the Snake River. These concerns arose when 2378-TCDD was found in the effluent bleached Kraft pulp mills in the United States. Dioxin compounds also received large amounts of media attention when they were linked to "Agent Orange" and health effects suffered by Vietnam veterans and their families (Holden, 1979).

In 1998, there was no 2378-TCDD detected in the Lower Granite sediment sample sites established by Potlatch (CH2M Hill, 1999). Both the Potlatch and Boise Cascade mills were not mentioned in the EPA's "The Incidence and Severity of Sediment Contamination in the Surface Waters of the United States" (1997). Both companies meet or discharge below the National Pollution Discharge Elimination System permit level. Still, there is considerable public interest in the potential for environmental harm caused by the release of sediments resulting from the breaching alternative. The Corps continues to maintain surveillance of sediments for possibility of various types of

Table 4.4-7. Summary of Sieve Test Results for Sediment Samples Collected from the Lower Snake River in 1997

	Average Grain Size (in percent)				Cumulative Percent			
Sediment Size	**IHR**	**LM**	**LGO**	**LGR**	**IHR**	**LM**	**LGO**	**LGR**
Gravel	2.4	2.8	1.9	0.4	2.4	2.8	1.9	0.4
Very fine gravel	0.1	0.6	0.7	0.3	2.5	3.4	2.6	0.7
Very coarse sand	0.1	1	0.7	0.5	2.6	4.4	3.3	1.2
Coarse sand	1.1	1.1	2.8	1.7	3.7	5.5	6.1	2.9
Medium sand	18.3	2.8	10.2	6.9	22	8.3	16.3	9.8
Fine sand	18.3	6.7	13.1	17.1	40.3	15	29.4	26.9
Very fine sand	23.3	13.2	16.8	20.1	63.6	28.2	46.2	47
Silt/clay	35.8	71.8	53.8	52.4	99.4	100	100	99.4

Notes: IHR = Ice Harbor reservoir (Lake Sacajawea), 41 samples
LM = Lower Monumental reservoir (Lake West), 77 samples
LGO = Little Goose reservoir (Lake Bryan), 127 samples
LGR = Lower Granite reservoir (Lower Granite Lake), 104 samples
Source: Appendix C, Water Quality

contamination in the Lower Granite and McNary reservoirs through its dredged material management program. Some additional dioxin samples were taken during the above referenced study to evaluate the sediments in the Port of Walla Walla channel leading to the Boise Cascade docks. Samples taken from this area did not yield a single detection of 2378-TCDD (Corps, 1998a).

Under contract by Potlatch Corporation, CH2M Hill conducted dioxin tests in the Lower Granite pool and Clearwater arm of the pool. Seven sites were selected and individual sub-sets were combined into composite sample for analysis. Results from sediments at all of the in-river sites sampled consisted of no detects and below detection limits for 2378-TCDD and 2,3,7,8-tetrachlorodibenzofuran (2378-TCDF). The only sample that contained a detectable level of contamination was the Corps East Pond (CH2M Hill, 1999). The concentrations of 2378-TCDD and 2378-TCDF were very low; 2.8 parts per trillion (ppt) and 3.4 ppt, respectively. The East Pond is directly adjacent to RM 3.5, but receives storm runoff from multiple sources. Potlatch again repeated the study in 1999 and discovered the only detection was for 2378-TCDF in the amount of 2.3 ppt.

While future data analysis is underway, it appears there is a downward trend in concentration levels of dioxin/furan compounds in the Snake River and possibly the McNary pool. Only with additional analysis and testing could this be confirmed. Additional historic data are presented in Appendix C, Water Quality, Section 3.3.

Glyphosate and AMPA

Glyphosate (N-[phosphonomethyl]glycine) is a post-emergence herbicide that is widely used for agricultural and domestic purposes. It is sold as a terrestrial and aquatic herbicide. A major metabolite of glyphosate is aminomethylphosphonic acid (AMPA).

Glyphosate and AMPA were detected in 36 percent and 16 percent, respectively, of all top layer sediment samples (94 total samples) in all of the lower Snake River reservoirs. The concentrations of glyphosate ranged from non-detected to a maximum of 68.9 parts

per billion (ppb); AMPA ranged from non-detected to a maximum of 29.3 ppb. The highest individual concentrations of glyphosate and AMPA were detected in samples collected from Lake Bryan (upstream of Little Goose Dam). The highest average reach concentrations of glyphosate were found in samples collected from Lake Sacajawea (upstream of Ice Harbor Dam). The average reach concentration of glyphosate increased downstream from Lower Granite Reservoir to Lake Wallula. The highest average concentration of AMPA was found in samples collected from Lake Herbert G. West (upstream of Lower Monumental Dam) and then decreases in Lake Sacajawea.

The suspected source of glyphosate and AMPA in the sediment samples collected from the lower Snake River is runoff from surrounding uplands and through transport via stream flow. Sources for these organic compounds may include agricultural, industrial, municipal, or domestic uses within the watershed.

Organochlorine Pesticides

Several organochlorine pesticides were detected in the sediment samples collected from the lower Snake River. Total DDT (DDD, DDE, and DDT) concentrations ranged from non-detectable to 32.8 ppb. The highest mean concentration for total DDT was 11.3 ppb for the Lower Granite reservoir. The average reach concentration of total DDT decreases steadily from the Lower Granite reservoir to 5.7 ppb, as recorded in Lake Sacajawea.

The predominant organochlorine compound detected was DDE, which ranged in average concentration from 2.68 in Ice Harbor to 6.48 in the Lower Granite reach, with an arithmetic mean concentration of 4.89 ppb. DDD was detected in 11 sediment samples with an average maximum concentration of 6.48 ppb in the Lower Granite reach and an arithmetic mean of 2.07 ppb. DDT was detected in only five samples with a mean arithmetic concentration of 1.62 ppb.

The maximum and average total DDT concentrations in the lower Snake River sediments exceed the guidance levels set forth in *Puget Sound Dredged Disposal Analysis Guidance Manual: Data Quality Evaluation for Proposed Dredged Material Disposal Projects* PTI, 1989a) or recommended screening concentration (6.9 ppb), but are lower than the bioaccumulation trigger concentration of 50 ppb as established in the Portland DMEF (Corps, 1998c). Concentration levels above the screening level prompt biological testing to ascertain health risks to aquatic organisms using the DMEF (Corps, 1998c).

The pesticides aldrin, dieldrin, endrin, heptachlor, and lindane were all detected in five or less of the 1994 dredge material sediment evaluation samples. The concentration of aldrin ranged from non-detect to 3.5 ppb, dieldrin from non-detect to 8.0 ppb, endrin from non-detect to 9.4 ppb, heptachlor from non-detect to 4.9 ppb, and lindane from non-detect to 5.5 ppb. The maximum concentrations of aldrin, dieldrin, heptachlor, and lindane in the Snake River sediment are lower than their screening level concentration of 10 ppb. No screening level has been established for endrin in the DMEF (Corps, 1998c).

Total Petroleum Hydrocarbons (TPHs) and Oil and Grease

The concentrations of total petroleum hydrocarbons (TPH) ranged from non-detectable to 256 ppm. Along the lower Snake River, the average concentration of TPH generally

increases in the downstream direction with the highest average concentration found in Lake Sacajawea. No screening levels were established for TPH under the Portland District's DMEF.

Most recently, the Walla Walla District conducted a sediment study (Corps, 2000) at the confluence of the lower Snake and Clearwater Rivers. The researchers sampled 38 sites for oil and grease and found concentrations ranging from 134 to 770 ppm. Only three of the sites had oil and grease concentrations greater than 400 ppm. There are insufficient data to conclude that TPH or oil and grease could pose a significant problem.

Polynuclear Aromatic Hydrocarbons (PAHs)

PAHs represent the largest class of suspected carcinogens and represent a significant threat to aquatic life. The PAHs typically found in dredge material in this region are most likely discharged by petroleum fueled internal combustion engines. These compounds are found in the engine's emission as a by-product of incomplete combustion. Another source of PAHs is the burning of coal. Many PAHs present in dust and soil are known carcinogens or mutagens, and adverse health effects have been linked to exposure to these compounds. Humans can be exposed to PAH, by inhaling contaminated air, by ingesting contaminated food, and by non-dietary ingestion of contaminated dust or soil.

Since 1985, sediment samples have been tested for PAHs in the Lewiston-Clarkston area near the confluence of the Snake and Clearwater Rivers. In sediment core samples, the total PAH concentration ranged from 77 ppb to 865 ppb. As a comparison, the Puget Sound Estuary Program (PSEP) apparent effects threshold (AET) concentrations for low weight and high weight PAHs are 5,200 ppb and 12,000 ppb, respectively.

Just prior to the completion of this document, the Walla Walla District Hydrology Branch evaluated sediments for the proposed fiscal year 2001 confluence dredging in the Lower Granite pool. Results from this investigation found phenanthrene, fluoranthene, and benzo (a) pyrene in a single sample from the Clearwater at about RM 3. The calculated concentrations of high molecular weight PAHs were 161.4 ppb (below the Puget Sound protocols). No low molecular weight compounds were detected. Over a period of 15 years when the Corps dredging teams tested the compounds in the Lower Granite confluence area, there was a steady decrease of PAHs in the sediments of this area.

The concentrations and distributions of PAH compounds are adequately documented in the Lower Granite pool. Almost no data exist on PAH distributions and concentrations in the Little Goose, Lower Monumental, and Ice Harbor pools. However, there is no heavy industrialization in the Lower Snake and mid Columbia River Dredge Management Areas and from the data collected over the last 15 years, apparent trends, and reduction of emissions overall, PAH compounds do not pose a concern compared to today's standard. Water quality impacts to specific dredged areas will need to continue monitoring PAHs because the traditionally dredged areas contain the bulk of the PAH contaminant detection.

Metals

Analyses were conducted for 18 metals in each of the 94 sediment samples. The metals included: arsenic, barium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, vanadium, and zinc. All of the metals were

detected in every sample except for the following: cadmium (2 samples), mercury (37 samples), silver (0 samples), and strontium (4 samples).

For the most part, metals detected in the 1997 Lower Snake River Juvenile Salmon Migration Feasibility Study and current studies agreed with each other and were within the range of expected background levels. Exceptions are manganese, lead, arsenic, aluminum, and copper.

Manganese appears to be higher in the Snake River sediments than in the Clearwater River sediments. Manganese concentrations were highly variable but each successive year of testing yielded a higher maximum concentration. The high manganese level concentrations occurred in results from several laboratories, suggesting that a procedural error is unlikely. At this time there is no explanation for this occurrence. Fractional isotope analysis could provide clues by determining what species of manganese salts and their proportion to geologic material is present.

Lead and arsenic appeared in quantities above background level (San Juan, 1994) in previous studies. Currently some of the highest levels are present in the Corps' East Pond in Lewiston. Since there are few industrial sources of pollution, the contamination most likely responsible for above background levels for lead and arsenic is attributed to past agricultural practices in areas historically containing orchards. Old pre-impoundment USGS 7.5-minute quad maps show orchards where there are now reservoir waters.

Aluminum levels are highly variable and have been found in orders of magnitude lower than background (San Juan, 1994) and levels as high as twice background. The higher levels appear to be found predominantly in areas with a higher percentage of fine sediments. Aluminum is to be considered a potential problem for water quality in this area and should be examined in further dredge material activities.

Metals pose a significant contamination problem. In this area of Eastern Washington and Eastern Oregon, the primary impacts from metals would be from past mining and agricultural practices. Very little manufacturing, if any, occurred in the last 100 years. One interesting aspect of the metals concentrations found on the lower Snake River is that they can appear as a substantial contaminant (tenfold over background average) one year and prove to be well below background level in subsequent years. Then, the metal of concern may be found at a different location in quantities well above background levels at a site where it was at non-detect levels a few years earlier.

Sediment Nutrients

During the 1997 sediment sampling study (see Section 4.4.2.3 and Normandeau, 2001), 84 samples from the four lower Snake River reservoirs were analyzed for a number of chemical parameters designated as the nutrient group. The mean reach concentrations for each of the nutrient group parameters are summarized in Table 4.4-8. No screening levels have been established under the DMEF (Corps, 1998a) for nutrients, and comparison with water quality standards is not appropriate.

Table 4.4-8. Summary of Mean Nutrient Concentrations for Sediment Samples Collected in the Lower Snake River

Parameter	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Ammonia	81.3	59.6	64.3	75.7
Total Kjeldahl Nitrogen	1317.1	1146.1	1344.1	1746.5
Nitrate/Nitrite	0.7	0.6	0.7	1.4
Total Organic Nitrogen	1235.7	1086.7	1280	1671.3
Total Organic Matter (percent)	2.5	2.2	3.3	5.2
Phosphorus Bicarbonate	37.7	38.2	35	34.1
Sulfate	7.7	8.4	10.5	17.9
PH (standard units)	6.9	6.9	7.1	6.8

Notes: All results in mg/kg unless otherwise noted
Ice Harbor Dam - Lake Sacajawea
Lower Monumental Dam - Lake West
Little Goose Dam - Lake Bryan
Lower Granite Dam - Lower Granite Lake
Source: Appendix C, Water Quality

Elutriate Fraction

For each of the sediment samples, an ambient pH elutriate was prepared and analyzed for organophosphorus pesticides, organochlorine pesticides, metals, nutrients, glyphosate, and AMPA. TPH and dioxin were not tested in the ambient pH elutriates. The purpose of the elutriate tests was to evaluate potential impacts to surface water quality from the resuspension of channel sediment. The elutriate tests were used to determine which inorganic or organic constituents would preferentially partition by dissolution into the water and to determine their resulting aqueous concentration. The elutriate concentrations (maximum values) were then compared with surface water quality standards. The following summarizes the results of these comparisons:

Organophosphorous Pesticides

The ambient pH elutriates were tested for the presence of organophosphorus pesticides, which as a group consist of 25 different organic compounds. The only organophosphorus pesticide detected was ethyl parathion, in one sample (LGO 8-4), at a concentration of 1.0 ppb (µg/l). Although identified in the one elutriate sample, ethyl parathion was not detected in any of the sediment samples. Parathion is a regulated substance in fresh waters in the states of Oregon and Washington with a maximum allowable concentration of 0.013 ppb (chronic).

Organochlorine Pesticides

No organochlorine pesticides were detected in any of the ambient pH elutriate samples. The organochlorine pesticides DDT (and its metabolites) aldrin, dieldrin, endrin, heptachlor and lindane had been detected in several of the sediment samples tested. The results of the elutriate tests suggest that although these compounds are present in the sediments they do not readily partition into water.

Glyphosate

Glyphosate was detected in only 2 of the 94 ambient pH elutriate samples, while AMPA was not detected. Glyphosate was detected at a concentration of 0.69 µg/L in a sample collected from Lake Bryan and at a concentration of 0.58 µg/L in a sample collected from Lake Sacajawea. In comparison, the maximum contaminant level established for glyphosate by the EPA in drinking water is 700 µg/L, well above the concentrations detected in the two elutriate analyses.

Metals

Each of the 94 ambient pH elutriates were tested for the same suite of metals that were analyzed on their corresponding sediments. For the 18 metals analyzed, only beryllium, silver, and thallium were not detected in the elutriate samples. Of these metals, only silver was not detected in the original sediment samples.

The mean metal concentrations for the ambient pH elutriates are summarized by river reach in Table 4.4-9. The predominant metals detected include barium and manganese. The average concentration of barium, by river reach, in the ambient pH elutriates increases from 83.3 ppb for the samples collected from Lower Granite Lake to 243.6 ppb for the sediment samples collected from Lake Sacajawea. Although a corresponding trend in the concentration of barium in the sediment samples was not observed, it was one of the predominant metals detected. Its relatively high concentration in the ambient pH elutriates is most likely the result of its concentration in the sediments and its relatively high solubility in water (Hem, 1989).

The predominant metal identified in the ambient pH elutriates was manganese (Table 4.4-9). The average concentration of manganese, by river reach, in the ambient pH elutriates ranged from 504 ppb for the samples collected from Lower Granite Lake to 1,432 ppb for the samples collected from Lake West. In general, the trend in manganese concentrations in the ambient pH elutriate samples increases with distance downstream. As observed with barium, there does not appear to be a clear relationship between the concentration of manganese in the sediment samples and in the ambient pH elutriates.

The maximum metal concentrations detected in the ambient pH elutriates (Anatek Labs, 1997) were also compared with the recommended surface water quality standards of the State of Oregon Department of Ecology, the United Nations (agricultural water quality goals), EPA, and Washington State Department of Ecology to identify any contaminants of concern. The maximum concentration of four metals: arsenic, copper, manganese, and mercury were found to exceed the water quality standards.

Because these metals also occur naturally in the environment, their concentrations were compared with representative background values to determine if they represent a concern. The results of the ambient pH elutriate tests were compared with historical water quality data collected by the USGS from the Snake River near Anatone, Washington. The maximum detected concentration of arsenic, copper, and mercury were found to be less than their average background concentrations and as a result were not considered to represent concern.

Table 4.4-9. Summary of Mean Metal Concentrations for Ambient pH Elutriate Samples Collected of the Lower Snake River Project

Metal (µg/L)	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Arsenic	3.9	2.6	2.2	1.8
Barium	243.6	197.5	140.9	83.3
Beryllium	ND	ND	ND	ND
Cadmium	ND	ND	0.1	ND
Chromium	0.6	0.8	0.4	0.6
Cobalt	0.5	1.2	0.4	0.5
Copper	2.9	3.2	3.2	4
Lead	ND	0.1	0.1	0.1
Manganese	861.5	1432.1	799.9	504.4
Mercury	ND	0.1	0.1	0.1
Molybdenum	3	3.5	3.8	2.2
Nickel	2.8	4.1	0.7	0.9
Selenium	2.3	1.2	0.3	0.3
Silver	ND	ND	ND	ND
Strontium	0.4	0.3	0.3	0.2
Thallium	ND	ND	ND	ND
Vanadium	2.1	1.2	1.8	1.5
Zinc	37.7	17.8	16.9	12.9

Notes: Ice Harbor Dam - Lake Sacajawea
Lower Monumental Dam - Lake West
Little Goose Dam - Lake Bryan
Lower Granite Dam - Lower Granite Lake
ND = Not detectable
Source: Appendix C, Water Quality

Nutrients

The ambient pH elutriate samples were also analyzed for the following nutrients: ammonia, nitrate/nitrite, phosphate, sulfate and TKN (Cascade Analytical, 1997). The mean concentrations of each of these nutrients for the four reaches along the lower Snake River are summarized in Table 4.4-10.

The dominant form of nitrogen found in the elutriate samples was ammonia. The dominance of ammonia may reflect the limited oxygen environment of the channel bed sediments as a result of the decomposition of organic material. The consumption of oxygen by the decay of organic material would lead to the reduction of nitrate/nitrite to ammonia, thus limiting their concentrations in both the sediment and elutriate samples. Concentrations of ammonia in sediment elutriate and in ambient river are summarized in Figure 4.4-12. These data indicate that erosion and suspension of sediments can substantially elevate ammonia in the water column above ambient levels. Although elevated ammonia levels are expected to be transient, they nevertheless could affect aquatic life.

Table 4.4-10. Summary of Mean Nutrient Concentrations for Ambient pH Elutriate Samples Collected during Phase 2 (1997) in the Lower Snake River

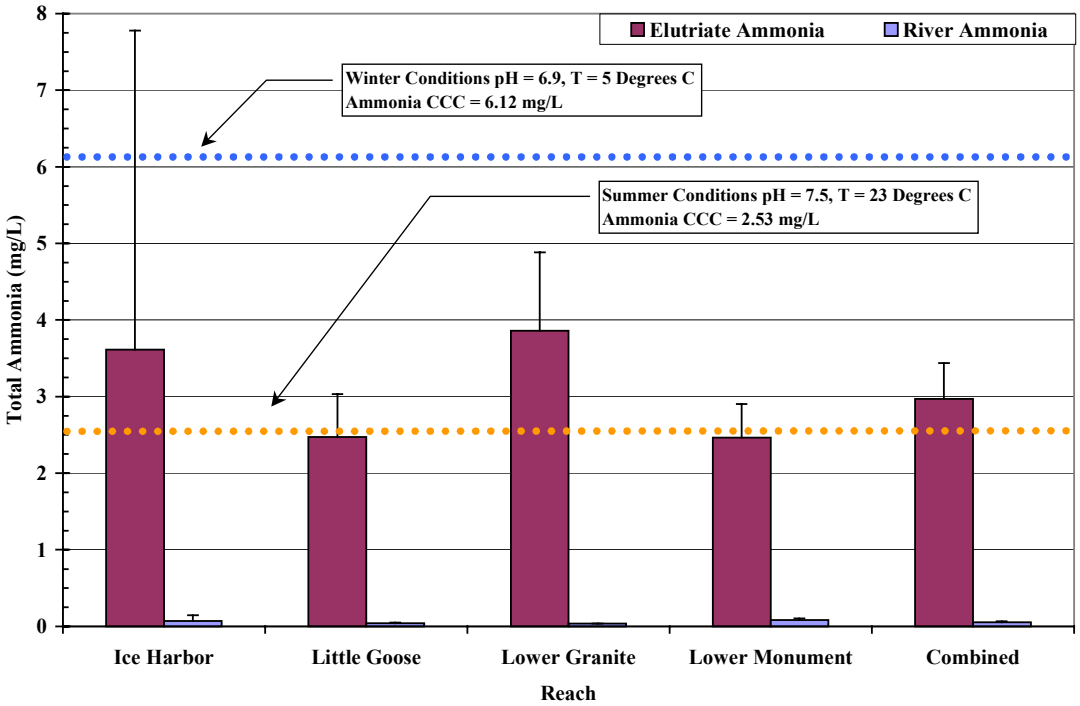
Parameter (mg/l)	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Ammonia	3.6	2.5	2.6	3.6
Total Kjeldahl Nitrogen (TKN)	8.8	5.7	4.1	6.2
Nitrate/Nitrite	0.2	0.2	0.3	0.4
Phosphate	0.1	0.1	0.1	0.1
Sulfate	19.6	17.9	26.9	29.7

Notes: Ice Harbor Dam - Lake Sacajawea
Lower Monumental Dam - Lake West
Little Goose Dam - Lake Bryan
Lower Granite Dam - Lower Granite Lake
Source: Appendix C, Water Quality

Total ammonia in fresh water exists as two chemical species, un-ionized ammonia (NH_3) and ammonium ion (NH_4^{+1}). Toxicity is primarily attributed to the un-ionized ammonia. In fresh water, the concentration of the un-ionized form is a function of temperature and pH. EPA (1999b) provides a detailed discussion of the dependence of ammonia toxicity on temperature and pH. Because un-ionized ammonia is difficult to measure directly, its acute[1] and chronic[2] effects can be expressed in terms of the total ammonia concentrations calculated for site-specific values of temperature and pH. In addition to dependence on pH and temperature, EPA (1999b) has shown that salmonids and early life stages of aquatic organisms are especially sensitive to ammonia. A listing of critical criteria continuous concentration (CCC) values for salmonids and early life stages at various pH and temperature conditions is provided in Table 4.4-11.

Potential ammonia toxicity associated with the resuspension of sediments is dependent on seasonal conditions of pH and temperature as shown in Figure 4.4-12. During the late summer conservative assumptions for the Lower Snake River are 23°C and pH 7.5, which correspond to an ammonia CCC value of 2.53 mg/L[3]. Under these conditions, the ammonia levels predicted by sediment elutriate measurements are just below the critical CCC value in the Little Goose and Lower Monument reaches, and exceed the CCC value in the Ice Harbor and Lower Granite reaches. Representative values during the winter are 5°C and pH 6.9, which correspond to an ammonia CCC value of 6.12 mg/L. Thus, under winter conditions, the ammonia levels predicted by the elutriate measurements would probably be well below the critical CCC value.

[1] Expressed as the criteria maximum concentration (CMC), which is a one-hour average acute limit that protects aquatic life from short-term exposure to relatively high concentrations.
[2] Expressed as a criteria continuous concentration (CCC), which is a four-day average chronic limit that provides protection of aquatic life and its uses.
[3] Values are expressed to 3 significant figures to minimize rounding errors.



Source: Appendix C, Water Quality

Figure 4.4-12. Mean Concentrations and 95% Confidence Limits of In River Water and In Sediment Elutriate at Ambient pH

Table 4.4-11. Critical Values for Total Ammonia CCC Values that are Protective of Salmonids and Sensitive Life Stages

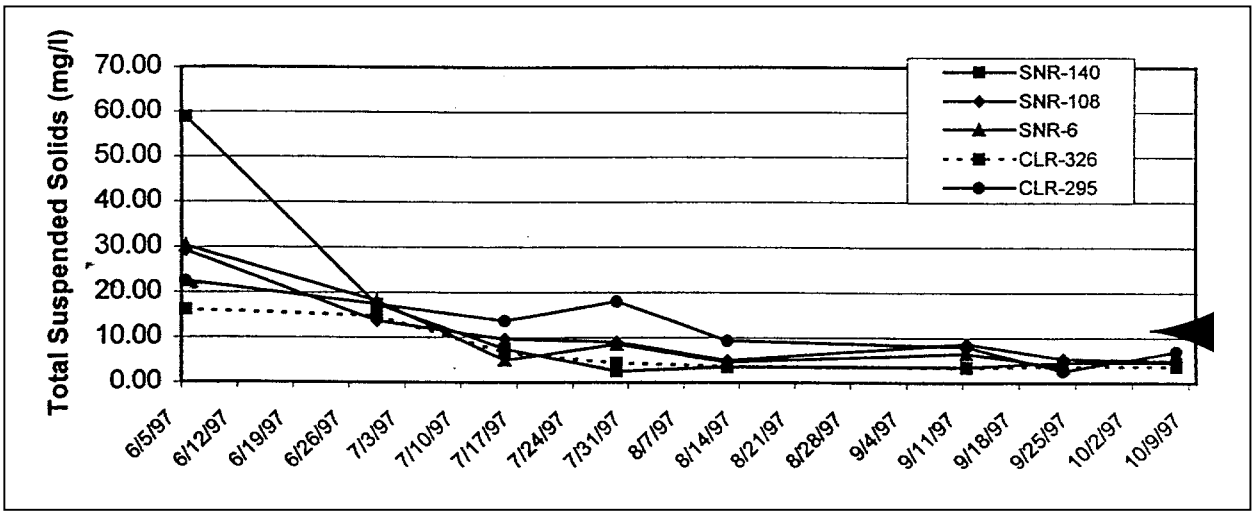
	pH										
Temperature (°C)	**6.5**	**6.6**	**6.7**	**6.8**	**6.9**	**7**	**7.1**	**7.2**	**7.3**	**7.4**	**7.5**
1	6.67	6.57	6.44	6.29	6.12	5.91	5.67	5.39	5.08	4.73	4.36
14[4]	6.67	6.57	6.44	6.29	6.12	5.91	5.67	5.39	5.08	4.73	4.36
15	6.46	6.36	6.25	6.10	5.93	5.73	5.49	5.22	4.92	4.59	4.23
16	6.06	5.97	5.86	5.72	5.56	5.37	5.15	4.90	4.61	4.30	3.97
17	5.68	5.59	5.49	5.36	5.21	5.04	4.83	4.59	4.33	4.03	3.72
18	5.33	5.25	5.15	5.03	4.89	4.72	4.53	4.31	4.06	3.78	3.49
19	4.99	4.92	4.83	4.72	4.58	4.43	4.25	4.04	3.80	3.55	3.27
20	4.68	4.61	4.52	4.42	4.30	4.15	3.98	3.78	3.57	3.32	3.06
21	4.39	4.32	4.24	4.14	4.03	3.89	3.73	3.55	3.34	3.12	2.87
22	4.12	4.05	3.98	3.89	3.78	3.65	3.50	3.33	3.13	2.92	2.69
23	3.86	3.80	3.73	3.64	3.54	3.42	3.28	3.12	2.94	2.74	2.53

Source: Appendix C, Water Quality

[4] When temperature is ≤ 14°C, the method of calculating CCC values yields identical results for each pH concentration regardless of temperature.

Suspended Sediment

Suspended sediment concentrations tend to be highest during the spring runoff and then decline as flows diminish through late summer and into fall. Figure 4.4-13 shows the suspended sediment at the five sample locations. The maximum suspended sediment concentrations tend to be lowest in the Clearwater River and upper Columbia River sites (8 to 16 mg/l) and approximately equal below Lower Granite Dam. Lower Granite Dam traps sediment transported by the Clearwater River and middle Snake River below Hells Canyon Dam. The maximum peak value measured was 65 mg/l above Lower Granite Dam at RM 148 and average 28 mg/l in the surface waters of the lower Snake River during the same time interval. By mid-to late summer, concentrations drop to slightly above 5 mg/l on the lower Snake River. During the spring runoff, the Palouse and Tucannon Rivers have much higher concentration of 1,035 mg/l and 130 mg/l, respectively. During the summer months, the concentrations for both rivers drop below 15 mg/l.



Source: Appendix C, Water Quality

Figure 4.4-13. Total Suspended Solids Data Measured in 1997 at Selected Stations throughout the Study Area

Turbidity

Turbidity measurements were made at several Snake River sampling stations during 1997. The results are presented in Table 4.4-12. Turbidity levels exceeded 5 NTUs in June 1997 at most stations.

Table 4.4-12. 1997 Turbidity Measurements (NTU[1/]) in Surface Waters at Selected Snake River Stations

Date	SNR-18	SNR-83	SNR-108	SNR-118	SNR-129	SNR-140
6/2 to 6/9/97	16	17	18	17	17	20
6/28 to 7/1/97	5	9	3	5	5	8
7/3/97	7	NC	NC	NC	NC	NC
7/14 to 7/19/97	4	3	3	2	2	3
7/28 to 7/31/97	4	2	2	3	3	2
8/11 to 8/14/97	5	3	2	2	2	2
9/8 to 9/11/97	3	2	1	2	2	2
9/15/97	3	NC	NC	NC	NC	NC
9/22 to 9/25/97	3	2	2	2	2	2
10/6 to 10/9/97	2	3	3	2	2	2

Notes: [1/] Formazin Turbidity Units (FTU) are equivalent to NTU
(SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)
Source: Appendix C, Water Quality

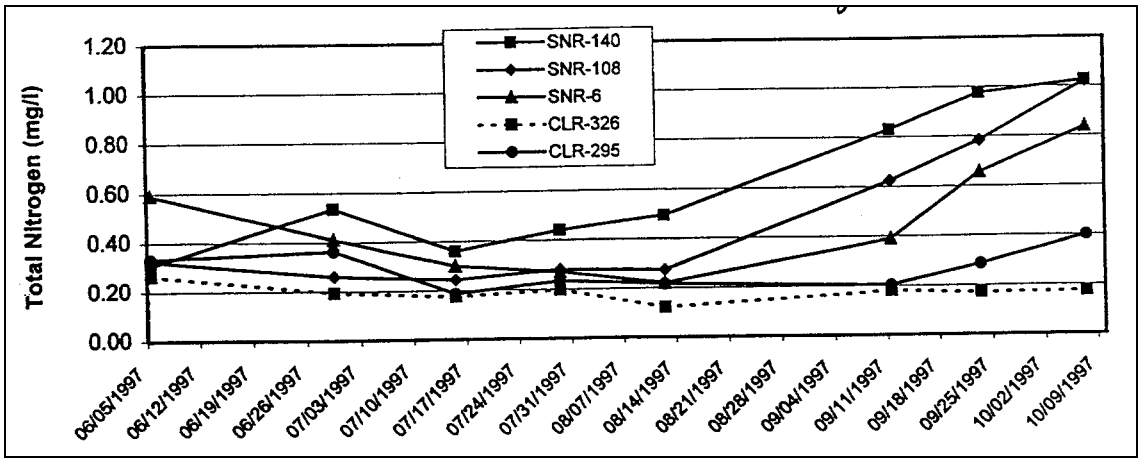
pH

The median pH has ranged from 7.9 to 8.2 in the lower Snake River along water sampling locations. The Clearwater River has a median pH of 7.4 to 7.7, reflecting buffer capacity and reduced primary productivity compared to the lower Snake River. The Palouse and Tucannon Rivers have slightly higher pH values than the lower Snake River.

Nutrients

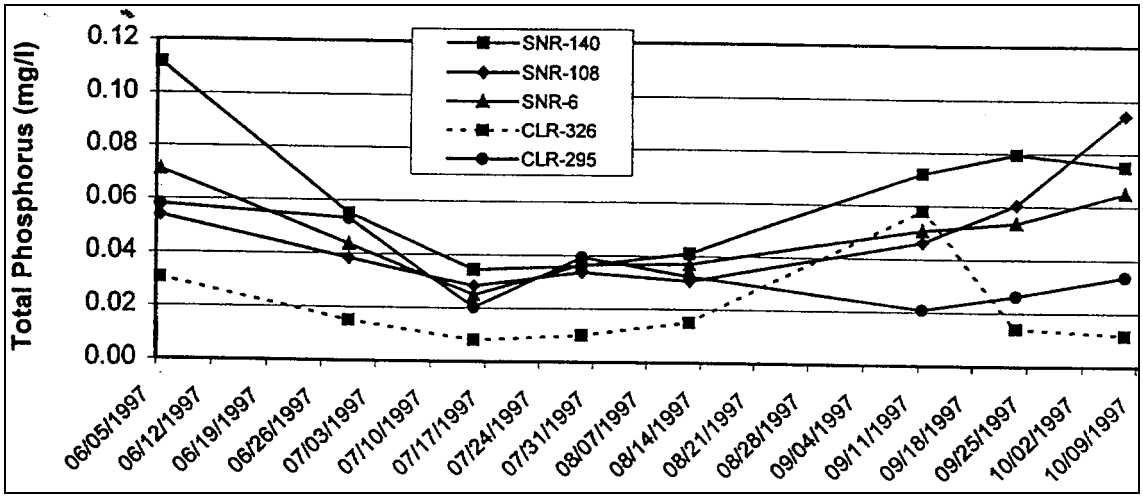
The total nitrogen concentrations for the Clearwater and Snake Rivers show a slight decline for the onset of the spring runoff to a minimum level in July, rising to maximum values in early autumn. The late season increase may be due to a reduction in plant uptake associated with aquatic plants and algae dying back or going dormant, or due to agricultural harvesting and fertilization in the watershed. In general, total levels decrease throughout the lower Snake River, but are still higher than observed in the Columbia River. In the spring and summer, the total-N levels range from about 0.30 mg/l to 0.60 mg/l at the lower Snake River station. In the fall, the total-N levels peak to between 0.8 and 1.1 mg/l (Figure 4.4-14). The Palouse River has the highest median nitrogen levels of 2.15 mg/l with a peak of 4.86 mg/l during the spring runoff.

The 1997 water quality data indicate that ortho-P levels in the lower Snake River tend to be moderately high in the spring (0.065 mg/l to 0.11 mg/l), relatively low in the summer (0.02 mg/l to 0.04 mg/l), and generally highest in the fall starting in mid-September (0.05 mg/l to 0.10 mg/l) (Figure 4.4-15). These levels suggest that the average phosphorus levels in the lower Snake River for much of the entire growing season would likely be above the Washington Department of Ecology phosphorus guideline of 0.035 milligrams per liter that was established to maintain existing conditions and prevent eutrophic conditions.



Notes: (SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)
Source: Appendix C, Water Quality

Figure 4.4-14. Total Nitrogen Measured in 1997 at Selected Water Quality Sampling Sites throughout the Study Area



Notes: (SNR—refers to Snake River Mile)
(CLR—refers to Columbia River Mile)
Source: Appendix C, Water Quality

Figure 4.4-15. Total Phosphorus Data Measured in 1997 at Selected Stations throughout the Study Area

4.4.2.4 Hazardous Materials, Substances, Chemicals, and Wastes

The Corps is required to comply with all Federal safety and health regulations. These regulations include procedures for handling and disposal of any hazardous, toxic, or radioactive wastes (HTRW), both to protect human life and the environment.

Each dam site has items that can be classified as hazardous/dangerous materials, substances, chemicals, or wastes under Federal and state laws (see Appendix D, Natural River Drawdown Engineering).

Many of the materials and items listed below would meet the definition of a solid waste given in 40 Code of Federal Regulation (CFR) 261.2 and WAC 173-303. This determines the item's ultimate disposal either as a solid waste or a dangerous/hazardous waste, depending on its condition at the time of disposal (e.g., whether it was used material or contaminated material). It should be noted that many of the materials and items listed below (if unadulterated with other regulated hazardous contaminants) are recycled or used at other Corps hydropower facilities, thereby eliminating the need to dispose of these materials. Specific licensed disposal sites are currently in operation in the Pacific Northwest. These facilities are used as needed for disposal of hazardous materials, substances, chemicals, or wastes.

PCBs—PCBs are still present in small amounts at most facilities, primarily in light ballasts and capacitors.

Asbestos—Most asbestos has been removed from the dam facilities. There are still some locations, such as breaker panels, where removing the asbestos is not feasible or necessary unless it becomes fixable or damaged and presents an exposure hazard to employees.

Paint—Most external structures at the dams are coated with high concentrations of lead-based paint.

Waste or Used Oil—Each hydropower facility has at least 570,000 liters to 950,000 liters (150,000 gallons to 250,000 gallons) of oil currently in use. Containerized oil containing contaminants such as solvents are commonly encountered at hydropower facilities. Oil sludges are common in tanks.

Mercury—Fluorescent light bulbs and thermostats or temperature regulating switches are the primary sources of mercury waste at these facilities. Other metallic mercury wastes found at hydropower facilities should be in minimal amounts.

Antifreeze—Antifreeze must be recycled or disposed of as a regulated dangerous/hazardous waste (WAC 173-303). Most, if not all, used antifreeze generated at hydropower facilities is reused or recycled.

Solvents—Solvents are used extensively for degreasing operations at hydropower facilities and are probably the second largest source of potential regulated hazardous wastes found there. Solvents are used as thinners for painting applications, and aerosol containers of degreasers and solvents are used in maintenance shops.

Greases—Greases are used on the turbine units and other equipment where there is direct contact with water.

Pesticides—Hydropower facilities use pesticides (herbicides and insecticides) on the levees or in and around the facilities for insect and weed control. Unless contaminated with other regulated wastes, pesticides can be reused at other hydropower facilities in

accordance with registered label directions. Rinsed pesticide containers are recycled or disposed of as a solid waste.

Petroleum-Contaminated Soils—Petroleum-contaminated soils are typically cleaned up as the spills happen, but there could potentially be some areas where the soil has been contaminated early in the history of the facility.

Freon and Halons—Freon and halon are used as refrigerants/coolants (heat pumps) and in fire extinguishing systems respectively at hydropower facilities. CFCs are also found in used oil after reclamation.

Gasoline and Diesel—Gasoline and diesel storage tanks are located at each facility. Unused product can be used for fuel. Gasoline and diesel contaminated with water may be burned for energy recovery.

Batteries—Batteries, including spent lead-acid batteries, and battery acid (electrolyte), are used in power houses and other facilities.

Wastewater Treatment Sludge—Powerhouse wastewater treatment and septic tank sludge is removed and disposed of. Sewage sludge (biosolids) may contain toxic pollutants (metals) which impact disposal options. Sewage sludge is generally excluded from Federal and state hazardous/dangerous waste disposal requirements (40 CFR 261.4 and WAC 173-303.071).

Radioactive Materials—There are no radioactive materials associated with any of the project facilities.

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4.5 Aquatic Resources

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The lower Snake River contains a wide variety of aquatic organisms. Of critical interest to this study are the various populations of anadromous and resident fish that periodically and permanently inhabit the river. This section describes the existing anadromous and resident fish resources of primarily the lower Snake River and Columbia basins.

4.5.1 Anadromous Fish

The Columbia-Snake River System supports large and varied populations of anadromous fish. Anadromous fish hatch in freshwater streams or lakes, migrate downriver to the ocean to mature, then return upstream to spawn (Figure 4.5-1). The range of anadromous fish in the Snake River are shown in Figure 4.5-2. Several species and many separate stocks of anadromous fish inhabit the Columbia and Snake Rivers. These fish include spring, summer, and fall chinook salmon; coho, chum, and sockeye salmon; steelhead; sea-run cutthroat trout; American shad; white sturgeon; and Pacific lamprey. Many of these stocks are severely depleted because of changing ocean conditions, continued harvest and hatchery production practices, the dams on the river system that have interfered with migration, and reduced spawning and rearing habitat quantity and quality.

The complicated nature of the lifecycle (Figure 4.5-1) and factors influencing fish at all stages ultimately has a large influence on enhancement and recovery efforts. The analysis in this document addresses primarily just a small portion of their total lifecycle, the period when they pass through the region directly influenced by the hydroelectric system. While an adult salmon or steelhead may live for typically 3 to 6 years, their occurrence within the direct influence of the hydrosystem is limited. The period includes a few days to several weeks as most juveniles migrate to the

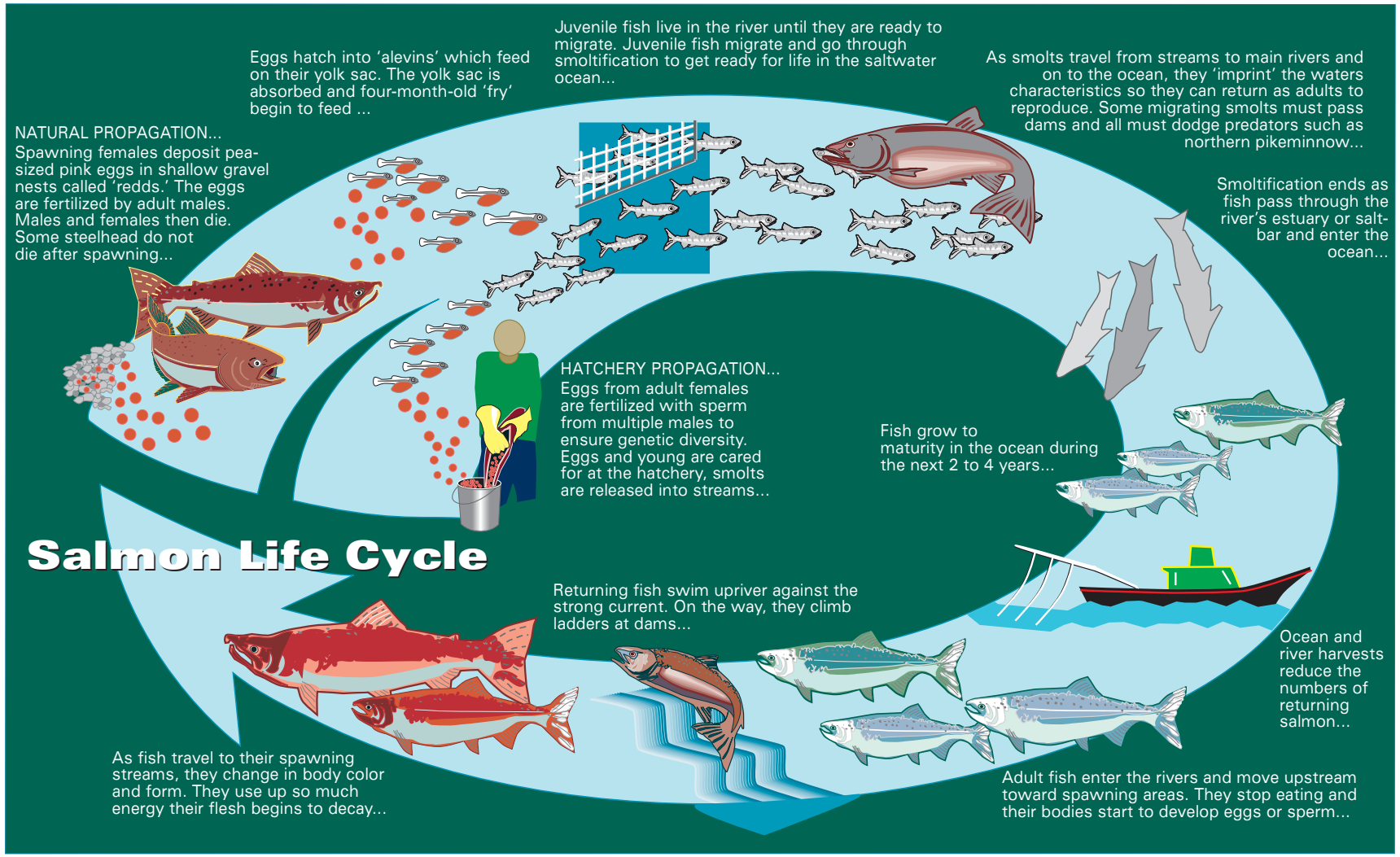


Figure 4.5-1. Salmon Life Cycle

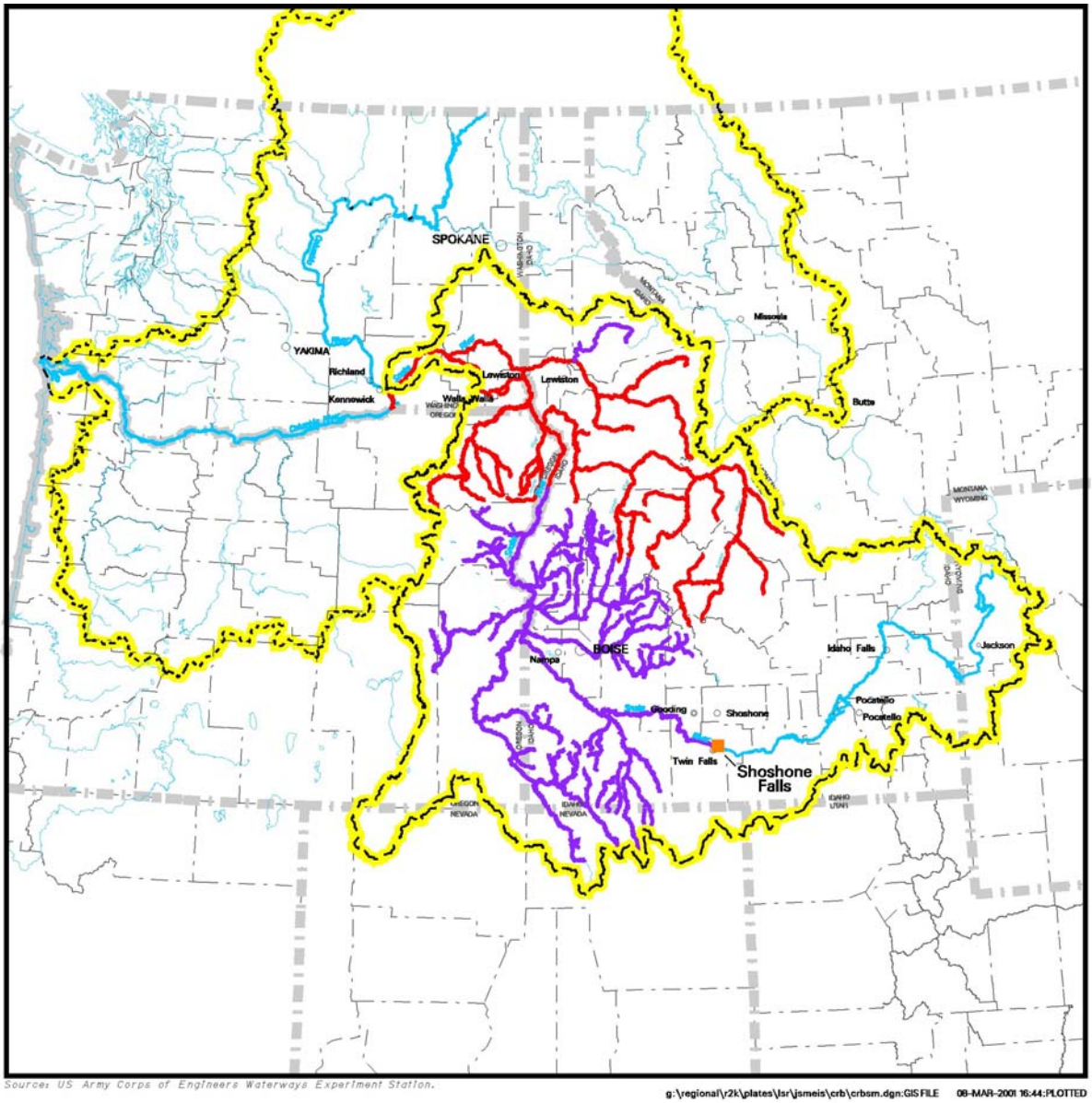


Figure 4.5–2.
SNAKE RIVER SALMON RANGE

ocean, and again mostly a few weeks as adults migrate upriver. The overall survival of these fish is influenced by conditions in all phases of their lifecycle from the streams where they are spawned, the downstream migration corridor, the conditions in the ocean where they reach their full growth, upstream migration corridor, and finally again the condition in their natal stream. The many-faceted nature of this lifecycle ultimately complicates efforts to enhance production of these fish. The life history and status of the various stocks, with emphasis on those originating in the Snake River, are presented in this section.

The four listed Snake River salmon stocks, status, and dates listed are:

- Snake River Fall-run Chinook ESU, listed as Threatened, April 1992
- Snake River Spring/Summer-run Chinook ESU, listed as Threatened, April 1992
- Snake River Sockeye ESU, listed as Endangered, November 1991
- Snake River Steelhead ESU, listed as Threatened, August 1997

4.5.1.1 Life History

Snake River Chinook

Populations of chinook, called “runs”, are grouped by the time they return to the rivers to begin their final spawning journey: spring, summer, and fall. Though chinook salmon can be found entering spawning rivers throughout the year, the majority return from April to December. Adult chinook salmon migrating upstream past Bonneville Dam from March through May, June through July, and August through October are categorized as spring-, summer-, and fall-run fish, respectively. In general, the habitats utilized for spawning and early juvenile rearing are different among the three forms. In both rivers, spring chinook salmon tend to use small, higher elevation streams (headwaters), and fall chinook salmon tend to use large, lower elevation streams or main-stem areas. Summer chinook salmon are more variable in their spawning habitats; in the Snake River, they inhabit small, high elevation tributaries typical of spring chinook salmon habitat, whereas in the upper Columbia River they spawn in larger, lower elevation streams more characteristic of fall chinook salmon habitat.

Differences are also evident in juvenile outmigration behavior. The two behavioral types are categorized as those juveniles that migrate seaward as subyearlings as "ocean-type" chinook and those that migrate seaward as yearlings as "stream-type" chinook. In both rivers, spring chinook salmon migrate swiftly to sea as yearling smolts, and fall chinook salmon move seaward slowly as subyearlings. Summer chinook salmon in the Snake River resemble spring-run fish in migrating as yearlings, but migrate as subyearlings in the upper Columbia River. The Columbia River is located in the middle of the range and produces chinook salmon populations with the highest diversity in juvenile migrational behavior and timing. Some tributaries or areas produce only ocean-type juveniles (main-stem areas of the Columbia and Snake Rivers), some produce only stream- type juveniles (upper tributaries of the Columbia and Snake Rivers), and some produce both types (many tributaries of the Columbia

River below the confluence of the Snake River). In both the Columbia and Snake Rivers, spring- and fall-run adults produce stream-type and ocean-type juveniles, respectively; however, in the upper Columbia River, summer-run adults produce ocean-type juveniles, whereas in the Snake River, they produce stream-type juveniles. Genetic data (discussed below) support the hypothesis that these affinities correspond to ancestral relationships.

The relationship between Snake River spring and summer chinook salmon is more complex. Some streams in the Snake River are considered to have only spring-run fish (e.g., those in the Grande Ronde River), some only summer-run fish (e.g., those in the Imnaha and the South Fork of the Salmon Rivers), and some both forms (e.g., many streams in the Middle Fork of the Salmon River and upper reaches of the Salmon River).

Elevation appears to be the key factor influencing run/spawn timing. In most cases, spring chinook salmon spawn earlier and at higher elevations than summer chinook salmon. This is generally true whether spring and summer runs from the same stream or different streams are compared. Where the two forms co-exist, spring-run fish spawn earlier and in the upper ends of the tributaries, whereas summer-run fish spawn later and farther downstream. Spawning fish in both groups tend to use the upstream portions of their respective spawning areas first and the downstream portions last. An obvious connection to elevation is water temperature, with higher elevations generally characterized by lower annual temperatures.

Two hypotheses can explain the presence of both spring and summer chinook salmon in some streams. The first hypothesis is that the two forms arose from a single colonization event by one of the forms. Subsequently, a slight shift in run-timing of some individuals in the population might have allowed expansion into habitat that could not be utilized by the original colonists. The result of this expansion might be a single population, with a cline in the frequency of genes controlling run-timing associated with the cline in stream elevation and incubation temperature. Alternatively, some degree of reproductive isolation between the two forms might develop following expansion into the new area.

The second hypothesis is that spring- and summer-run fish are two independent evolutionary units, and the reason both forms are sometimes found in the same stream is that two colonization events occurred. Under this hypothesis, habitat suitable for summer- run fish is unlikely to be adequate for spring-run fish (and vice versa); therefore, such habitat can only be colonized by fish of the appropriate run-time from another area.

Both hypotheses are consistent with the idea that environmental factors are important in determining time of spawning and, therefore, time of entry into fresh water. That is, "spring" chinook salmon return early and spawn early because the streams they spawn in are colder and the eggs require longer incubation time; furthermore, adverse weather conditions may reduce the success of individuals that spawn too late in the season. In this view, "summer" fish can afford to migrate upriver and spawn later in the season because their spawning locations, being typically at somewhat lower elevation, present less exacting requirements for spawn timing and embryo development. The two hypotheses differ in their predictions regarding the

evolutionary relationships between the two forms. According to the first hypothesis, spring- and summer-run fish from the same stream would be more closely related to each other than either is to fish of the same run-time from other streams, whereas the second hypothesis leads to the opposite prediction. At present, there is insufficient information to determine which of these hypotheses is true. (It is also possible that the first hypothesis is true in some cases and the second hypothesis in others.) (Matthews and Waples, 1991).

Spawning and rearing times are dependent on timing of the individual runs. Because of their large body size, chinook tend to use deeper water and larger gravel size to spawn than other salmon (up to cantaloupe size rocks). The female digs the nest or redd in areas with moderate to high velocity water about a foot deep. Most spawning and rearing activity of fall chinook takes place in the main stream channels immediately above the saltwater limit or hundreds of miles upstream. The eggs of the chinook salmon are larger than any other salmon species. Depending on her size a female can produce 2,000 to 14,000 eggs, averaging about 5,000. Adults die soon after spawning. The young chinook salmon typically emerge from their gravel nests in three to five months. Research shows that low dissolved oxygen and/or low water temperature increase the length of time the eggs take to develop. The juvenile salmon grow and feed as they migrate downstream towards the sea, stopping to rear in coastal estuaries for periods up to 5 months, and then migrating to the open ocean. Chinook salmon can mature and return to spawn in as little as one year or as long as nine. The chinook salmon is an opportunistic and carnivorous feeder throughout its life, primarily feeding on insects, crustaceans, invertebrates, and other fish.

Like salmon runs from other parts of the Columbia River Basin, Snake River salmon depend upon conditions in the estuary and the nearshore ocean during the critical first few months of their saltwater life. From April through November of every year, juvenile chinook salmon inhabit the estuaries and inter-tidal areas of the Pacific Coast. These estuarine areas with fresh and salt water wetlands and vegetation provide habitats that are crucial to survival. Not only do they provide habitat for the young salmon, they provide the food upon which the chinook prey: crustaceans, insects, and other fish. Healthy estuaries with adequate food are essential to the juvenile salmon's transition from fresh water to salt water. Relatively little is known about passage survival rates during this phase of their life, other than what can be inferred from tagging studies. Typically, a portion of the production from a particular brood year (jacks and minijacks) returns to the Columbia River after a few months to 1 year in seawater. The rate of return of jacks may provide a good indication of the strength of future year classes. Adults return to spawn after 2, 3, 4, or more years at sea, and the cycle continues (Appendix A).

Good water quality is also important to the young salmon. Siltation from improper land use practices, excessive high or low water temperature, and loss of stream cover or canopy all have negative impacts on chinook survival. Man-made dams with large reservoirs flood the much needed shallow main-stream channel areas utilized by both the juvenile and adult chinook salmon for spawning and rearing. Healthy watersheds and fish-friendly forest practices are very important to the chinook salmon's survival.

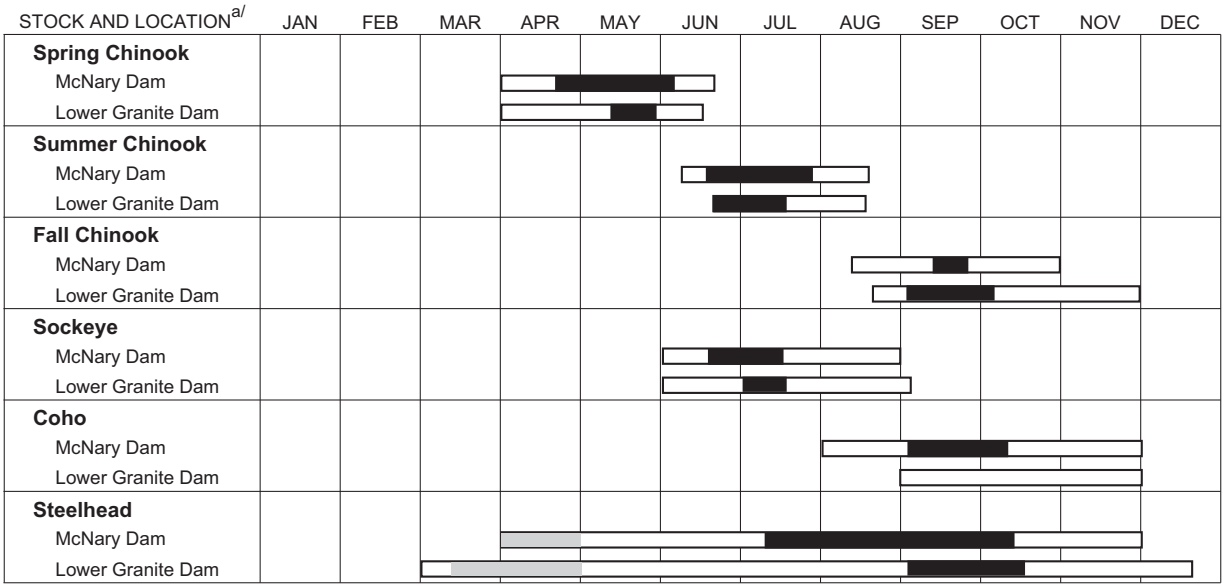
Spring Chinook Salmon

Adult spring run chinook salmon begin entering the Columbia River in February. By late June, most have passed the Corps dams on the lower Columbia and Snake Rivers (Figure 4.5-3). Most spring chinook salmon migrate upstream from early April through mid-June and spawn in tributaries far upstream of project influences. Peak spawning occurs from August through October. Of the chinook stocks, spring chinook salmon typically travel the farthest up tributaries to spawn. In systems with both spring and summer chinook salmon, spring chinook salmon tend to spawn farther upstream and earlier (Matthews and Waples, 1991). However, spawning area and timing may overlap between the two stocks in some areas. This possible overlap of spawning area and timing is one of the main reasons that the NMFS designates Snake River spring and summer chinook salmon as one group (spring/summer) in their Endangered Species Act (ESA) listing (see Section 4.5.1.2, Run Status). Snake River spring and summer chinook also have the same juvenile outmigration age and timing. Within the Snake River System there are five major spawning and rearing basins for spring/summer chinook. These include three large river basins (Clearwater, Grande Ronde, and Salmon Rivers) and two smaller basins (Tucannon and Imnaha Rivers).

Juveniles typically rear in the rivers for more than a year, migrating downstream their second spring as yearlings from about March to June (Figure 4.5-4). The majority pass the dams during April and May. Fish then rear in the ocean mostly for 2 years before returning to the river as adults. However, a significant number spend 3 years in the ocean, some spend 4 to 5 years, and a few return after one year as “jacks” (early maturing fish) (Howell et al., 1985).

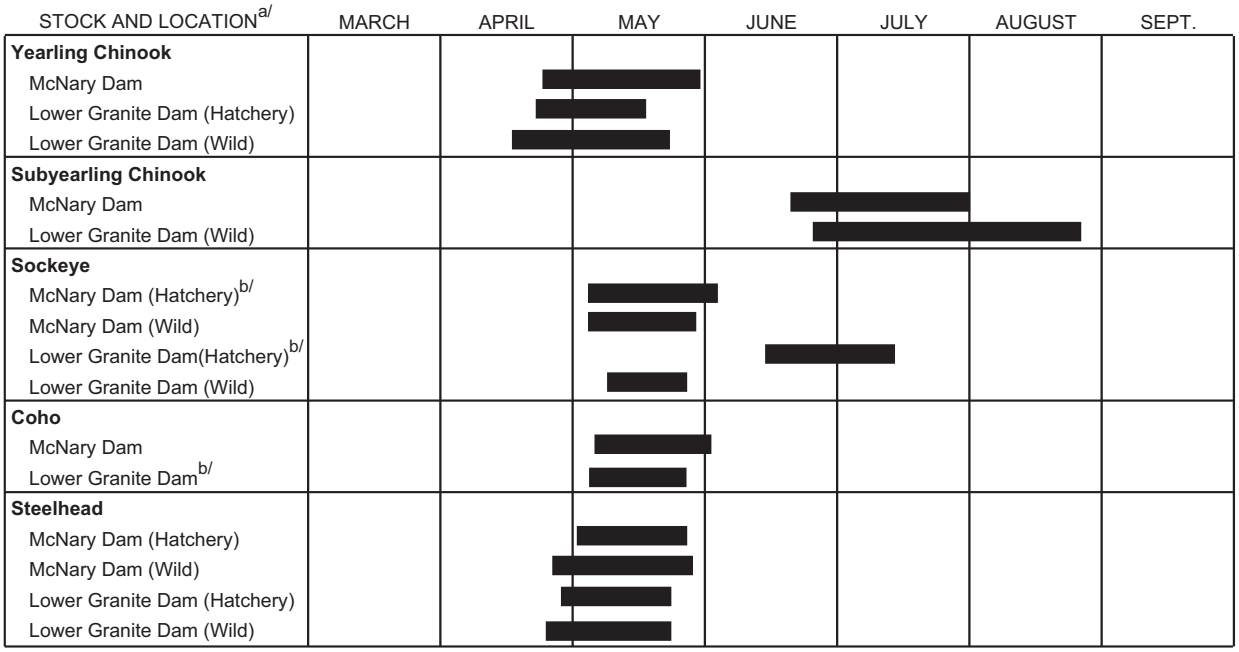
Summer Chinook Salmon

Adult summer chinook salmon begin entering the Columbia River in May and pass the mainstem dams by September (Figure 4.5-3). The majority pass from mid-June through mid-August. Summer chinook salmon generally spawn and rear upstream of the influence of the dams, although some of the upper Columbia River subyearlings rear in the lower Columbia region. Summer chinook salmon have typically dominated spawning in lower elevation streams in the upper Columbia River. In the Snake River System, spawning regions are typically in tributaries, but often downstream of spring chinook salmon. Spawning typically occurs from August



a/ Migration period range and peak annual counts shown as darker central region, shaded area indicates small secondary peak.
Source: Corps, 1998a (Annual Fish Passage Report); Corps, 1998b (Fish Passage Plan)

Figure 4.5-3. Adult Salmonid Main Upstream Periods



a/ Range of 10% and 90% passage for 1991 to 1997 (Fish Passage Center, 1999)
b/ Range of 10% and 90% passage for 1998 (Fish Passage Center, 1999)

Figure 4.5-4. Peak Periods of Downstream Migration of Salmonid Smolts

through October, peaking in the Snake River System in September. Juvenile summer chinook salmon outmigrate mostly as subyearlings in the upper Columbia River and yearlings in the Snake River. The yearlings outmigrate from the Snake River during March through June, with the majority passing in April and May (Figure 4.5-4). Most Snake River adults spend 2 to 3 years in the ocean before returning, while upper Columbia River stocks may spend up to 5 years (CBFWA, 1991; Howell et al., 1985; Matthews and Waples, 1991).

Fall Chinook Salmon

Before widespread dam construction in the Snake River Basin, fall chinook salmon spawned in the Snake River as far upstream as Shoshone Falls about 977 km from the Snake River mouth (Fulton, 1968). During the pre-dam era, it is reasonable to assume that fall chinook salmon sometimes spawned in the lower reaches of Snake River tributaries such as the lower Clearwater River when adult escapement was high and environmental conditions were favorable. However, the core (or source) population of the fall chinook run in the Snake River Basin reportedly spawned in the vicinity of Marsing, Idaho (rkm 683) (Groves and Chandler, 1999). By 1964, the ongoing construction of Brownlee, Oxbow, and Hells Canyon Dams (hereafter, the Hells Canyon Complex) had blocked access to the historic production area for Snake River fall chinook salmon located near Marsing, Idaho. There are two primary present-day spawning areas: a 173-km reach of the Snake River downstream of the Hells Canyon Complex, and a 64-km reach of the lower Clearwater River downstream of Dworshak Dam (Idaho Power Company, Nez Perce Tribe, USFWS, unpublished). Both of these spawning areas are located downstream of hydroelectric dams. Therefore, Snake River fall chinook salmon egg incubation, parr rearing, and growth are influenced by water temperatures regulated by dams. Subyearling fall chinook salmon smolts must also pass up to eight mainstem reservoirs and dams to reach the sea.

Adult fall chinook salmon begin entering the Columbia River in July and pass the mainstem dams by the end of November (Figure 4.5-3). Fall chinook in the Columbia River System consists of two distinct groups: “tules” which are confined primarily to the lower Columbia River tributaries (below Bonneville pool), and “upriver brights” which mainly spawn in the mainstem Columbia in the Hanford reach (downstream of Priest Rapids Dam) and in the Snake River System. The majority of upriver bright fall chinook salmon pass the dams from mid-August to November. The tules returning to the Bonneville pool area are primarily hatchery fish. Tules spawn typically from mid-September to mid-October, while upriver brights spawn during October and November (Dauble and Watson, 1990; Waples et al., 1991).

The current spawning area for Snake River fall chinook salmon is limited to the 103 miles of the Snake River below Hells Canyon Dam, and to parts of the lower reaches of the Clearwater, Grande Ronde, Imnaha, Tucannon, and Salmon Rivers. Since 1993, there has been an increasing portion of spawning in the Grande Ronde and Clearwater rivers (Appendix M, Fish and Wildlife Coordination Act Report). Additionally, incidental deep water spawning has been observed below Lower Granite, Little Goose and Ice Harbor (Dauble et al., 1999).

Juvenile upriver bright fall chinook rear primarily in the mainstem river and reservoir reaches of the Columbia and Snake Rivers. Those below Priest Rapids rear in the shallow water areas downstream, including the four lower river reservoirs. Those in the Snake River rear in the flowing water areas below Hells Canyon Dam and into the reservoirs. Juvenile fall chinook salmon predominately migrate as subyearlings, leaving in their first spring or summer of fresh water residence. Subpopulations of subyearling chinook may rear and overwinter in the lower Snake River or McNary Reservoir and finish their outmigration the following spring as yearlings (Peters et al., 1999). The smolt-to-adult ratio (SAR) of such observed passive integrated transponder (PIT)-tagged populations overwintering and outmigrating in 1995 and 1996 returned at SARs of three times the SAR of their true sybyearling cohorts. Lower river, hatchery, and wild tules migrate from March through October; the majority pass the dams in July and August (Figure 4.5-4). Hanford reach upriver brights pass primarily during the same time period. Those from the Snake River pass the upper dam primarily in late June and July (Figure 4.5-4) with some passing as late as November (Appendix M, Fish and Wildlife Coordination Act Report). However, most leave before late-July due to warming temperatures that are not suitable for chinook salmon in the Snake River.

Tule stocks typically rear in the ocean for 2 to 3 years (CBFWA, 1991). The Snake River fall chinook salmon typically return after 1 to 4 years in the ocean; most return after 3 years (Chapman et al., 1991).

Sockeye Salmon

The life history of sockeye is variable throughout the Pacific Northwest, depending largely on the region of origin and local stream conditions. Spawning migrations into fresh water commonly occur from June to August, with the actual spawning taking place August through December. Most sockeye migrate great distances up freshwater streams through lakes and into tributary streams, although some do spawn in the shores of freshwater lakes. The females select and dig the nest or redd site before depositing 2,200 to 4,300 eggs, depending on her size. Both males and females can spawn with multiple mates, and the female guards her nests until she dies a few days after spawning. Egg incubation in the gravel and fry emergence from the gravel are temperature dependent, therefore this stage can last from 2 to 7 months depending on stream conditions. Incubation can be 50 days to 5 months while emergence can take between 2 to 10 weeks, depending on local stream conditions. Young sockeye will usually migrate towards a lake immediately upon emerging from the gravel. Most young sockeye will live in freshwater lakes for 1 year, although some will stay as long as 2 or 3 years before starting the migration to the ocean. Migration from the lake to the ocean usually occurs March through July, with very little time being spent in the estuaries. Sockeye will spend 1 to 4 years at sea depending on the region of the Pacific coast in which they originated from. Sockeye usually return to spawn as 3, 4, or 5 year old adults, depending on the different lengths of time they spend in freshwater and saltwater.

Under natural conditions, egg to sub-adult mortality is high in sockeye salmon. Man-made changes to the environment can further increase the high mortality rates. Abnormally high or low water temperatures, siltation, and pollution can greatly affect

the egg development, incubation time, and fry emergence from the gravel. The sockeye salmon's long residency time in freshwater lake environments makes it even more susceptible to environmental changes than other salmon which spend less time in freshwater and do not migrate as far inland.

For the Snake River sockeye salmon, the habitat would include tributaries to Redfish Lake, the lake itself, the outlet stream, the Salmon River, Snake River, Columbia River, the Columbia estuary, and the area of the Pacific Ocean where the stock migrates. Critical habitat for sockeye salmon populations in the Snake River differ between life stages and available fish collection/transportation technology. BPA believes the critical habitat of juvenile Snake River sockeye salmon consists of the spawning and rearing areas in the Stanley Basin lakes and the migratory path of the juveniles from the lakes to McNary Dam. Critical habitat for adult sockeye salmon includes the entire migratory pathway from the Pacific Ocean to the spawning grounds.

Sockeye salmon are carnivorous and opportunistic feeders like other salmon, but prefer to feed on plankton, crustacea, and insects throughout their life. The sockeye salmon is a highly migratory species that often migrates hundreds of miles up freshwater streams to spawn above lakes. Obstacles such as dams, large reservoirs, and irrigation diversions can seriously affect upstream and downstream migrations. Dams on the Snake and Columbia Rivers have affected the wild populations of sockeye that historically supported large commercial and tribal fisheries. An estimated 96% of the Columbia Basin's nursery lakes for sockeye salmon have been completely cut-off by tributary dams and/or type-converted for management of competing sportfish.

Adult sockeye salmon begin entering the Columbia River in April and continue to pass by dams through October. The majority of passage occurs from June through early August (Figure 4.5-3). Sockeye are unique among salmonids in their requirement for lakes for juvenile rearing areas. Because of this requirement, sockeye distribution in the Columbia and Snake Rivers is primarily limited to the Wenatchee and Okanogan river areas of the upper Columbia region and the upper Salmon River, a tributary to the Snake River. Juveniles rear in lakes in these systems for typically 1 to 2 years (Bjornn et al., 1968; Kline and Lamansky, 1997) before migrating to the ocean, typically from April into July (Figure 4.5-4). In the Snake River, some outmigration of wild juveniles occurs into November (Appendix M, Fish and Wildlife Coordination Act Report). Most adults spend 2 years in the ocean before returning to spawn, although some Okanogan River fish return after 1 year (Bjornn et al., 1968; Mullan et al., 1986).

Coho Salmon

Almost all coho salmon are restricted to the Bonneville pool downstream. Snake River coho were initially eliminated in the early 1900s, later re-introduced in the 1950s, and this stock went extinct in 1986 and have recently been stocked into the Clearwater River (see Section 4.5.1.2, Run Status). The only wild run above Bonneville Dam is found in Hood River, a tributary entering the Bonneville pool (BPA et al., 1995 [Appendix C]). Coho salmon enter the Columbia from August

through December. Passage over dams occurs from August through November, with the peak period in September and early October. The recent small numbers of reintroduced returns of coho salmon to the Clearwater River System from releases of hatchery fish by the Nez Perce Tribe have been passing Lower Granite primarily from September through November (Figure 4.5-3) (Appendix M, Fish and Wildlife Coordination Act Report). The spawning period in lower river areas typically would be from late September into December (BPA et al., 1995). The peak spawning period for the Hood River stock is November and December (Howell et al., 1985). Juveniles rear in tributary streams and outmigrate as yearlings in the spring, typically during April and May. The current hatchery stocks being released into the Clearwater River would be expected to pass the Snake River dams from late March into April (Appendix M, Fish and Wildlife Coordination Act Report), although recent counts show that most pass in May (FPC, 1999). Except for "jacks," which return after only one summer in the ocean, coho are consistent in their ocean rearing, spending only about 1.5 years in the ocean before returning to their natal stream to spawn.

Steelhead

Oncorhynchus mykiss have the greatest diversity of life history patterns of any Pacific salmonid species, including varying degrees of anadromy, differences in reproductive biology, and plasticity of life history between generations.

Although steelhead is defined as anadromous *O. mykiss*, resident forms can exist and are usually referred to as "rainbow" or "redband" trout. Few detailed studies have been conducted regarding the relationship between resident and anadromous *O. mykiss* and as a result, the relationship between these two life forms is poorly understood, there are areas where the separation between rainbow or redband trout and steelhead is obscured. In areas where anthropogenic barriers have isolated populations of *O. mykiss*, these landlocked populations could conceivably residualize and, therefore, continue to exist in the nonanadromous form. Where the two forms co-occur, "it is possible that offspring of resident fish may migrate to the sea, and offspring of steelhead may remain in streams as resident fish". Mullan et al. (1992) found evidence that in very cold streams, juvenile steelhead had difficulty attaining "mean threshold size for smoltification" and concluded that "Most fish here [Methow River, Washington] that do not emigrate downstream early in life are thermally-fated to a resident life history regardless of whether they were the progeny of anadromous or resident parents." In some inland populations, growth rate can cause *O. mykiss* to residualize (Mullan et al. 1992); this apparently involves both fish that grow too quickly and those that grow too slowly.

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity; since these runs are usually named for the season in which the peak occurs, some rivers may have runs known as winter, spring, summer, or fall steelhead. Through time, the names of seasonal runs have generally been simplified to two: winter and summer steelhead.

Biologically, steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry and duration of spawning

migration. The stream-maturing type (commonly known as fall steelhead in Alaska, summer steelhead in the Pacific Northwest and northern California) enters fresh water in a sexually immature condition and requires several months to mature and spawn. The ocean-maturing type (spring steelhead in Alaska, winter steelhead elsewhere) enters fresh water with well-developed gonads and spawns shortly thereafter.

In the Pacific Northwest, steelhead entering fresh water between May and October are considered summer steelhead, and steelhead that enter fresh water between November and April are considered winter steelhead. Variations in migration timing exist between populations, although there is considerable overlap. Some river basins have both summer and winter steelhead; others have only one type. It appears that the summer, or stream-maturing, steelhead occur where habitat is not fully utilized by winter steelhead; summer steelhead usually spawn farther upstream than winter steelhead. In rivers where the two types co-occur, they are often separated by a seasonal hydrologic barrier, such as a waterfall. Coastal streams are dominated by winter steelhead, whereas inland steelhead of the Columbia River Basin are almost exclusively summer steelhead. Winter steelhead may have been excluded from inland areas of the Columbia River Basin by Celilo Falls, or by the great migration distance from the ocean. It is thought that hatchery practices and modifications in the hydrology of the basin caused by large-scale water diversions can alter the migration timing of steelhead into certain basins.

A- and B-run steelhead--Inland steelhead of the Columbia River Basin, especially the Snake River Subbasin, are commonly referred to as either A-run or B-run. These designations are based on the observation of a bimodal migration of adult steelhead at Bonneville Dam (Columbia River kilometer [RKm] 235) and differences in age (1- versus 2-ocean) and adult size observed among Snake River steelhead. Adult A-run steelhead enter fresh water from June to August; as defined, the A-run passes Bonneville Dam before 25 August. Adult B-run steelhead enter fresh water from late August to October, passing Bonneville Dam after 25 August. Above Bonneville Dam (e.g., at Lower Granite Dam on the Snake River, 695 km from the mouth of the Columbia River), run-timing separation is not observed, and the groups are separated based on ocean age and body size. A-run steelhead are defined as predominately age-1-ocean, while B-run steelhead are defined as age-2-ocean. Adult B-run steelhead are also thought to be on average 75-100 mm larger than A-run steelhead of the same age; this is attributed to their longer average residence in salt water. It is unclear, however, if the life history and body size differences observed upstream have been correlated back to the groups forming the bimodal migration observed at Bonneville Dam. Furthermore, the relationship between patterns observed at the dams and the distribution of adults in spawning areas throughout the Snake River Basin is not well understood. A-run steelhead are believed to occur throughout the steelhead-bearing streams of the Snake River Basin; additionally, inland Columbia River steelhead outside of the Snake River Basin are also considered A-run. B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon Rivers.

Oncorhynchus mykiss that are anadromous can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. The half-pounder life history type in southern Oregon and northern

California spends only 2 to 4 months in salt water after smoltification, then returns to fresh water and outmigrates to sea again the following spring without spawning. Another life history variation is the ability of this species to spawn more than once (iteroparity), whereas all other species of *Oncorhynchus*, except *O. clarki*, spawn once and then die (semelparity).

The most widespread run type of steelhead is the winter (ocean-maturing) steelhead that occur in essentially all coastal rivers of Washington, Oregon, and California. Inland steelhead of the Columbia River Basin, however, are essentially all stream-maturing steelhead; as discussed earlier, these inland steelhead are referred to in terms of A-run and B-run.

Available information for natural populations of steelhead reveals considerable overlap in migration and spawn timing between populations of the same run type. Moreover, there is a high degree of overlap in spawn timing between populations regardless of run type. Most populations in Washington begin spawning in February or March. Relatively little information on spawn timing is available for Oregon and Idaho steelhead populations.

Steelhead exhibit great variation in smolt age and ocean age both within and between populations, but there are some trends. Smolt age is based on scale and otolith data from adult steelhead. The emphasis on adult steelhead is based on the assumption that fish surviving to spawning age are expressing the successful and adaptive life history strategy for steelhead in a given geographical location. Steelhead from British Columbia and Alaska most frequently smolt after 3 years in fresh water. In most other populations for which there are data, the modal smolt age is 2 years. Hatchery conditions usually allow steelhead to smolt in 1 year; this difference is often used by biologists to distinguish hatchery and wild steelhead. There appears to be an increase in the frequency of naturally produced 1-year-old smolts in the southern portion of the steelhead range. North American steelhead most commonly spend 2 years (2-ocean) in the ocean before entering fresh water to spawn.

For most steelhead populations, total age at maturity can be estimated by adding the smolt age and saltwater age. However, summer steelhead (especially in the Columbia River Basin) enter fresh water up to a year prior to spawning, and that year is generally not accounted for in the saltwater age designation; for example, a 2-ocean steelhead from the Yakima River may actually have 3 years between smolting and spawning.

Determining total age at maturity for inland steelhead of the Columbia River Basin is complicated by variations in reporting methods. Generally, these fish spend a year in fresh water prior to spawning and this is not included in the age designation. Therefore, by adding 1 year after freshwater entry, most Columbia River inland steelhead are 4 years old at maturity. Most of the available age data for Snake River steelhead are based on length frequency; smolt age is often assumed or not reported. The data that are available from scales show a high degree of variability in age structure, from 4-year-old spawners in the Clearwater River to 7 year-old spawners in the South Fork Salmon River.

As noted above, most species of *Oncorhynchus* die after spawning, whereas *O. mykiss* may spawn more than once. The frequency of multiple spawnings is variable both within and among populations. For North American steelhead populations north of Oregon, repeat spawning is relatively uncommon, and more than two spawning migrations is rare. In Oregon and California, the frequency of two spawning migrations is higher, but more than two spawning migrations is still unusual. The largest number of spawning migrations for which we found data was five, from the Siuslaw River, Oregon. Iteroparous steelhead are predominately female.

Steelhead adults typically spawn between December and June. Depending on water temperature, steelhead eggs may incubate in "redds"" for 1.5 to 4 months before hatching as "alevins"" (a larval life stage dependent on food stored in a yolk sac). Following yolk sac absorption, alevins emerge from the gravel as young juveniles or "fry" and begin actively feeding. Juveniles rear in fresh water from 1 to 4 years, then migrate to the ocean as "smolts".

Two major genetic groups or "subspecies"" of steelhead occur on the west coast of the United States: a coastal group and an inland group, separated in the Fraser and Columbia River Basins by the Cascade crest approximately. Behnke (1992) proposed to classify the coastal subspecies as O. m. irideus and the inland subspecies as O. m. gairdneri. These genetic groupings apply to both anadromous and nonanadromous forms of O. mykiss. Both coastal and inland steelhead occur in Washington and Oregon. California is thought to have only coastal steelhead while Idaho has only inland steelhead.

Historically, steelhead were distributed throughout the North Pacific Ocean from the Kamchatka Peninsula in Asia to the northern Baja Peninsula. Presently, the species distribution extends from the Kamchatka Peninsula, east and south along the Pacific coast of North America, to at least Malibu Creek in southern California. There are infrequent anecdotal reports of steelhead continuing to occur as far south as the Santa Margarita River in San Diego County. Historically, steelhead likely inhabited most coastal streams in Washington, Oregon, and California as well as many inland streams in these states and Idaho. However, during this century, over 23 indigenous, naturally-reproducing stocks of steelhead are believed to have been extirpated, and many more are thought to be in decline in numerous coastal and inland streams in Washington, Oregon, Idaho, and California. Forty-three stocks have been identified by Nehlsen et al. (1991) as being at moderate or high risk of extinction.

This inland steelhead ESU occupies the Snake River Basin of southeast Washington, northeast Oregon and Idaho. The Snake River flows through terrain that is warmer and drier on an annual basis than the upper Columbia Basin or other drainages to the north. Geologically, the land forms are older and much more eroded than most other steelhead habitat. The eastern portion of the basin flows out of the granitic geological unit known as the Idaho Batholith. The western Snake River Basin drains sedimentary and volcanic soils of the Blue Mountains complex. Collectively, the environmental factors of the Snake River Basin result in a river that is warmer and more turbid, with higher pH and alkalinity, than is found elsewhere in the range of inland steelhead.

Snake River Basin steelhead are summer steelhead, as are most inland steelhead, and comprise 2 groups, A-run and B-run, based on migration timing, ocean-age, and adult

size. Snake River Basin steelhead enter fresh water from June to October and spawn in the following spring from March to May. A-run steelhead are thought to be predominately l-ocean, while B-run steelhead are thought to be 2-ocean. Snake River Basin steelhead usually smolt at age-2 or -3 years.

The steelhead population from Dworshak National Fish Hatchery (NFH) is the most divergent single population of inland steelhead based on genetic traits determined by protein electrophoresis. Additionally, steelhead returning to Dworshak NFH are considered to have a distinctive appearance and are the one steelhead population that is consistently referred to as B-run. NMFS considered the possibility that Dworshak NFH steelhead should be in their own ESU. However, little specific information was available regarding the characteristics of this population's native habitat in the North Fork Clearwater River, which is currently unavailable to anadromous fish due blockage by Dworshak Dam.

Historically, Snake River steelhead spawned naturally in tributaries or the mainstem of the Clearwater, Salmon, Weiser, Payette, Boise, and Bruneau rivers, and numerous smaller streams in Idaho, the Tucannon River, Asotin Creek and smaller streams in Washington, and the Grande Ronde, Imnaha, Powder, Burnt, and Owyhee Rivers and other smaller streams in Oregon. Construction of storage, mill, and power dams cut off access to most spawning areas.

Steelhead and rainbow trout usually spawn from 2-4 years after their parents spawned. This age can vary greatly depending on size and genetics (Behnke, 1992). Trout that have a territory that is very productive will usually have a large body size at an early age, and therefore will often breed sooner that a fish that lives in a less productive area. On the other hand, anadromous and lacustrine populations of rainbow trout have a genetic disposition for an older age at first breeding. Increased fecundity in these populations offsets disadvantages of later breeding. The relative fecundity ranges from 1,200 to 3,200 eggs per kilogram of body weight (Behnke, 1992). The majority of rainbow trout die after spawning. Only 5 to 20 percent of steelhead runs are repeat spawners (Behnke, 1992).

Steelhead spawning behavior typically begins during the spring (December - April). The actual spawning times vary greatly among regions with temperature and water flow. Temperatures of 3-6 degrees Celsius often initiate spawning behavior, although actual spawning does not usually occur until temperatures reach 6-9 degrees Celsius (Behnke, 1992). Along with temperature and water flow, light also tends to trigger spawning behavior in rainbow trout. When the temperature is correct, the water flow is elevated (if in moving water), and the amount of daylight in a day is adequate, the rainbow trout begin their spawning migrations. In lacustrine populations, this often means moving from the lake waters into the in-current stream in which they were hatched. If the lake is not stream-fed, the trout will usually move into shallow waters near the shore. In freshwater river populations, migration means moving from the feeding-grounds of a large river or stream into a smaller, cool-water tributary. When the environmental conditions are correct for an anadromous rainbow trout (steelhead), they begin their migration from the sea into their freshwater birthing-grounds. They use a combination of olfactory senses and lateral line sensing, to detect scents, pH, and electromagnetic fields from their native spawning habitat. In all of the forms of

rainbow trout, the environmental conditions which promote spawning behavior activate the pituitary gland. The gland releases hormones which cause the gonads to develop into spawning form. The gonads then produce hormones which are responsible for changes in body color, fin development, and body and head form (most evident in steelhead).

Behnke (1992) describes four types of habitat that rainbow trout need during their life. The first is spawning habitat, which is typically is small, cool-water streams. The spawning habitat must have adequate gravel for the redd, and the gravel must not be too fine or it will not let oxygen to the eggs. The water flow must not be too rapid. Very rapid water flow will carry the gravel of the redd, and the eggs, downstream. The second necessary habitat type for rainbow trout is rearing habitat. This habitat must have very adequate protective cover. At this stage of life, the fish is extremely susceptible to predation. The area must have water of low velocity. The fish are not yet strong enough to fight heavy currents for long periods of time. It also must have adequate food sources. A large amount of growth occurs during this time. Trout will usually stay in rearing habitat from birth to the second year of life. The third necessary habitat type is adult habitat. Trout tend to move to these areas during the second year of life. This habitat usually has water depths of 0.3 meters or greater. It is usually an area in which rapid-flow water meets calm water. This allows the fish to rest in the calm water and search for food and cover in the faster water. The cover in these areas often includes boulders, logs, vegetation, and undercut stream banks. The fourth necessary habitat type is overwintering habitat. These areas are usually in deep waters. Stream fish move down to larger rivers, while lake fish move into deeper parts of the lake where the water tends to be low velocity. There has to be a large amount of protective cover and an adequate amount of food. Obviously, all of these trout habitat categories apply to the anadromous steelhead. The spawning and rearing habitats tend to be the same, although the duration in which they stay in these habitats may be shorter. At the smolt stage of trout development, after rearing, the anadromous trout migrate to sea. In the sea they tend to be epipelagic swimmers. The epipelagic zone of the sea has a high food supply, cover near the shore, slow moving water. It almost is analogous with the overwintering habitat of the rainbow trout or steelhead that remain in freshwater.

Regardless of the habitat they are in, rainbow trout require high amount of dissolved oxygen in the water (at least 80 percent saturation). Optimal temperature is between 7 and 17 degrees Celsius. Rainbow trout will die at temperatures above 28 degrees Celsius. Optimal pH for trout survival is between 7 and 8.

The water column of a lake environment can be described into three zones, all of which may contain steelhead and rainbow trout. The littoral zone, which is close to shore, usually has an abundance of vegetation and may be the only real trout cover in the lake. This zone contains the majority of aquatic insects in the lake. The majority of rainbow trout in a lake are probably found in this zone. The limnetic zone is the open water of the lake. It goes down to the depth of light penetration. The profundal zone is underneath the limnetic zone to the bottom of the lake. Organic material in the limnetic zone often sinks into this zone. Trout will feed here if competition is high in the other zones, or if the food biomass is high in this zone.

Steelhead in the ocean are predominantly epipelagic swimmers. The epipelagic zone is the lighted layer of the ocean near the surface where steelhead can feed on a large variety of oceanic food occupying this zone. Steelhead have been documented swimming in the middle of the Pacific Ocean, but the majority stay closer to the shores.

Steelhead and rainbow trout are typically diurnal, opportunistic feeders. They are carnivores, which feed in a rover-predator style. The majority of their diet consists of aquatic insects, although they will eat crayfish, grasshoppers, winged bugs, worms, salamanders, and other fish (including other trout). They will also occasionally feed on benthic invertebrates when the benthic food supply is great, and/or the competition for epipelagic food is increased (Behnke, 1992).

Steelhead and rainbow trout optimal feeding temperature is between 13 and 16 degrees Celsius. They will usually cease feeding between temperatures of 22 and 25 degrees Celsius. Rainbows in streams usually occupy a "station", which they have obtained through dominance and/or battle. This station usually has some sort of cover so the trout can hide from predators while it searches the water for food.

Dominance plays an important role in the feeding behavior of rainbow trout. Larger rainbows tend to have dominance over the quantity and quality of food sources in limited food environments and are more likely to feed in the risk of predation than smaller rainbows. This behavior may have to do with the increased ability of escape of the larger fish, which in turn may enable the fish to feed in more productive areas (high risk-high gain feeding). On the other hand, juvenile steelhead and rainbow trout are preyed upon by a number of organisms. Pikeminnow and bass are well known trout predators, often feeding on trout that are delayed by low flow or artificial barriers. Other salmonids will also prey upon developing rainbow trout, including salmon, steelhead, and larger trout. There are also numerous predators on land and in the air, including bears, martins, fishers, otters, osprey, and eagles.

Like salmon runs from other parts of the Columbia River Basin, Snake River salmon depend upon conditions in the estuary and the nearshore ocean during the critical first few months of their saltwater life. Relatively little is known about this phase of their life, other than survival rates inferred from tagging studies. Typically, a portion of the production from a particular brood year (jacks and mini-jacks) returns to the Columbia River after a few months to 1 year in seawater. The rate of return of jacks may provide a good indication of the strength of future year classes. Adults return to spawn after 2, 3, 4, or more years at sea, and the cycle continues.

Chum Salmon

Although a few chum salmon do pass Bonneville Dam, they are essentially restricted in their distribution to a few small Columbia River tributaries below Bonneville Dam, including Grays Basin, Hardy Creek, and Hamilton Creek (Howell et al., 1985). Recently, some have been observed spawning in a small area of the mainstem Columbia River just downstream of Bonneville Dam. They enter the Columbia River in mid-October through November. Peak spawning typically occurs in late November into mid-December in tributary streams. Juveniles emerge from the gravel their first winter/spring and migrate almost immediately downstream to the ocean as fry stage

juveniles (Salo, 1991), with peak stream abundance from mid-March to mid-May (Howell et al., 1985). Columbia River stock adults rear in the ocean primarily 3 to 4 years before returning to their natal streams to spawn.

American Shad

American shad, a member of the herring family, is a non-native fish imported from the Atlantic coast which has successfully established a population in the Columbia-Snake River System. They were first introduced to the Pacific Coast in the 1870s and 1880s in the Sacramento River. They were first observed in the Columbia River in 1877 and were later released into the Columbia River System in 1885 and 1886 (Craig and Hacker, 1940). Adults enter the Columbia River beginning in April through August. The majority of passage occurs from mid-May through July at Bonneville Dam. Abundance decreases as they move upstream but some fish do pass Lower Granite. Passage stops at Priest Rapids Dam on the upper Columbia. Shad spawn in varied areas but may prefer shallow, gently sloping areas with clean sand and gravel (BPA et al., 1995). Tailwater regions below various dams may be important spawning areas (Appendix M, Fish and Wildlife Coordination Act Report). The spawning period peaks from late June to early August at Bonneville Dam and upstream. Larvae and juveniles rear in the reservoirs, outmigrating in the late fall and winter (October through December) of their first year, when they are about 4 inches long. Adults spend 3 to 4 years in the ocean before returning to spawn in their natal stream (Wydoski and Whitney, 1979).

Sturgeon

White sturgeon, a member of an ancient group of cartilagineous fish without true bones, are the largest anadromous fish in the Western Pacific, reaching a size of up to 1,800 pounds. They may live over 80 years (Wydoski and Whitney, 1979). The stock is indigenous to the Columbia River System, and there are both anadromous and non-anadromous varieties. However, the anadromous variety from below Bonneville Dam is considered to be essentially separate from the resident populations found in the reservoirs and rivers upstream of Bonneville Dam because few anadromous fish migrate past the dams (ODFW and WDFW, 1998). This species is also relatively abundant in the Snake River above Lower Granite (BPA et al., 1995). The populations within the reservoirs complete their lifecycle without ever entering the ocean, with most remaining entirely within the reservoir of their birth. The anadromous form is present in the Columbia River below Bonneville Dam the entire year, although seasonal movements occur. Fish are not likely to spawn until they are greater than 10 and 20 years of age for males and females, respectively (Scott and Crossman, 1973). Adults may spawn only once every 2 to 8 years. Spawning typically occurs from April into July in the lower Columbia River (Parsley et al., 1993). In reservoirs and below Bonneville Dam, spawning often occurs in the tailrace areas which contain suitable habitat that varies with flow quantity (Parsley and Beckman, 1994; Parsley et al., 1993). Eggs develop into larvae which settle to the bottom. Young-of-the-year and juveniles are found in mid-depth to deep water shelves in lower Snake River reservoirs (Bennett et al., 1988, 1997) and in deep water

areas of lower Columbia River reservoirs and below Bonneville Dam (Parsley et al., 1993; McCabe and Tracy, 1994).

Pacific Lamprey

The Pacific lamprey are members of a primitive group of fish with cartilage instead of bones. Lamprey resemble eels. As adults in the marine environment, they are parasitic on other fish. Adults enter freshwater between April and June, migrating to spawning areas by September (Close et al., 1995). Peak upstream dam passage typically occurs during July, August, and September (Corps, 1997, 1998b). Spawning typically occurs the following June and July, generally in low-gradient stream sections where gravel is deposited. Spawning typically occurs in flowing water areas, although it may occur in slack water environments (Close et al., 1995). Spawning has been observed in small tributaries entering mainstem reservoirs (Wydoski and Whitney, 1979). Current distribution includes fish ascending to both the Hells Canyon and Chief Joseph Dams. Although distribution within tributaries is not well known (Close et al., 1995), there are low numbers in many major tributaries above Bonneville Dam (Jackson and Kissner, 1998). After hatching, juvenile stages (ammocoetes) drift downstream and burrow into the substrate sand or mud. After residing in the substrate for 5 to 6 years, juvenile lamprey metamorphose and outmigrate to the sea, primarily from April through mid-July. Passage at dams on the Columbia River, based on juvenile collection facility capture, has been from March to June, with the majority passing dams in May and June. But most migrants may not use the passage facilities, and these facilities are not operated in late fall and winter, so estimates of migration timing may not be completely accurate (Close et al., 1995). After 20 to 40 months in the ocean, they return to spawn in the river systems (Kan, 1975).

4.5.1.2 Run Status

Before Euro-Americans settled and developed the region, annual runs of salmon and steelhead returning to the Columbia River were estimated to be 8 to 16 million fish (NPPC, 1986). During the late 1970s and early 1980s, it was estimated that total runs had decreased to about 2.5 million salmon and steelhead (including fish harvested in the ocean) (NPPC, 1986). With the increase in hatchery production, the portion of wild fish decreased from about 75 percent in the 1970s to about 25 percent by the mid- to late-1980s. Since 1938, the estimate of minimum total salmon and steelhead surviving the ocean conditions and ocean harvest and returning to the river has ranged from 0.7 to 3.2 million fish (Figure 4.5-5). The values in Figure 4.5-5 are based on Bonneville Dam counts, plus estimates from lower river harvest and tributary turnoff. Because fish count data are reported over different time periods by location and stock, and because FR/EIS decisions were primarily based on information that is not the most recent (2001 returns), most count data reported here are limited to the period from 1999 to 2000. However, counts of fish over dams during 2001 are noted where information is readily available. In 1995, the lowest historical estimate of 670,000 salmon and steelhead entered the Columbia River occurred, but estimates have increased in recent years. During 2001, total salmon and steelhead entering the Columbia River greatly exceeded 2 million fish, based on the number counted at Bonneville Dam. Only about one-quarter of all recently returning fish are wild fish

(ODFW and WDFW, 2000). Many factors affect abundance of stocks that return to the Columbia River System. These include conditions in both the freshwater and marine environment. Some may be local and others more regional in their effect. For example, the large increase in returning chinook in the mid-1980s appeared to be a regional phenomenon; many west coasts stocks of chinook from California to Washington showed a large increase in returns during this year (Olsen and Richards, 1994). The causes are likely related to regional weather and ocean rearing conditions during this period.

While much of the habitat for salmon and steelhead has been lost or altered, many areas still support runs. Table 4.5-1 lists the salmon and steelhead races in streams. The overall trend for wild salmon and steelhead originating from the Columbia-Snake River System has been a decrease in numbers. NMFS has used the term "Evolutionary Significant Units" (ESUs) to define anadromous fish populations being considered for listing under the ESA (Waples, 1991). The term ESU may include portions or combinations of more commonly used definitions of stocks within or across regions and therefore may not correlate exactly with stocks discussed. This declining trend and the low numbers of returning wild fish have resulted in the listing of 12 ESUs and the currently proposed listing of one other in the Columbia-Snake River System as threatened or endangered under the Federal ESA (Table 4.5-2). The listings include four Snake River ESUs: sockeye salmon, fall chinook salmon, spring/summer chinook salmon, and steelhead. As a result of these listings, the portions of the Columbia and Snake Rivers used by the listed Snake River salmon species have been designated as critical habitat under the ESA. Other anadromous fish ESUs in the Columbia-Snake River System that are listed, proposed for listing, or proposed as candidate species include: listed as endangered—the upper Columbia River steelhead and upper Columbia River spring-run chinook salmon; listed as threatened—lower Columbia River steelhead; lower Columbia River chinook salmon, and upper Willamette River chinook salmon, middle Columbia River steelhead, and upper Willamette River steelhead; and the Southwestern Washington/Columbia River coastal cutthroat trout; candidate species—the southwest Washington/lower Columbia River coho salmon. The proposed listing of the Deschutes River fall chinook as part of the threatened Snake River fall chinook ESU has been deferred.

Snake River Spring and Summer Chinook Salmon

Prior to the arrival of Euro-Americans, the Snake River Basin produced about 1.4 million chinook salmon (NPPC, 1986). By the mid-1950s, this number was reduced by 95 percent, and another tenfold decrease has occurred in the last 30 to 40 years (Matthews and Waples, 1991).

The numbers of spring and summer chinook redds in index areas have decreased steadily from initial counts in 1957 of over 13,000 redds in all index areas (Matthews and Waples, 1991) to less than 600 in 1980. Index counts of spring and summer chinook salmon in comparable regions of Idaho and Northeast Oregon have decreased from the early 1960s to 1980. Counts have fluctuated since then with lowest counts occurring in 1995 at less than 200 total redds counted in all index areas (Figure 4.5-6) (ODFW and WDFW, 2000).

Table 4-5-1. Wild and Hatchery Races of Salmon and Steelhead in the Columbia River Basin

	Race							
	Spring Chinook	**Summer Chinook**	**Fall Chinook**	**Coho**	**Sockeye**	**Chum**	**Winter Steelhead (B Run)**	**Summer Steelhead (A Run)**
Lower Columbia River (Below Bonneville Dam)[1/]								
Lower Columbia River (Mainstem)			X	X		X	X	X
Grays River			X	X		X	X	
Elochoman River			X	X		X	X	X
Cowlitz River	X		X	X			X	X
Kalama River	X		X	X			X	X
Lewis River	X		X	X		X	X	X
Willamette River	X		X	X			X	X
Sandy River	X		X	X			X	X
Washougal River	X		X	X			X	X
Mid-Columbia (Bonneville Dam to Priest Rapids Dam)[1/]								
Mid-Columbia (Mainstem)			X	X				X
Wind River	X		X	X			X	X
Little White Salmon River	X		X	X				
White Salmon River	X		X	X			X	X
Hood River	X		X	X			X	X
Klickitat River	X		X	X			X	X
Fifteen Mile Creek							X	
Deschutes River	X	X	X	X				X
John Day River	X							X
Umatilla River	X		X	X				X
Walla Walla River	X							X
Mid-Columbia Mainstem (Hanford Reach)			X					X
Yakima River	X	X	X	X	X			X
Snake River								
Snake River (Mainstem)			X					X
Tucannon River	X							X
Clearwater River	X	X	X	X[2/]				X
Grande Ronde River	X		X					X
Imnaha River	X		X					X
Salmon River	X	X	X		X			X
Upper Columbia River (Priest Rapids Dam to Chief Joseph Dam)[1/]								
Upper Columbia (Mainstem)			X	X				X
Wenatchee River	X	X			X			X
Entiat River	X							X
Methow River	X	X						X
Okanogan River	X	X			X			X

Source: CBFWA, 1991.
1/ Definition and terminology for Columbia River reaches are those of the source.
2/ Introduced in 1995.

Table 4.5-2. Federally Listed, Proposed, or Candidate Anadromous Fish Species in the Columbia River Basin

	Major Regional Distribution[1/]			
Species/ESU Status/Fed. Reg. Month & Year	**Snake River**	**Upper Columbia River (above McNary Dam)**	**Middle Columbia River (Between McNary and Bonneville Dams)**	**Lower Columbia River (Below Bonneville Dam)**
Snake River Fall-Run Chinook Salmon (T, 4/92)	X			
Snake River Spring/Summer-Run Chinook Salmon (T, 4/92)	X			
Snake River Sockeye Salmon (E, 11/91)	X			
Snake River Steelhead (T, 8/97)	X			
Upper Columbia River Spring-Run Chinook Salmon (E, 3/99)		X		
Upper Columbia River Steelhead (E, 8/97)		X		
Middle Columbia River Steelhead (T, 3/99)		X (Below Priest Rapids Dam)	X	
Southwest WA/Columbia River Coastal Cutthroat Trout (PT, 3/99)			X (Below The Dalles Dam)	X
Lower Columbia River/Southwest WA Coho Salmon (C, 7/95)			X (Below The Dalles Dam)	X
Lower Columbia River Chinook Salmon (T, 3/99)				X
Lower Columbia River Steelhead (T, 3/98)				X
Columbia River Chum Salmon (T, 3/99)				X
Upper Willamette River Chinook Salmon (T, 3/99)				X
Upper Willamette River Steelhead (T, 3/99)				X

[1/] Minor exceptions to distribution region may occur
E = Endangered, T = Threatened, P = Proposed, C = Candidate

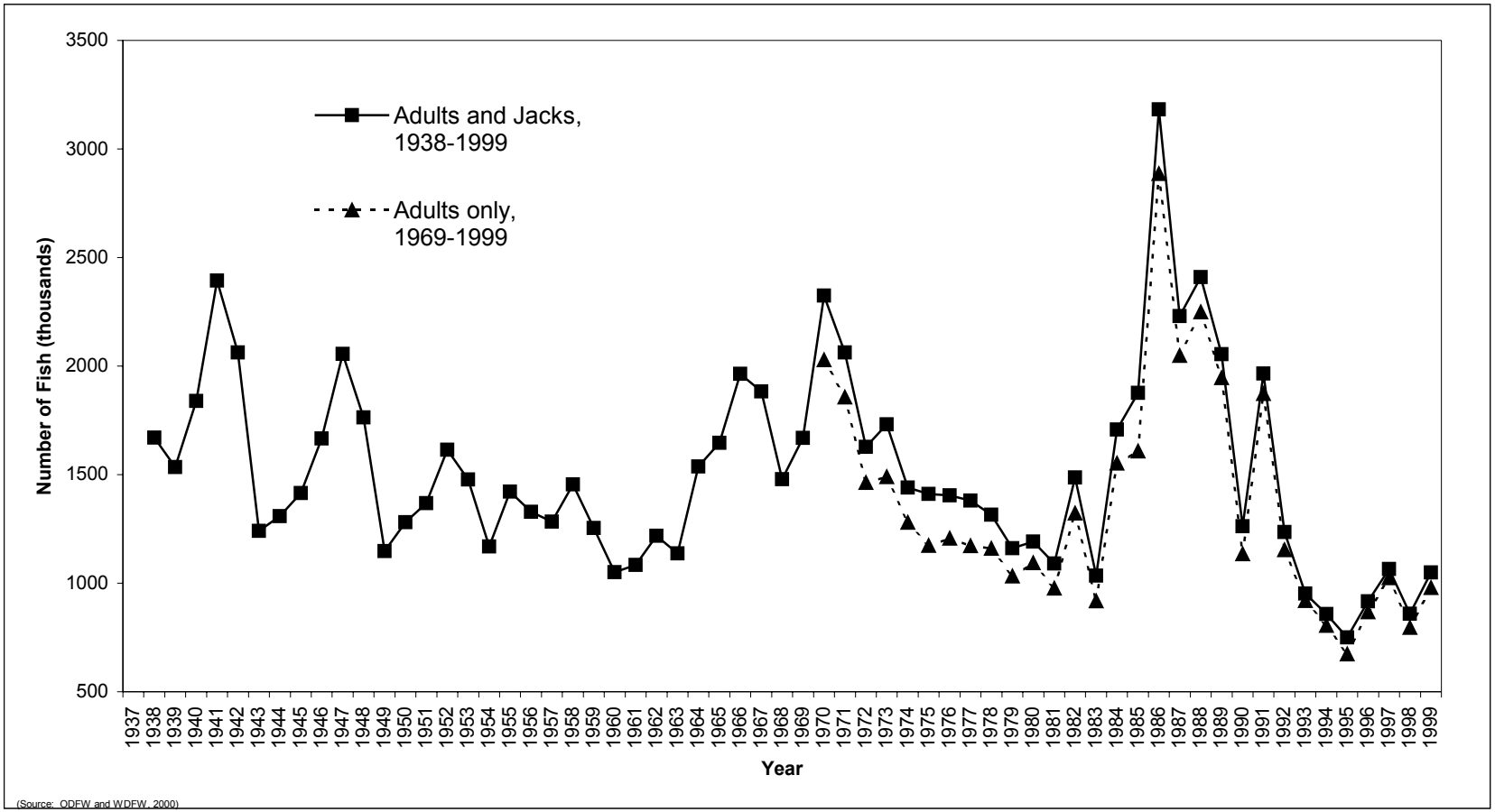


Figure 4.5-5. Minimum Numbers (in Thousands) of Salmon and Steelhead Entering the Columbia River, 1938 to 1999

Post-1977 estimates of wild and hatchery fish over Lower Granite, including most endangered stocks of spring and summer chinook salmon, showed a high in 1978 of 31,375 wild spring and 11,600 wild summer chinook salmon. Beginning in 1978,wild fish numbers decreased dramatically with subsequent moderate fluctuations (Figures 4.5-7 and 4.5-8). Lowest values were 305 summer chinook in 1994, and 745 spring chinook in 1995 over Lower Granite. Both stocks have increased substantially from these lowest values in recent years, including substantial increases in 2000 and 2001, but returns, especially of wild fish, still remain relatively low for purposes of species recovery. Hatchery fish, which are not considered part of the listed spring and summer stocks, have had large fluctuations. They had the lowest returns in 1995 with less than 400 fish from spring and summer stocks passing Lower Granite (Figures 4.5-7 and 4.5-8). These low values were followed in 1997 by the largest recorded count of these hatchery stocks over Lower Granite. In 2000, a count of total spring chinook (hatchery plus wild) showed that they were at their third highest level recorded at Lower Granite Dam at 33,822 since counts began in 1975. In 2001, the total count of hatchery and wild over Lower Granite Dam exceeded all counts, at 171,958 spring chinook. Total summer chinook (hatchery plus wild) in 2000 was about equal to the 10-year average at 3,933. Summer chinook in 2001 also increased to a high number of 13,735 adults. These are the highest since counts began in 1975.

Snake River Fall Chinook Salmon

Fall chinook salmon in the Snake River are assumed to have made up a significant portion of all chinook salmon in the system. Between 1910 and 1967, several hundred miles of spawning area were lost because dams were built upstream from Hells Canyon. Additional spawning area was lost when dams were built on the lower Snake River. Wild fall chinook salmon declined from an estimated average of 72,000 between 1938 and 1949 to 29,000 in the 1950s (Waples et al., 1991) to about 1,000 in the mid-1970s. Wild fish generally decreased through the 1970s and 1980s to a low in 1990, when 78 fall chinook passed Lower Granite. In recent years, however, fall chinook returns have increased, except in 1998, over Lower Granite (Figure 4.5-9). In fact, the second highest count on record of wild fish over Lower Granite Dam (905 fish) occurred in 1999. The determination of wild count has not been made for 2000 but overall count (hatchery plus wild) were 3,602, the highest count recorded at Lower Granite Dam. The 2001 counts of hatchery and wild fall chinook were also the highest on record at Lower Granite Dam, at 8,919. And like other chinook stocks "jack" counts were exceedingly high at 8,830 in 2000, suggesting a very high fall chinook return in 2001. Hatchery fish have also been increasing over Lower Granite in the mid-1980s because of hatchery releases from the Hagerman Hatchery. Later increases resulted from Lyons Ferry Hatchery strays on the lower Snake River, and Umatilla Hatchery strays, not of Snake River origin. Most recently, hatchery returns have increased from supplementation releases of Lyons Ferry juveniles on the Clearwater and Snake Rivers upstream of Lower Granite. Unlike the other listed salmon in the Snake River System, Lyons Ferry stock is considered part of the threatened Snake River fall chinook ESU. However, hatchery strays from other systems such as the Umatilla and Klickitat have also been increasing with many passing over Lower Granite Dam (Mendel, 1998).

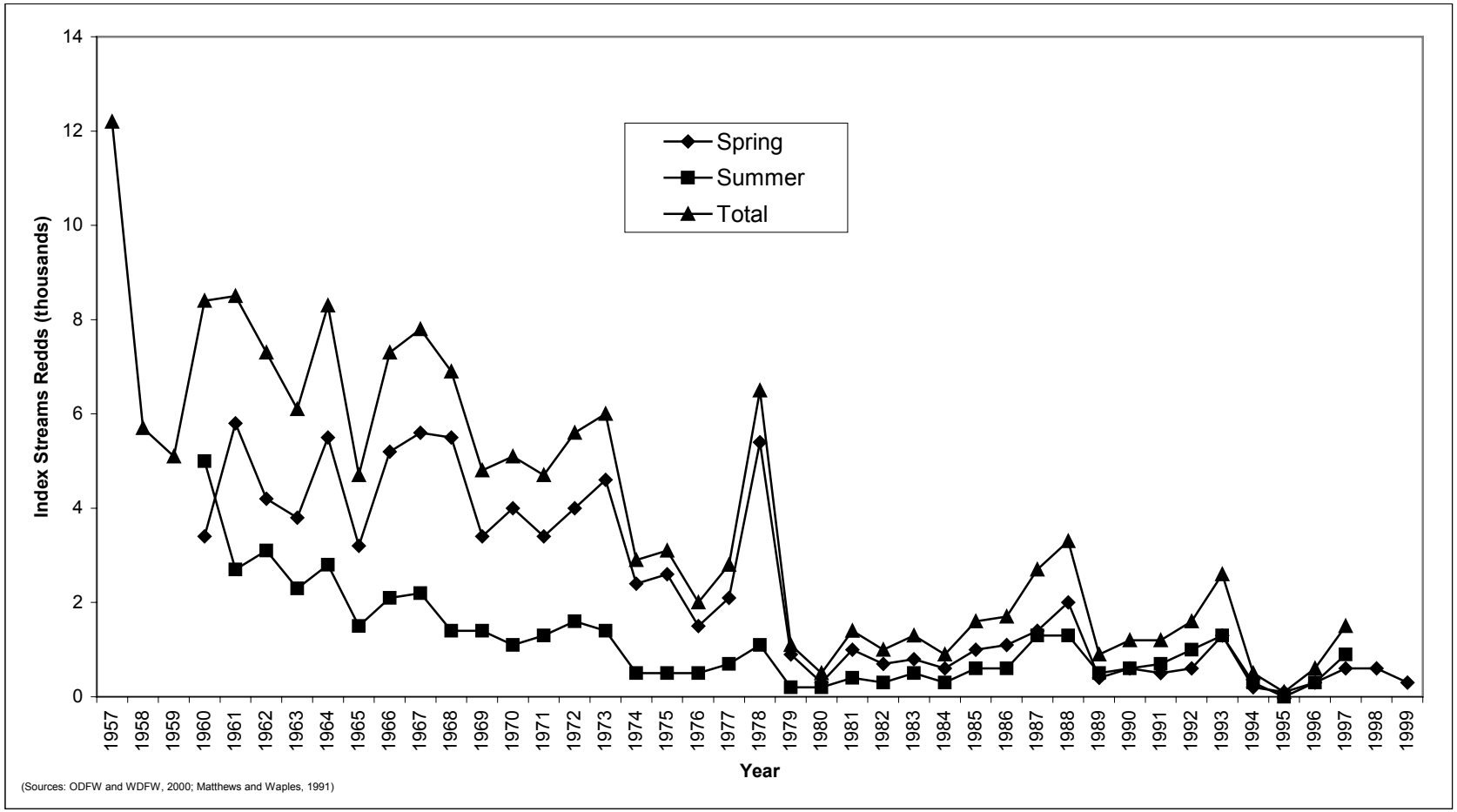


Figure 4.5-6. Index Streams Spring and Summer Chinook Redd Counts in Northeast Oregon and Idaho, 1957 to 1999

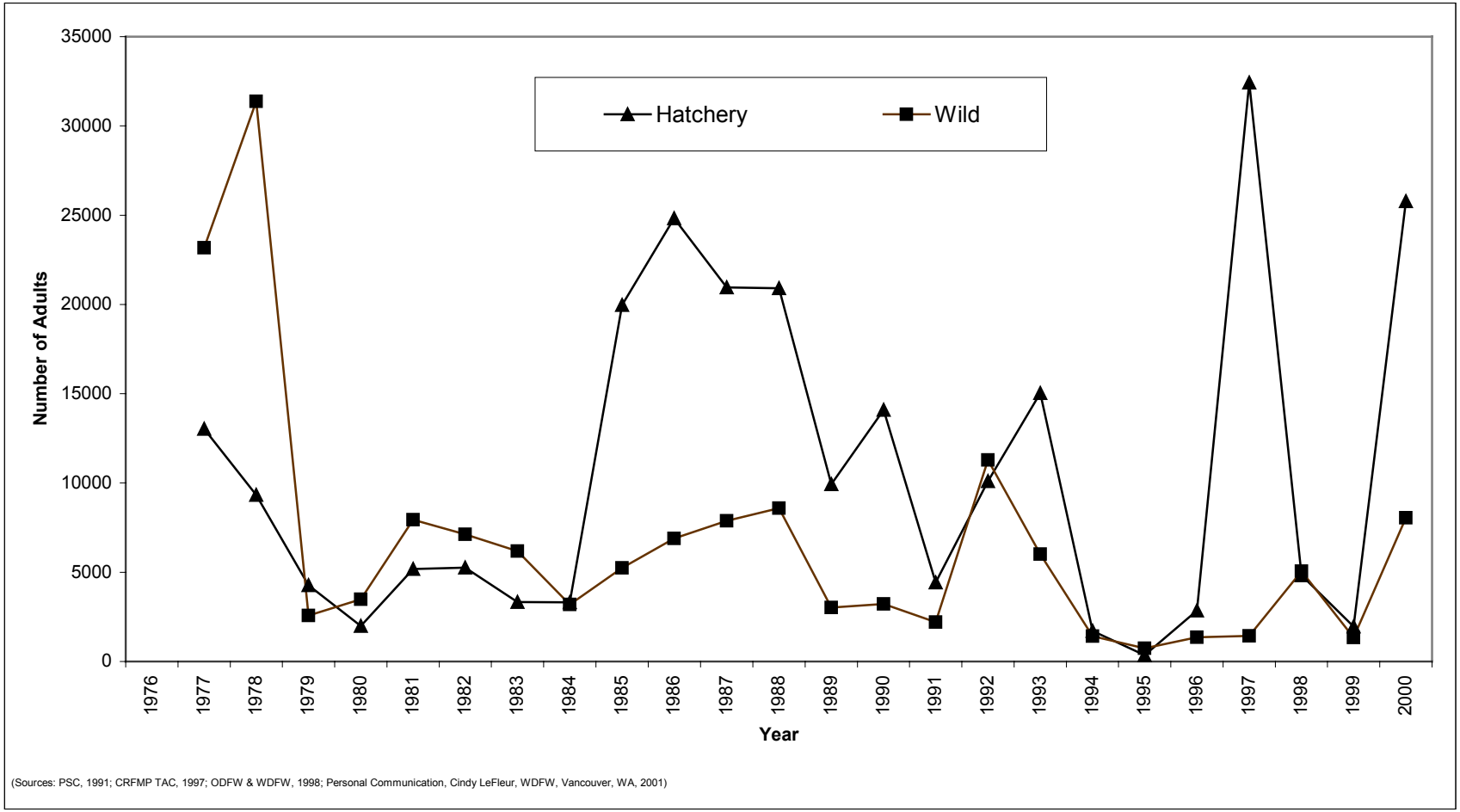


Figure 4.5-7. Estimated Wild and Hatchery Adult Spring Chinook Passing Lower Granite Dam, 1977 to 2000

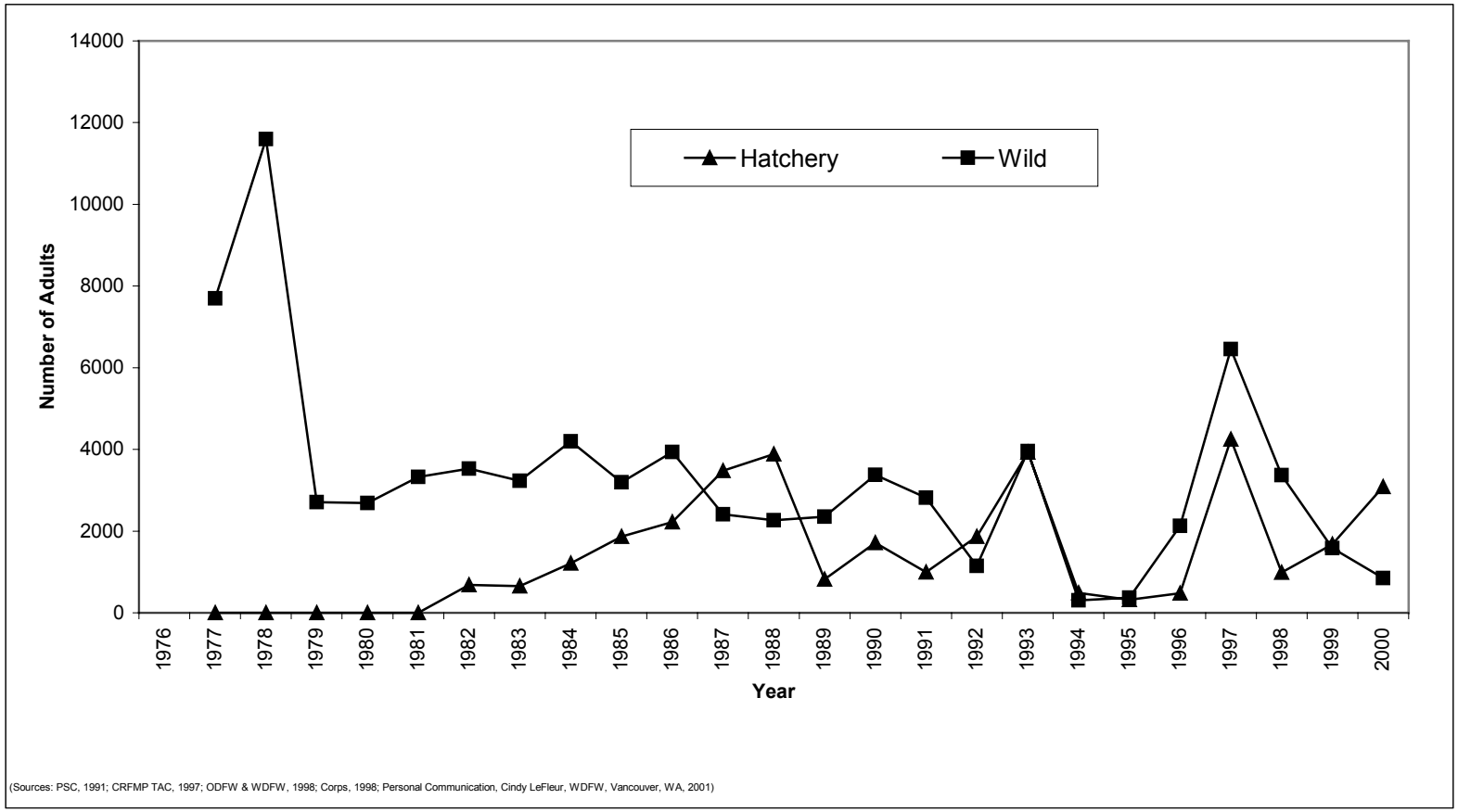


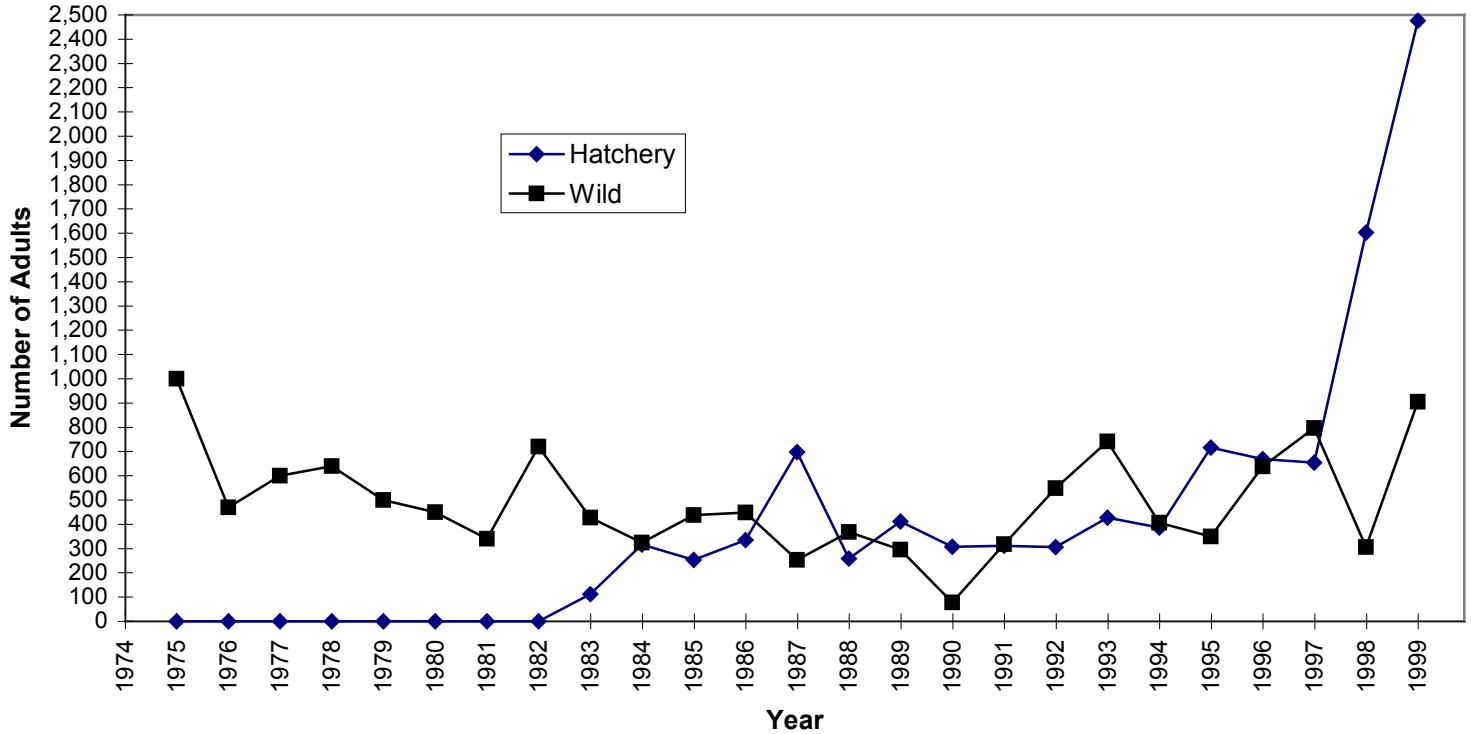
Figure 4.5-8. Estimated Wild and Hatchery Adult Summer Chinook Passing Lower Granite Dam, 1977 to 2000

The straying of adults from other systems, hatchery introductions, and changes in the system lead to the question of whether the current stock is the same as the original stock that was adapted to this system (Waples et al., 1991). Based on available information, it was concluded that it was not possible to determine that they were not the original stock, even though many changes had occurred. The historical juvenile rearing habitat may have also changed. Due to earlier warming of the water before completion of the Hells Canyon Complex of three dams, it appears that juvenile fall chinook may have migrated out of the system early under the declining peak flows of May and June, possibly to continue their rearing farther downstream (Appendix M, Annex D). Little information is available to indicate the rearing extent within the Snake River proper of the native stocks. It is known that historical summer temperatures in July and August were well in excess of optimal temperatures for juvenile chinook. This early migration out of the middle and lower Snake River may still be occurring with some alternate life-history subpopulation of fall chinook. PIT tag studies have found that some fish that left the Snake River in one year appeared the next spring passing McNary Dam. Survival of these fish was in fact much higher overall—over three times that of fish that left as smaller subyearlings the previous spring (PATH Decision Analysis Report for Snake River fall chinook [Draft], May 14, 1999).

Snake River Sockeye Salmon

Historical Snake River sockeye salmon runs might have numbered 150,000 fish (NPPC, 1986). Much of the rearing habitat, primarily lakes, is no longer accessible or suitable due to nutrient depletion or displacement from state eradication programs where outcompeted by rainbow trout or other species' stocking programs. In the Snake River subbasin, sockeye were eliminated from the Payette River, Wallowa River, and Salmon River by tributary dams in the late 1800s and early 1900s. Sockeye currently present in Red Fish Lake may have originated from either residuals, or those that may have spawned below Sunbeam Dam until fish ladders allowed passage or the dam was breached in 1934. Currently, the minimum estimate of spawners that the habitat is capable of producing in the Sawtooth Valley lakes of the upper Salmon River is about 6,000 fish (CBFWA, 1991). Until recently, only Redfish Lake in the Sawtooth Valley was accessible to sockeye salmon. The recent removal of blockages has allowed access to Lake Pettit and Alturus Lake.

The current restoration activities include using some of the historical lakes for outplanting captive broodstock offspring. Additionally, fertilization has been occurring in Redfish, Pettit, and Alturas Lakes to enhance production and ultimately growth and survival of hatchery reared juvenile sockeye that are being stocked into these lakes. Juveniles from the captive broodstock program have been stocked into these lakes with the goal of producing returning adults to these systems (Kline and Lamansky, 1997; Taki and Mikkelsen, 1997; Meeting Minutes, Stanley Basin Sockeye Technical Oversight Committee, February 25, 1999 and November 18, 1998). The peak for Redfish Lake escapement was measured at 4,361 fish in 1955 but declined after 1958 to fewer than 500 fish. Until 2000, dam counts had been below 100 since 1981 (Chapman et al., 1990). From 1989 through 1998, less than 12 total fish were counted over the dam, but in 1999 at least 14 sockeye were counted,



(Sources: PSC 1991, CRFMP TAC 1997, ODFW and WDFW 1998, Personal Communication, Debra Milks [WDFW], March 19, 2001)

Figure 4.5-9. Estimated Wild and Hatchery Adult Fall Chinook Passing Lower Granite Dam, 1977 to 1999

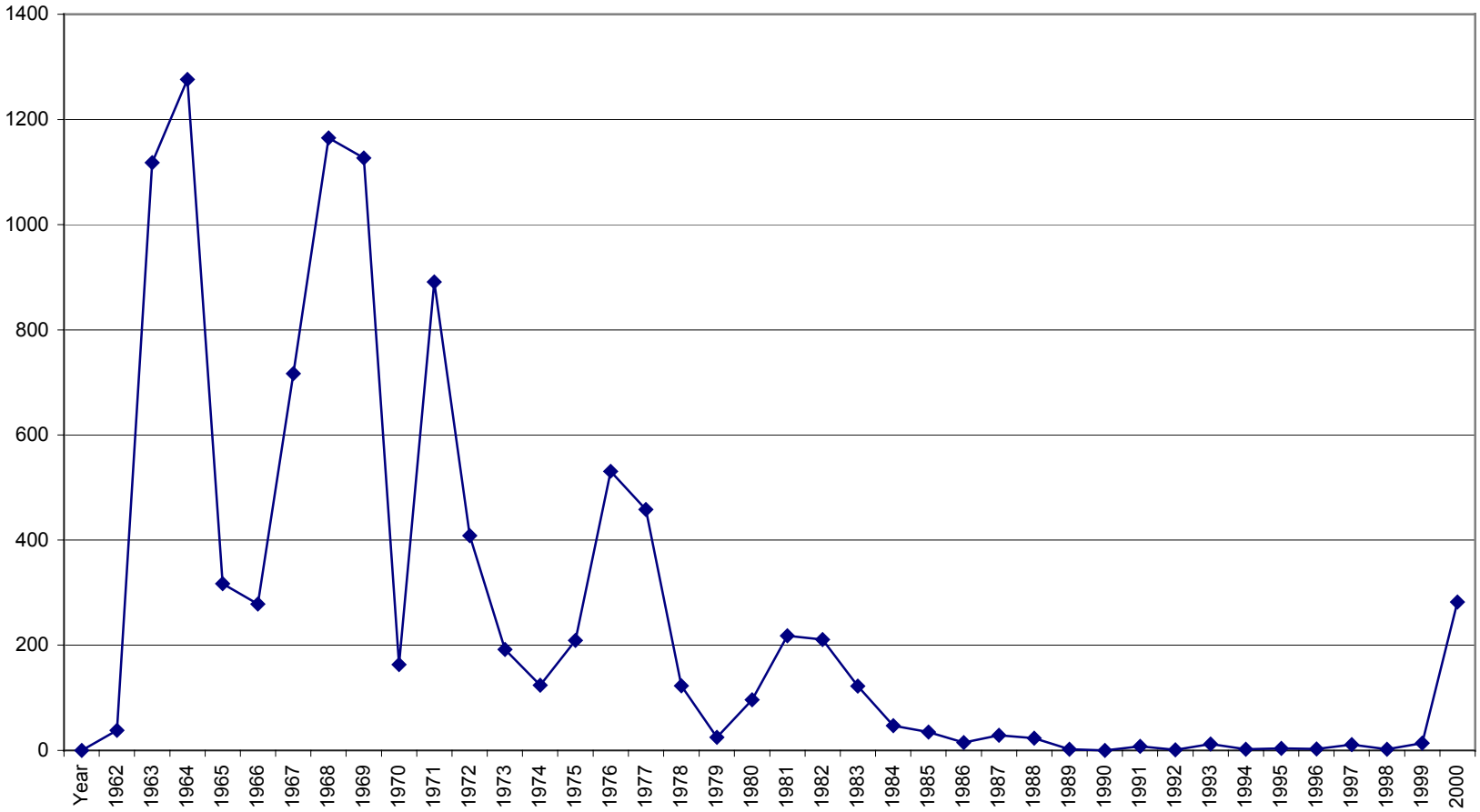
and in 2000, 282 sockeye were counted (Figure 4.5-10). Returns in 2001 were lower again, at 36 over Lower Granite Dam. All but one of the fish passing in 1999 were small jack-sized fish originating from releases into upstream lakes from the captive brood stock program. Between 0 and 8 sockeye salmon have arrived at Redfish Lake each year between 1990 and 1998 (Pavecek and Johnson, 1997; personal communication, Mr. Gislason, BPA, February 19, 1999). In 1999, a total of 7 small fish, all but one originating from the captive broodstock program, arrived at Redfish Lake. In 2000, returns from the captive broodstock releases greatly increased with at least 243 fish returned to Redfish Lake and other upper basin areas (Stanley Basin Technical Oversight Committee, November 15, 2000). The presence of fin clips indicated all but possibly 4 of these fish originated from captive broodstock releases (personal communication, Mr. Gislason, BPA, March 26, 2001).

From 1991 to 1999, all fish returning to the Redfish Lake trap were retained for a captive breeding program in an attempt to protect this stock from extinction. In 2000, only 44 fish were retained for the captive broodstock program, while 198 were released to the wild to spawn naturally in Redfish, Alturus, and Pettit Lakes (personal communication, Mr. Gislason, BPA, March 26, 2001). The 1999 returns were the first documented adult fish to have returned to any of the lakes from the captive broodstock fish releases.

Steelhead

One estimate of pre-European settlement steelhead run to the whole Columbia River Basin was about two million fish (NPPC, 1986). A large portion of these fish originated in the Snake River Basin. The winter steelhead, which are mostly located below Bonneville Dam, have had a generally decreasing trend for at least the last decade, including both hatchery and wild fish. Index counts have ranged from about 11,000 to 169,000 from 1953 through 1998, with lowest counts in the recent years (1997-98) (ODFW and WDFW, 2000). Lower river summer steelhead have also been decreasing in numbers (63 FR 53). The continued decrease in abundance of these stocks among other factors has resulted in NMFS listing the lower Columbia River steelhead ESU as threatened (63 FR 53).

Prior to 2001, the run of 423,000 upper Columbia and Snake River summer steelhead in 1940 was the largest recorded since Bonneville Dam was built. Nearly all were of wild origin. However, the 2001 total count over Bonneville Dam was the highest on record, at over 782,000. About 80 percent of that total was hatchery fist. In later years, the hatchery portion of the runs became a much larger component of the total run. Summer steelhead above Bonneville Dam are characterized as A-run or B-run. Total abundance of these two groups of summer steelhead, including hatchery fish, remained high until the 1950s. They declined in the late 1970s to between 84,000 and 195,000 fish. By the late 1980s, upriver summer steelhead numbers increased to between 285,000 to 384,000 fish. The total number decreased by 1990 and has fluctuated between 165,000 and 324,000 since then (ODFW and WDFW, 2000). The increase in the late 1980s appears to reflect primarily hatchery fish since wild summer steelhead A-run and B-run counts above Bonneville Dam have not improved. The trend of generally low wild runs of A-run and B-run summer steelhead is shown in Figure 4.5-11 for the Snake River summer steelhead.



Source: ODFW and WDFW, 2000; Corps Fish Passage Center Website

Figure 4.5-10. Estimated Sockeye Passing the Uppermost Dam on the Snake River (Lower Granite Dam after 1974), 1962 to 2000 (May Include Kokanee Prior to 1992)

Since 1993-94, total A-run and B-run wild steelhead counts have ranged from 4,700 to 19,600 fish over Lower Granite Dam. The B-run portion has been especially low, with counts of less than 1,000 fish for 3 years during this period. However, the projected return for 2000-01 is expected to improve to about 2,700 (personal communication, Sharon Kiefer, IDFG, March 20, 2001). The hatchery component of these two groups has fluctuated without definite trends since counts began (1985 to 1986) (Figure 4.5-11). NMFS listed this Snake River Basin steelhead ESU as threatened because of the recent declining numbers of wild fish and the high portion of hatchery fish (over 80 percent of all steelhead passing over Lower Granite). NMFS determined there was a demographic and genetic risk to the small population because few natural steelhead are spread over a wide geographic area (62 FR 159). Other summer steelhead passing over Bonneville Dam are parts of two other ESUs, the middle Columbia River steelhead and the upper Columbia River steelhead. Both of these ESUs are also considered in decline and are listed as endangered (upper Columbia River steelhead) (64 FR 57) and threatened (middle Columbia River steelhead) (64 FR 57).

Other Anadromous Fish

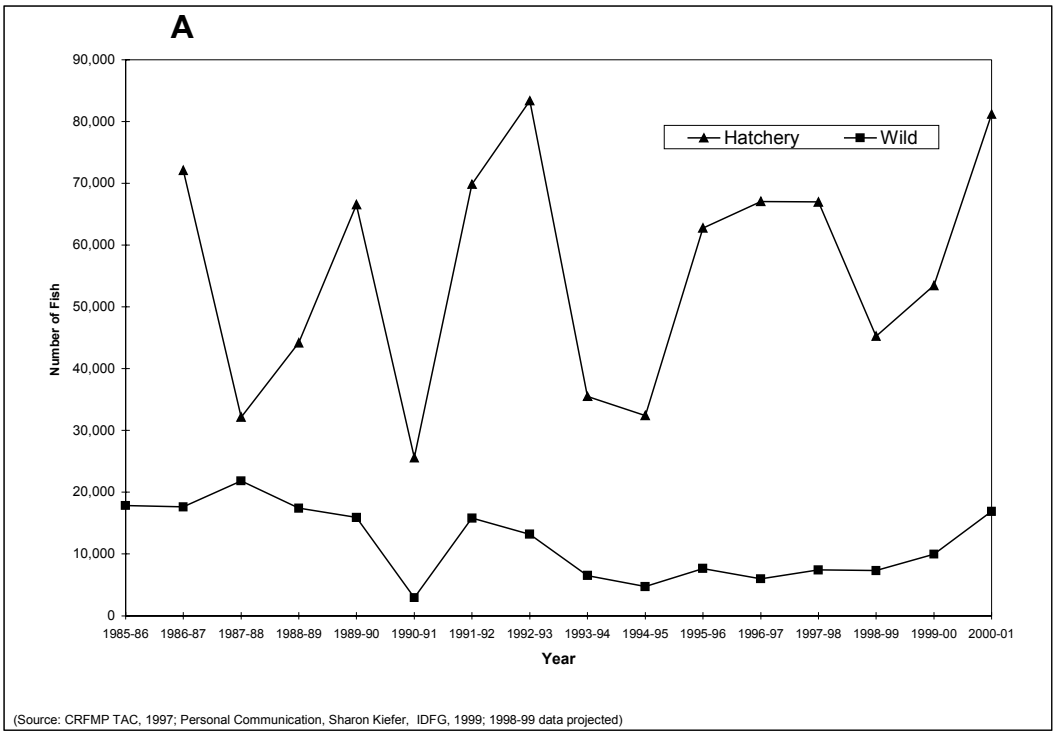
The numbers of other anadromous stocks on the Columbia River show varying trends. Shad populations have been very high in the last decade. Eight of the 10 highest recorded runs occurred in the last 10 years, all over 2 million fish. A peak of 4 million shad entered the Columbia River and 3 million passed over Bonneville Dam in 1990 (ODFW and WDFW, 2000).

White sturgeon in the lower Columbia River, below Bonneville Dam, are considered to be on the rebound after overharvest in the mid-1980s following implemented harvest restrictions (ODFW and WDFW, 2000). The relatively non-migratory sturgeon populations in the Columbia River pools are considered depressed and have suffered relatively low productivity and high mortality from harvest. Pacific lamprey are also considered to be on the decline in the Columbia-Snake River System (CRFMP TAC, 1997; Close et al., 1995).

Columbia River Chinook Salmon

The status of other chinook salmon stocks on the Columbia River System are varied. Upper Columbia River spring and summer chinook salmon numbers were depressed before Grand Coulee Dam was constructed in the 1930s. Summer chinook in the upper Columbia River have been relatively stable over the last 30 years. However, the Upper Columbia River summer-run chinook salmon and Upper Columbia River fall-run chinook salmon were considered for ESA listing. NMFS issued a determination on September 23, 1994 that the Upper Columbia River summer-run chinook salmon did not warrant listing (59 FR 194) and later indicated that this run and the Upper Columbia River fall-run chinook salmon (considered by NMFS as one ESU) were not warranted for listing (63 FR 45). However, the Upper Columbia River spring-run chinook salmon was also listed as endangered (64 FR 56).

Spring chinook redd counts in upper Columbia River tributaries have changed little in recent times. But salmon counts over Priest Rapids Dam have grown from the 1960s



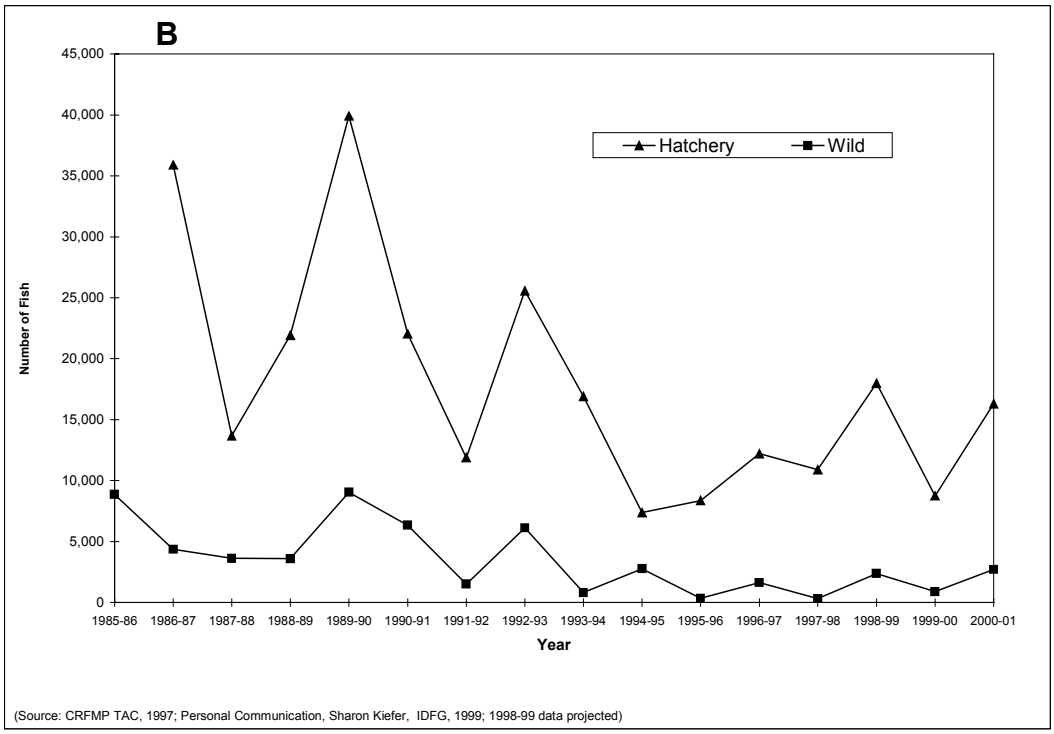


Figure 4.5-11. Estimated Wild and Hatchery A-Run (A) B-Run (B) Summer Steelhead Passing Lower Granite Dam, 1985-1986 to 1998-1999

to the 1980s, primarily because of increased hatchery production (ODFW, 1991). The large extent of hatchery influence on this stock was one of the reasons NMFS listed the Upper Columbia River spring chinook as endangered (64 FR 56). Returns of 2001 spring chinook salmon were the highest ever recorded at Bonneville Dam since counting began in 1938, while summer chinook of 2000 were the highest since 1988. Additionally, jack spring and summer chinook at Bonneville Dam (which includes hatchery and wild fish from all regions upstream) were also at record levels for 2000. The high jack counts suggest that 2001 returns may have the highest total return of spring (which they were) and summer chinook to Bonneville Dam on record. These fish would include members of the Columbia and Snake River stocks. Priest Rapids Dam spring chinook adults in 2000 were about double the 10-year average. Jack counts in 2000 were also the highest documented, about 5 times the 10 year average, suggesting stocks specifically upstream of the Snake River will be increasing in 2001. However, because the counts include both hatchery and wild fish, specific increasing projections for wild fish returns is unclear.

Upriver bright wild fall chinook, a late-spawning subspecies, have increased in the last decade. The highest return of 420,600 upriver bright fall chinook occurred in 1987, but this number fell to 81,000 in 1992. Returns have increased since then with the recent 5 years ranging from 142,000 to 167,000, with 2001 returns expected to be slightly lower, at about 127,000 (ODFW and WDFW, 2000, Columbia Basin Bulletin [CBB] 3/02/01). While most of these fish are wild Hanford reach stock fish, some are products of hatcheries, and their numbers have followed similar trends.

The Mid-Columbia River spring-run chinook (which includes stream type chinook in major tributaries from the Yakima River downstream to the Deschutes River) have had recent low returns in some areas but overall have had generally long-term increasing trends. For these reasons, NMFS has determined this ESU does not warrant listing (63 FR 45).

The Lower Columbia River chinook salmon is widely scattered with only a few large stocks (e.g., the Lewis). These fish have been adversely affected by many activities including land use practices, high ocean harvest rates, extensive hatchery planting, and barrier dams. The widely scattered characteristics of the subpopulations contribute to future risks for this stock and NMFS has listed it as threatened (64 FR 56).

Coho Salmon

While coho salmon were historically widely distributed in the Columbia River Basin, extending into the upper Columbia and Snake Rivers, in recent times they have been primarily restricted to below Bonneville Dam, except for fish originating from hatchery releases. In the Snake River Basin, the native Wallowa River coho were extirpated in the early 1900s, and reintroduced by the Oregon Fish Commission in the 1950s (the Wallowa River is a tributary to the Grande Ronde River). The progeny of the reintroduction, not native Wallowa River coho, became extinct in 1986. As late as 1968, up to 6,000 coho returned to the Snake River. Most of these fish originated in the Grande Ronde River, a tributary to the Snake River. Recently, the Nez Pierce Tribe has been releasing coho salmon into the Clearwater River System. Coho

salmon from these plants first returned in 1997 with 85 fish over Lower Granite Dam, and increased to 884 and 1,035 fish in 2000 and 2001, respectively.

Historically about 120,000 to 166,500 coho were in the middle and upper Columbia River (Mullan, 1984). Nehlsen et al. (1991) considered all coho stocks above Bonneville Dam as extinct (except the Hood River, a tributary that empties into the reservoir behind Bonneville Dam).

The last recorded estimate of the Hood River run was only 100 to 300 fish in 1963 to 1971 (CBFWA, 1991). Below Bonneville Dam hatchery releases, outplanting and stock transfer has been extensive (60 FR 142). However, some native stocks may still exist in some streams such as the Clackamas (a lower river tributary to the Willamette River). NMFS considers lower Columbia stocks to be part of the same group as southwest Washington stocks and has designated this ESU as a Federal candidate species. In fact, Oregon has placed the lower Columbia River coho as a state endangered species.

Currently, less than 10 percent of returning Columbia River coho salmon are considered wild. The 1991 return of 1.0 million coho was the second largest return since 1970 (ODFW and WDFW, 2000); however, Columbia River returns followed the same trends as other regional coho stocks, with sharp decreases in returns in 1995. Only 88,900 fish returned, the lowest number since 1960 (ODFW and WDFW, 2000). Returns, however, have been increasing since 1995, with a projected 1.3 million expected to return in 2001, the second highest return since 1970 (CBB 3/02/01).

Columbia River Sockeye Salmon

Other Columbia River anadromous stocks have varied in their overall health. From 1938 to 1959, total sockeye salmon runs over Bonneville Dam ranged from a low of 10,900 in 1945 to a high of 335,300 in 1947; runs were stable in the 1950s. These figures include runs from the Deschutes, Yakima, Wenatchee, and Okanogan Rivers, in addition to the Snake River sockeye. Since 1960, runs over Priest Rapids Dam have decreased and varied widely, ranging from 8,700 to 170,100 (ODFW and WDFW, 2000). The count of 111,000 in the year 2001 over Priest Rapid Dam was, however, the highest since 1985. NMFS does not consider the upper Columbia River sockeye warranted for listing.

Chum Salmon

Columbia River chum salmon at one time contributed over 500,000 fish to the harvest in the Columbia River. Currently there are likely a few thousand up to 10,000 chum spawning annually, nearly all in the lower Columbia River. The minimum run entering the Columbia River has ranged from 1500 to 3300 fish between 1995 and 1999 (ODFW and WDFW, 2000). While stock abundance has remained fairly constant since the mid-1950s, NMFS considers the chum salmon to be at a significant risk of extinction and has listed it as threatened (64 FR 57).

4.5.1.3 Lyons Ferry Hatchery

While hatcheries are numerous in the Columbia-Snake River System, the only hatchery that could be directly affected by any of the alternatives is the Lyons Ferry Hatchery. This hatchery is located on the north shore of the Snake River Lower Monumental Pool downstream from the mouth of the Palouse River. It is the only facility on the Snake River that currently directly collects and raises Snake River fall chinook salmon. These fish are considered part of the Snake River fall chinook ESU listed under the ESA. This is the only hatchery facility in the Snake River that has its main stock as a designated portion of a listed ESU (Snake River fall chinook). This collection and rearing of a listed ESU (other than the captive brood stock programs) is unique among hatcheries of the Columbia-Snake River System.

Lyons Ferry Hatchery also raises steelhead and spring chinook which are reared, but are not collected or released directly from this facility. Most of the fall chinook salmon brood stock are collected at Ice Harbor or from direct adult returns to the hatchery. Some also are collected at Lower Granite Dam.

4.5.2 Resident Fish and Aquatic Community

Resident fish are freshwater fish that live and migrate within rivers, streams, and lakes. Resident fish existed in all parts of the Columbia and Snake river basins before and after the dams were built. They mixed with anadromous fish in stream reaches accessible to the latter, and were the only fish present in areas above barriers to anadromous fish passage. There are both native and non-native (introduced) resident fish in the Snake River Basin. While fish are the most visible and familiar element of the aquatic community, they depend on the health of other ecological components. Aquatic plants, planktonic (small drifting) organisms, and benthic (bottom-dwelling) organisms are three other key elements of the aquatic community.

4.5.2.1 Species Composition

Fish species in the reservoirs of the lower Snake River include a mixture of native riverine and introduced species that typically are associated with lake-like conditions (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981; Mullan et al., 1986). The lower Snake River before impoundment and its post-impounded reservoirs typically warm during the summer and do not vertically stratify, but may have a weak gradation of temperature difference.

They have a relatively long (roughly 15 to 25 years) history of sedimentation; therefore, finer substrates prevail. The fine substrates, shifted temperature buffering, and associated dissolved oxygen saturations tend to favor warm- and cool-water species (Bennett et al., 1983). Warm-, cool-, and cold-water species have preferences for summer water temperatures that are approximately greater than 75°F, between 65°F and 75°F, and less than 65°F, respectively (Holton, 1990).

Cold-water resident species such as trout and mountain whitefish that were once common in the Snake River have declined since the construction of the dams. Species composition has changed because spawning migrations have been blocked and habitats modified (Mullan et al., 1986). The food web has also changed since the construction of the dams due to substrate composition changes and distributions, decreasing the availability of emerging aquatic insects and snails, while increasing the availability of crayfish and zooplankton. In the lower Columbia River, a shift in prey organisms may have contributed to the decline of cold-water resident species (Sherwood et al., 1990). During average and high flow years, mid-summer water temperatures are typically in the mid 60s°F. In contrast, during low flow years requiring cool water releases for flow augmentation for juvenile salmon passage, mid-summer water temperatures are in the upper 50s°F to low 60s°F, whereas historically low flow years produced mid-summer water temperatures inhemid 60s°F to low 70s°F. Regardless of flow year, peak water temperatures are usually in the upper 60s°F to low 70s°F.

The diversity of fish species is substantially higher than historical conditions. Thirty-five species of resident fishes have been observed to inhabit the lower Snake River reservoirs (Table 4.5-3). About half of these are introduced species. Native fishes include white sturgeon, trout and salmon, minnows, suckers, and sculpins. The largest group of introduced fish are in the sunfish family (Centrachidae). Eight

Table 4.5-3. List of Resident Fish Species Present in Lower Snake River Reservoirs

Family	Common Name	Scientific Name	Native or Introduced	Habitat Guild[1/]
		Cold-water Fishes		
Salmonidae	Rainbow trout	*Oncorhynchus mykiss*	N	HP/R
	Kokanee	*O. nerka*	N	
	Brown trout	*Salmo trutta*	I	HP/R
	Bull trout	*Salvelinus confluentus*	N	
	Mountain whitefish	*Prosopium williamsoni*	N	MP/LP-S
Cyprinidae	Northern Pikeminnow (Northern squawfish)	*Ptychocheilus oregonensis*	N	MP/LP-S (juv) MP/LP-D (ad)
	Speckled dace	*Rhinichthys osculus*	N	HP/R
	Longnose dace	*R. cataractae*	N	Rif/Rap
	Redside shiner	*Richardsonius balteatus*	N	MP/LP-S
	Peamouth	*Mylocheilus caurinus*	N	MP/LP-S
	Chiselmouth	*Acrocheilus alutaceus*	N	HP/R
Cottidae	Prickly sculpin	*Cottus asper*	N	Rif/Rap HP/R
	Piute sculpin	*C. beldingi*	N	Rif/Rap HP/R
	Mottled sculpin	*C. bairdi*	N	Rif/Rap HP/R
Catostomidae	Largescale sucker	*Catostomus macrocheilus*	N	HP/R Rif/Rap (ad)
	Bridgelip sucker	*C. columbianus*	N	HP/R
Acipenseridae	White sturgeon	*Acipenser transmontanus*	N	MP/LP-D
Percopsidae	Sand roller	*Percopsis transmontana*	N	MP/LP-D
		Cool-water Fishes		
Percidae	Yellow perch	*Perca flavescens*	I	S/B
	Walleye	*Stizostedion vitreum*	I	
Centrarchidae	Smallmouth bass	*Micropterus dolomieui*	I	MP/LP-S S/B (juv) MP/LP-D (ad) HP/R (ad)
		Warm-water Fishes		
Centrarchidae	Bluegill	*Lepomis macrochirus*	I	S/B
	Pumpkinseed	*L. gibbosus*	I	S/B
	Warmouth	*L. gulosis*	I	S/B
	Green sunfish	*L. cyanellus*	I	S/B
	Largemouth bass	*Micropterus salmoides*	I	S/B
	White crappie	*Pomoxis annularis*	I	S/B
	Black crappie	*P. nigromaculatus*	I	S/B
Ictaluridae	Channel catfish	*Ictalurus punctatus*	I	MP/LP-D
	Brown bullhead	*I. nebulosus*	I	S/B
	Yellow bullhead	*I. natalis*	I	S/B
	Black bullhead	*I. melas*	I	S/B
	Flathead catfish	*Pylodictis olivaris*	I	MP/LP-D
	Tadpole madtom	*Noturus gyrinus*	I	S/B
Cyprinidae	Common carp	*Cyprinus carpio*	I	S/B

Source: Appendix B, Resident Fish
[1/]Habitat Guilds:
Rif/Rap: Riffle/Rapids, Velocity > 2.0 ft/sec
HP/R: Head of pool/run, Depth < 10 ft, Velocity = 0.5 – 2.0 ft/sec
MP/LP-S: Mid-pool/lower-pool, Shallow, Depth < 10 ft, Velocity < 0.5 ft/sec
MP/LP-D: Mid-pool/lower-pool, Deep, Depth = 10 – 35 ft, Velocity < 0.5 ft/sec
S/B: Slough/backwater, All depths, Velocity < 0.5 ft/sec

members have been introduced including largemouth bass, smallmouth bass, pumpkinseed, bluegill, black crappie, white crappie, green sunfish, and warmouth.

A number of non-native fish were introduced or immigrated into the Columbia Basin beginning late in the 19th century and continuing today. Among these are:

> **American shad**—Introduced into the Sacramento River in the 1890s, immigrated to Columbia Basin in early 1900s. Shad are currently the most successful anadromous fish in the Columbia Basin, returning 1.5 to 4 million adults per year;
>
> **Carp**—Introduced to west coast in 1890s, into Columbia Basin in early 1900s. Carp are the most prevalent fish in many backwater areas, lakes, and ponds. They comprise the majority of the biomass (biomass that could be comprised in part of salmonids) in most of the water bodies in the Basin;
>
> **Smallmouth bass, Largemouth bass, White crappies, Black crappies, Bluegill, Channel catfish, Flathead catfish, Brown bullhead, Yellow bullhead, Yellow Perch, Walleye**—These warmwater fish were introduced widely during the 1930s by Civilian Conservation Corps participants from the southeast United States. They are currently managed by the state agencies as game fish and are protected by seasons and limits. Some Pumkinseeds like the walleye, have recently been introduced to Warmouth reservoirs in Idaho and Oregon upstream from the Green sunfish lower Snake River and are showing up in increasing numbers at juvenile fish collection facilities.

The effects of introduction of these species and their widespread establishment as resident populations on Columbia River salmon and steelhead populations are not fully understood. Some have been identified as predators on juvenile salmon and steelhead (bass, catfish, walleye, and others). Some have been implicated in harboring and transmitting diseases to salmonids (carp). Some, like the juvenile shad, may provide food sources for juvenile salmonids. However, juvenile shad may also provide food sources for other predators, like the northern pikeminnow, bass, catfish, and walleye, during seasons when juvenile salmon are not as plentiful. This may result in predator populations being higher when juvenile salmonids migrate downstream and increase predation rates and juvenile salmon mortality. Carp cause significant impacts to habitat by rooting up vegetation and stirring up muddy water that effects aquatic plants and other organisms.

There is little difference in the species composition of the four lower Snake River reservoirs (Bennett et al., 1983; Bennett and Shrier, 1986; Bennett et al., 1988). Native species found in high abundance in all reservoirs include suckers (largescale and bridgelip), northern pikeminnow (formerly called northern squawfish), and redside shiner. The introduced species found in high abundance include smallmouth bass, white crappie, yellow perch, and channel catfish. Although smallmouth bass are abundant in the reservoirs relative to the entire suite of introduced species, they are found at low absolute densities compared to other locations within their range (Appendix B, Resident Fish), including the unimpounded lower Snake River reach below Hells Canyon Dam (Petersen et al., 1999), suggesting that reservoir conditions are suboptimal and species such as smallmouth bass can utilize a wide range of coolwater habitats and limnological conditions. Species in the sunfish family, the

crappies, and largemouth bass can generally be found in the backwaters of all reservoirs. Minor variations in species composition are related to variations in the availability of backwater habitats and flowing waters in the various reservoirs. Numerically, native species continue to dominate the composition of fish fauna, primarily due to the abundance of suckers, northern pikeminnow, and redside shiner. However, as mentioned earlier, the native resident fish species considered commercially and recreationally important (trout and sturgeon) account for a relatively minor portion of the fish fauna. The distribution of bull trout is discussed in Section 4.5.2.4, Resident Fish Species Listed Under ESA.

In addition to the species mentioned above, walleye have been captured in the Snake River below Ice Harbor and within the mid- and lower Columbia River (Zimmerman and Parker, 1995). Although adult walleye have not been captured during resident fish surveys within any of the lower Snake River reservoirs, at least six walleye have been observed at juvenile facility separators at Lower Monumental and Little Goose (Appendix B, Resident Fish).

4.5.2.2 Habitat Use

The physical characteristics of the reservoirs are fundamental to the types of habitat available to fish. In many respects, the four reservoirs have physical characteristics that are not substantially different from each other (Table 4.5-4). The four reservoirs impound nearly 137 miles of the lower 156 miles of the lower Snake River. Little Goose is the largest of the four with a surface area of 10,825 acres and mean depth of 56.4 feet at the normal pool elevation. Lower Monumental is the smallest of the four and about two-thirds the size of Little Goose. Ice Harbor is relatively shallow compared to the other three and has only a small amount of deep water habitat. One notable difference among the reservoirs is that the lower two normally fluctuate by no more than 3 feet over a weekly period while the upper two reservoirs fluctuate by no more than about 5 feet. However, these fluctuation levels are not large relative to many other reservoirs in the Columbia River System (BPA et al., 1995). Furthermore, fluctuations are minimized (about 1 foot) near the Minimum Operating Pool (MOP) elevation during the spring and early-summer salmonid outmigration period.

Resident fish in the reservoirs occupy numerous habitats and often use separate habitats during different life history stages (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981; Bennett et al., 1991). Each reservoir has three general zones characterized by different habitat characteristics (Zimmerman and Parker, 1995): the forebay zone, which is typically lake-like in nature; the tailrace zone, which tends to be shallower and have significant water velocities; and the mid-reservoir zone which is a transitional area between the tailrace and forebay zones. Lower Granite does not strictly have a tailrace zone because it is the most upstream of the four reservoirs. However, its upper reach does have many riverine characteristics comparable to the tailrace zone. Each zone can include several habitat types; however, most can be characterized as either backwater (including sloughs and embayments) or open-water habitats (Hjort et al., 1981; Bennett et al., 1983; La Bolle, 1984).

Table 4.5-4. Physical Characteristics of Lower Snake River Reservoirs

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Distance of Dam from Snake R. Mouth (mi)	9.7	41.6	70.3	107.5
Normal Pool Elevation (ft)	440	540	638	738
Normal Pool Fluctuation (ft)	3.0	3.0	5.0	5.0
Reservoir Length (mi)	31.9	28.7	37.2	43.9
Surface Area (acres)	9,002	4,690	10,825	8,448
Maximum Depth at Normal Pool (ft)	110	130	135	138
Mean Depth at Normal Pool (ft)	48.6	57.2	56.4	54.4
Maximum Width (ft)	5,280	4,220	4,700	3,700
Mean Width (ft)	2,000	1,900	1,700	2,110
Major Tributaries	None	Palouse R., Tucannon R.	None	Clearwater R.
Reservoir Name	Lake Sacajawea	Lake West	Lake Bryan	Lower Granite Lake

Source: Bennett et al., 1983

Backwaters and embayments generally provide low water velocity, slightly warmer water, finer substrate, and submersed and emergent vegetation. Bass, black crappie, white crappie, bluegill, pumpkinseed, yellow perch, and carp use backwater areas for spawning and rearing (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981; Bennett et al., 1991; Zimmerman and Rasmussen, 1981). The centrarchids normally spawn in shallow water less than 6.5 feet deep (Bennett et al., 1983) while yellow perch generally utilize waters less than 10 feet deep (Stober et al., 1979). Spawning nests are found on a variety of substrate types ranging from silt and mud to rubble (Bennett et al., 1983). Yellow perch have shown a preference for spawning on submerged vegetation, providing it is silt-free (Nelson and Walburg, 1977; Muncy, 1962). Spawning and incubation times vary between species; however, most of these backwater species spawn from May through mid-July (Appendix B, Resident Fish).

The cyprinids, suckers, and possibly redside shiner spawn in open water. White sturgeon spawn over areas with rocky bottoms and high water velocity (Parsley et al., 1993). Prickly sculpin spawn in both open water and backwater, based upon the distribution of larvae (Hjort et al., 1981). The greatest abundance of larvae is generally found in the backwaters and nearshore areas. Only yellow perch and prickly sculpin larvae are commonly found in open-water areas.

Most of the native species spawn in flowing waters in the tailwater of the next upstream dam, in tributary streams, or in free-flowing mainstem waters (Lower Granite only). Some species, however, may also spawn in the reservoirs. For instance, northern pikeminnow and kokanee may spawn either in flowing water or along gravel beaches in reservoirs (Wydoski and Whitney, 1979). However, no significant kokanee spawning beaches have been identified in any of the four lower Snake River reservoirs. Kokanee do not appear to be self-sustaining within any of the reservoirs, but are occasionally observed in Lower Granite as a result of entrainment through Dworshak Dam located on the North Fork Clearwater River.

Juvenile fish are found in abundance in backwater and open-water areas where flowing water is found. The two habitats are occupied by distinctly different fish species. Introduced species, which are primarily lake-dwelling fishes, are more common in the forebay zone and backwater areas while native riverine species are more common in the flowing water regions found in the tailrace zone (Hjort et al., 1981; Bennett et al., 1983; Bennett and Shrier, 1986; Mullan et al., 1986).

Adult distribution is generally similar to spawning and juvenile distribution, but can change depending upon feeding strategy. Adults may occur throughout the habitats and move seasonally or daily to different areas (Bennett et al., 1983; Bennett and Shrier, 1986; Hjort et al., 1981). Although adults will use various habitats, lake-dwelling species are generally more abundant in shallow, slower velocity backwater areas and native riverine species occur abundantly in areas with flowing water (Bennett et al., 1983).

To aid in the analysis of the alternatives, the fish species found in the lower Snake River have been placed into five habitat-use guilds (Table 4.5-3; Appendix B, Resident Fish). The selection of guilds is based upon the expectation that particular habitat types would be present following implementation of one of the alternatives and the assumption that grouped species exploit stream resources in a similar manner (Leonard and Orth, 1988). The use of guilds explicitly generalizes habitat requirements by lumping common attributes and does not consider microhabitat differences known to exist among the species. The simple habitat guild system that was developed (Appendix B, Resident Fish) is provided in Table 4.5-5.

Native fish inhabiting the lower Snake River reservoirs tend to be categorized in the riffle/rapids guild or head of pool/run guild. In contrast, the introduced species more commonly occur in the shallow mid/lower pool guild or slough/backwater guild. Smallmouth bass are the major exception to these general patterns. Smallmouth bass are considered habitat generalists and do not conveniently fit in just one or two of the described guilds. In general, the backwater areas have the greatest abundance of fish in all life stages. Deep habitats support fewer fish. The majority of the species found in deeper waters are suckers and minnows. White sturgeon are also found in deeper waters. Mid-depth habitats support a community higher in species diversity and abundance than deep habitat, but generally lower in abundance than shallow habitat (Bennett et al., 1991).

Little Goose and Lower Monumental have a greater number of backwater areas than Lower Granite and Ice Harbor (Bennett et al., 1983). The confluence of two major tributaries (Palouse and Tucannon Rivers) with the Snake River provide additional backwater habitat in Lower Monumental. Therefore, these reservoirs tend to support larger numbers of species that depend upon these shallow-water habitats during some part of their life histories. Channel catfish and carp are more abundant in Lower Monumental and Ice Harbor. Their abundance in these reservoirs is believed to be related to the availability of suitable habitat (waters with little current, often soft substrates with emergent and submerged aquatic vegetation). Yellow perch are also more abundant in reservoirs with aquatic vegetation. Smallmouth bass, pumpkinseed, and white crappie are more abundant in upriver reservoirs (Bennett et al., 1983). The mouths of the Palouse and Tucannon Rivers where they enter the Snake River provide access to flowing water for native species in Lower Monumental. The confluence of

the Clearwater and Snake Rivers provides important flowing water habitat in Lower Granite. The native species primarily spawn in the tributaries; however, headwaters of reservoirs serve a similar function. For example, in Lower Granite, northern pikeminnow migrate upstream to the lotic (flowing water) conditions in the Snake and Clearwater Rivers. In other reservoirs without major tributaries (such as Little Goose), fish migrate to the tailwaters of the next dam upstream for spawning and possibly feeding benefits. Although no data were found to compare relative abundance of native species in the four reservoirs, the availability of flowing water habitat in Lower Granite and Lower Monumental would provide better habitat for native species than Little Goose and Ice Harbor.

Most of the dominant sport fishes in the lower Snake River reservoirs require high-quality, shallow-water (6.5 feet or less) habitats for spawning and rearing (Bennett et al., 1983; Bennett and Shrier, 1986). In addition to the requirement of shallow-water habitat, that habitat must also remain inundated throughout the incubation period to ensure good egg survival and the presence of submerged and emergent vegetation is beneficial. Fluctuations in water surface elevation can, therefore, have potentially large effects on spawning success, particularly in April through July when most shallow-water species spawn. However, Bennett et al. (1983) found that project operations during 1979 and 1980 appeared to have little effect on recruitment into the sport fishery. During this period, standard operating procedures maintained relatively small fluctuations, usually less than 5 feet for Lower Granite and Little Goose and less than 3 feet for Lower Monumental and Ice Harbor (Bennett et al., 1983; Corps, 1995c).

Water temperature is a factor that is critical for the success of most resident fish species inhabiting the reservoirs (Appendix B, Resident Fish). Water temperature is a key stimulus for the onset of spawning for many of the species and controls the development of eggs into free-swimming fry. Water temperature can also influence the availability of prey items and the growth of juvenile fish. Temperature fluctuations are hypothesized to be the major factor influencing year-class strength (Appendix B, Resident Fish). Many of the warm-water fish species have evolved to spawn during increasing water temperatures. Flow augmentation from upstream reservoirs designed to speed passage of migrating salmonids also reduces water temperatures. Reduced water temperatures can delay spawning times and shorten the growing season. Large water temperature fluctuations can be stressful to young-of-the-year fish, further stunting their growth. These effects can result in young-of-the-year fish that may be too small to survive over-wintering.

Table 4.5-5. Characteristics of Habitat Use Guilds for Resident Fish Currently Present in the Snake River System

Guild	Velocity	Substrate	Depth	Zone
Riffle/Rapids Guild	Higher (>2.0 feet/second) in areas of steep or moderate channel slope	Large (cobble/boulder) due to lack of deposition of finer materials	Varies, but generally use areas less than 10 feet deep	Tailrace zone
Upper Pool Guild (Head of Pool-Run)	Moderate and variable (0.5 to 2.0 feet/second); "head of pool" areas represent transitional habitats between swift areas of rapids and the deeper, slower main portions of the pools	Variable and dependent on velocities (higher velocities result in coarser substrate), but generally smaller particles (cobbles and gravel) than those in rapids, with only minimal deposition of fines and limited embeddedness	Use shallow areas less than 10 feet deep	Tailrace and mid-reservoir zones
Mid/Lower Pool Guild-Shallow	Less than 0.5 feet/second	Variable, but should range among the smaller-sized particles (gravel, sands, and some silt)	Use shallow areas less than 10 feet deep	Littoral areas within the mid and forebay reservoir zones
Mid/Lower Pool Guild-Deep	Less than 0.5 feet/second	Finer substrates (fine gravel, sand, and silt)	Prefer waters greater than 10 feet deep	Open water within the mid and forebay reservoir zones
Slough/Backwater Guild	Little or no current	Variable, typically with a high fines component; this contributes to the development of macrophytes that add to habitat complexity	Sloughs and backwaters may be shallow or provide a full range of depths	Any of the three reservoir zones where sloughs or backwaters are present

Source: Appendix B, Resident Fish

4.5.2.3 Aquatic Food Chain

Benthic Organisms

One part of the aquatic ecosystem, the benthic community (or benthos), consists of organisms that live on the bottom of lakes or rivers. Benthic plants such as algae and benthic animals such as larval, pupating, and adult forms of insects, worms, snails, and crayfish are components of this community. Benthic organisms contribute significantly to the diets of many reservoir fish species, as well as insect larvae as prey for juvenile anadromous species (Bennett et al., 1983); they are essential elements in the food chain. In particular, crayfish are an important component to the diet of smallmouth bass, northern pikeminnow, and channel catfish in the Little Goose and Lower Granite reservoirs (Bennet et al., 1983). Benthic production is usually minimal in shallow-water areas if the water levels fluctuate and expose the organisms. As a result, benthic organisms will die along shorelines, for example, where water levels have substantial fluctuations (Mullan et al., 1986).

Frest and Johannes (1992) listed seven species of mollusks inhabiting the lower Snake River, of which six are native. The most abundant species they observed was the introduced Asian clam. In addition, they listed 34 native species that were known or likely to be present historically, suggesting that diversity has declined dramatically. Several mollusk populations that are part of the Columbia River Basin benthic community have been identified by the U.S. Fish and Wildlife Service (USFWS) as species of concern. These are the California floater and the Columbia pebble-snail.

Phytoplankton and Zooplankton

Two other very important parts of the food chain include phytoplankton and zooplankton. The phytoplankton, or drifting plants, are microscopic algae that nourish themselves from the energy of the sun (Barnes, 1980). They are at the base of the food chain. Phytoplankton can be seen in surface waters when large colonies bloom and form a green film. They provide a food source for bacteria, water molds, and zooplankton. Zooplankton are tiny, floating transparent animals (Barnes, 1980). Both phytoplankton and zooplankton are a food source for larger aquatic organisms, such as snails and small fish. In addition, fish species such as white crappie, black crappie, and redside shiner feed directly on zooplankton which compose an important component to their diet (Bennett et al., 1983).

The use of backwater areas by numerous species may be at least partially related to the availability of prey. High concentrations of zooplankton in the backwater areas attract smaller prey species that feed upon these organisms. In turn, high concentrations of prey fish attract larger predator fish species. Therefore, higher concentrations of zooplankton in backwater areas may affect the habitat selection of several species.

Factors thought to influence zooplankton abundance in Lake Roosevelt on the upper mainstem Columbia River include photoperiod, water temperature, and water retention time (Peone et al., 1990) and a similar relationship is likely true for the lower Snake River reservoirs. Higher primary production leads to increased secondary (e.g., zooplankton) and higher trophic level production. Water retention time was considered to be the most critical of the three factors in Lake Roosevelt

because it is directly influenced by dam operations within the system (Peone et al., 1990). The lower Snake River dams have relatively low storage volumes (i.e., they are run-of-river) and water retention times are driven by the operation of storage dams elsewhere in the system. During spring floods, water velocities are generally high and waters are vertically mixed. Long water retention times reduce the amount of plankton flushed from the reservoir. Backwaters and embayments have slower water velocities and somewhat warmer water, allowing the development of higher density plankton populations compared to mid-reservoir and tailwater areas. Longer water retention times during late spring and summer also encourage the development of vertically stratified waters which help to keep phytoplankton within the photic zone or upper depths within which adequate sunlight is available for photosynthesis (Barnes, 1980). Releases of cool water during low flow years to augment juvenile salmon passage can also reduce the production of plankton.

Aquatic and Terrestrial Plants

Aquatic plants include phytoplankton (described above), algae, and macrophytes. Each of these plant types are important components to the primary production within the reservoirs. Filamentous green algae can be found attached to rocks, woody debris, and other structures. Filamentous green algae was described as part of the diet for several of the fish species in the Little Goose reservoir, but was not prominent in any diet (Bennett et al., 1983). Filamentous algae historically present in the natural river bed have been partially replaced by diatoms, a type of phytoplankton with unicellular or colonial forms. Although diatoms have become very abundant in the reservoirs, their size or structure has prevented their use as a major food source by macroinvertebrates.

Macrophytes are large vascular aquatic plants that grow in shallow water along the shorelines of lakes or in the slow-moving reaches of rivers. Macrophytes can be entirely submerged or emergent. Emergent macrophytes are an important element in the food chain because they provide homes for insects, which in turn can be food for fish, and they function as a direct food source for many aquatic organisms. Macrophytes also supply surfaces for fish eggs to incubate as well as protection for fish species during various life stages. These plants are especially important for young fish that hide among plant stems and leaves to escape predators. Additionally, macrophytes help stabilize shorelines by reducing erosion and recycling nutrients, an important function in nutrient-poor areas.

In many reservoir systems, fish abundance in shallow waters has been shown to correlate with the presence of macrophytes. However, the results of studies conducted at Little Goose (Lake Bryan) by Bennett et al. (1983) did not indicate a positive correlation between fish abundance and macrophytes except for yellow perch and carp. There is very little aquatic macrophyte production in Lower Granite Lake.

Terrestrial plants growing adjacent to the reservoirs can contribute woody debris, leaf litter, and other organic debris that can be utilized as cover, substrate, and nutrients by invertebrate and vertebrate aquatic fauna if it falls into water. However, terrestrial plants generally do not contribute directly to fish diets. A notable exception is the presence of wheat in the diets of channel catfish, northern pikeminnow, and redside shiner (Bennett et al., 1983). At some locations, wheat ranked as high as second or third in importance for catfish and northern pikeminnow in Lake Bryan. Apparently,

this food item results from losses occurring during transport by barge through the reservoirs.

Fish Predation

Fish predation occurs by species that occupy the highest trophic level of the aquatic food web. The most important piscivorous fish species include smallmouth bass, northern pikeminnow, channel catfish, crappies, and yellow perch. Individuals of these species can forage on a variety of smaller species. Of particular importance, the larger individuals may seasonally forage on juvenile salmonids residing in, or migrating through, the reservoirs. However, other than fall chinook, fish predation

appears to be relatively low in yearling chinook and steelhead. The most significant predator on juvenile salmonids in Lower Snake River Reservoirs are smallmouth bass because of their abundance, overlapping rearing habitat preference, and reduced alternative prey diversity and abundance (i.e., crayfish) in the reservoir environment, especially in Lower Granite Reservoir (Appendix B, Resident Fish). Salmonids were reported as an important component to the diet of channel catfish (Bennett et al., 1983; Bennett et al., 1988), but little is known about catfish abundance and the total amount of salmonid predation they may incur. Predation by northern pikeminnow has been reduced substantially in the lower Columbia and Snake Rivers in recent years as the result of high harvest levels supported by the Sport Reward Program and scientific sampling funded by BPA (Friesen and Ward, 1999). However, overall predation of salmon in Lower Granite pool and tailrace by northern pikeminnow is very low (Naughton, 1998).

Sport Fishery for Resident Fish

A sport fishery has developed within the four lower Snake River reservoirs, but most of the fishery is focused on anadromous fish rather than resident fish. In a recent 1997 survey, most anglers (73 percent) pursued adult steelhead (University of Idaho et al., 1998). For those anglers pursuing resident fish, targeted species included channel catfish (26 percent), smallmouth bass (18 percent), and rainbow trout (14 percent). However, crappies were the most often captured fish, followed by channel catfish, smallmouth bass, and northern pikeminnow (see Appendix B, Resident Fish). Surveys conducted in 1979 and 1980 on Lake Bryan indicated that crappies and white sturgeon are also species targeted by fishermen (Bennett et al., 1983). Although yellow perch were rarely sought by fishermen during 1979 and 1980, they were an important component to the catch, particularly by shore-based fishermen.

4.5.2.4 Resident Fish Species Listed Under ESA

Bull trout, a species listed as threatened under the ESA, have occasionally been recorded at lower Snake River dam passage facilities (Kleist, 1993; Corps et al., 1999), the Tucannon River, Grande Ronde River, and Asotin Creek (WDFW and Western Washington Treaty Indian Tribes, 1998). Bull trout usually require very cold waters (less than 59°F); (Rieman and McEntyre, 1993) throughout the year. A few individuals of the species for each year since the mid-1990s have been documented passing through the ladder at Little Goose Dam (Corps et al., 1999; Corps data available on request; USFWS, 1998a).

Bull Trout (*Salvelinus confluentus*)—Bull trout within the lower Snake River were listed as threatened on July 10, 1998. Bull trout are piscivorous and require an abundant supply of forage fish. They exhibit four distinct life history forms: resident, fluvial, adfluvial, and anadromous. Resident bull trout spend their entire life cycle in the same (or nearby) streams in which they were hatched. Fluvial and adfluvial populations spawn in tributary streams where the young rear from 1 to 4 years before migrating to either a lake (adfluvial) system or a river (fluvial) system, where they grow to maturity. Anadromous fish spawn in tributary streams, with major growth and maturation occurring in salt water. Fluvial and adfluvial life history forms of bull trout probably used the lower Snake River during a portion of the year prior to dam construction, but the extent of this historical utilization would be speculative.

Bull trout today remain fluvial or adfluvial in their life history form and likely use the mainstem reservoirs as migration corridors between tributary streams. Bull trout display a high degree of sensitivity at all life stages to environmental disturbance and have more specific habitat requirements than many other salmonids. Bull trout growth, survival, and long-term population persistence appear to depend particularly upon five habitat characteristics: 1) cover, 2), channel stability, 3) substrate composition, 4) temperature, and 5) migratory corridors (Rieman and McIntyre, 1993). Preferred spawning habitat consists of low-gradient streams with loose, clean gravels. An extremely long period of residency in the gravel (200 or more days) makes bull trout especially vulnerable to fine sediments and water quality degradation. Successful bull trout spawning and development of embryos and juveniles requires very cold water temperatures with spawning occurring below 9°C (48.2°F). Optimal incubating temperature seems to be from 2 to 4°C (35.6 to 39.2°F). Spawning occurs from August through November, and eggs hatch in late winter or early spring. Emergence occurs in early April through May, commonly following spring peak flows. Bull trout require complex forms of instream cover. Adults use pools, large woody debris, large boulders, and undercut banks for resting and foraging. Juveniles also live on or within the streambed cobble and use side channels and smaller woody debris in the water. Channels for moving between safe wintering areas and summer foraging areas are also necessary.

Extensive migrations are characteristic of the species. Migratory bull trout facilitate the interchange of genetic material between populations, ensuring sufficient variability within populations. Migratory corridors tie seasonal habitat together for anadromous, fluvial, and adfluvial forms and allow for the dispersal of resident forms for recolonization of rebounding habitats.

Major tributaries to the Snake River below Hells Canyon Dam that support bull trout subpopulations include: 1) Tucannon River, 2) Asotin Creek, 3) Grand Ronde River, 4) Imnaha River, 5) Clearwater River, and 6) Salmon River. The only subpopulation of bull trout associated with the four lower Snake River reservoirs spawns and rears in the Tucannon River basin. Both resident and migratory forms occur here. Only resident fish are present in the headwater of Pataha Creek, but both forms exist in the mainstem Tucannon River and its upper tributaries. Evidence suggests that migratory bull trout from the Tucannon River utilize the mainstem Snake River on a seasonal basis. Kleist (1993) reported several observations of adult bull trout passing Lower Monumental and Little Goose Dams. From 1994 to 1996, there were 27 bull trout

passing the adult fish counting station (mainly in April and May) at Little Goose Dam (S. Richards, WDFW, fishery biologist, personal communication). At least six bull trout passed counters at Lower Monumental and Little Goose Dams in 1991 and 1992 (Kleist, 1993). Kleist also observed one bull trout in 1993 just downstream of the count window at Lower Monumental Dam. Furthermore, one bull trout was captured in the Palouse River below Palouse Falls in 1998 (G. Mendel, WDFW, fishery biologist, personal communication). These were likely migratory fish from the Tucannon River. One bull trout was observed at Lower Granite Dam in 1998 (D. Hurson, Corps, fishery biologist, personal communication), which may indicate fluvial fish are migrating to other upstream populations. Bull trout are also currently found in Dworshak Reservoir migrating adfluvially in from tributaries such as the North Fork of the Clearwater River (Maiolie et al., 1988).

Bull trout associated with both the Tucannon River and Dworshak reservoir were rated as "healthy" by WDFW and IDFG, respectively, although some habitat degradation has occurred to both subbasins due to timber harvest and recreational use. These populations are not currently at risk of extinction, and not likely to become so in the foreseeable future because of sufficient habitat protection (wilderness designation) in the upper watersheds and the lack of brook trout encroachment from Pataha Creek for the Tucannon River population. The Pataha Creek subpopulation is at risk of extinction as a result of habitat degradation and competition and hybridization from brook trout.

4.6 Terrestrial Resources

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4.6.1 Vegetation

This section describes vegetation resources within the lower Snake River study area. Many factors, including water level, sediment composition, and river flow affect the abundance, distribution, and species composition of wetland, riparian, and associated upland vegetation zones (Gosselink and Mitsch, 1993; Brinson et al., 1981). Because the proposed alternatives may affect hydrology, this section describes the existing vegetation and habitats that may be potentially altered by structural and/or operational changes to the Lower Snake River Project.

The study area is located within the Columbia Basin physiographic province and includes two major vegetation zones—steppe and shrub-steppe (Franklin and Dyrness, 1973). Steppe communities are dominated by bunchgrasses, such as Idaho fescue, bluebunch wheatgrass, and Sandberg's bluegrass, while shrub-steppe

communities are co-dominated by sagebrushes, such as big sagebrush. Prior to construction of dams and impoundments, rich alluvial soils associated with the Snake River floodplain allowed the development of quality riparian vegetation along the river. Over 50 vegetated islands were present in the study area, with sand and gravel bars common (Appendix M, Fish and Wildlife Coordination Act Report).

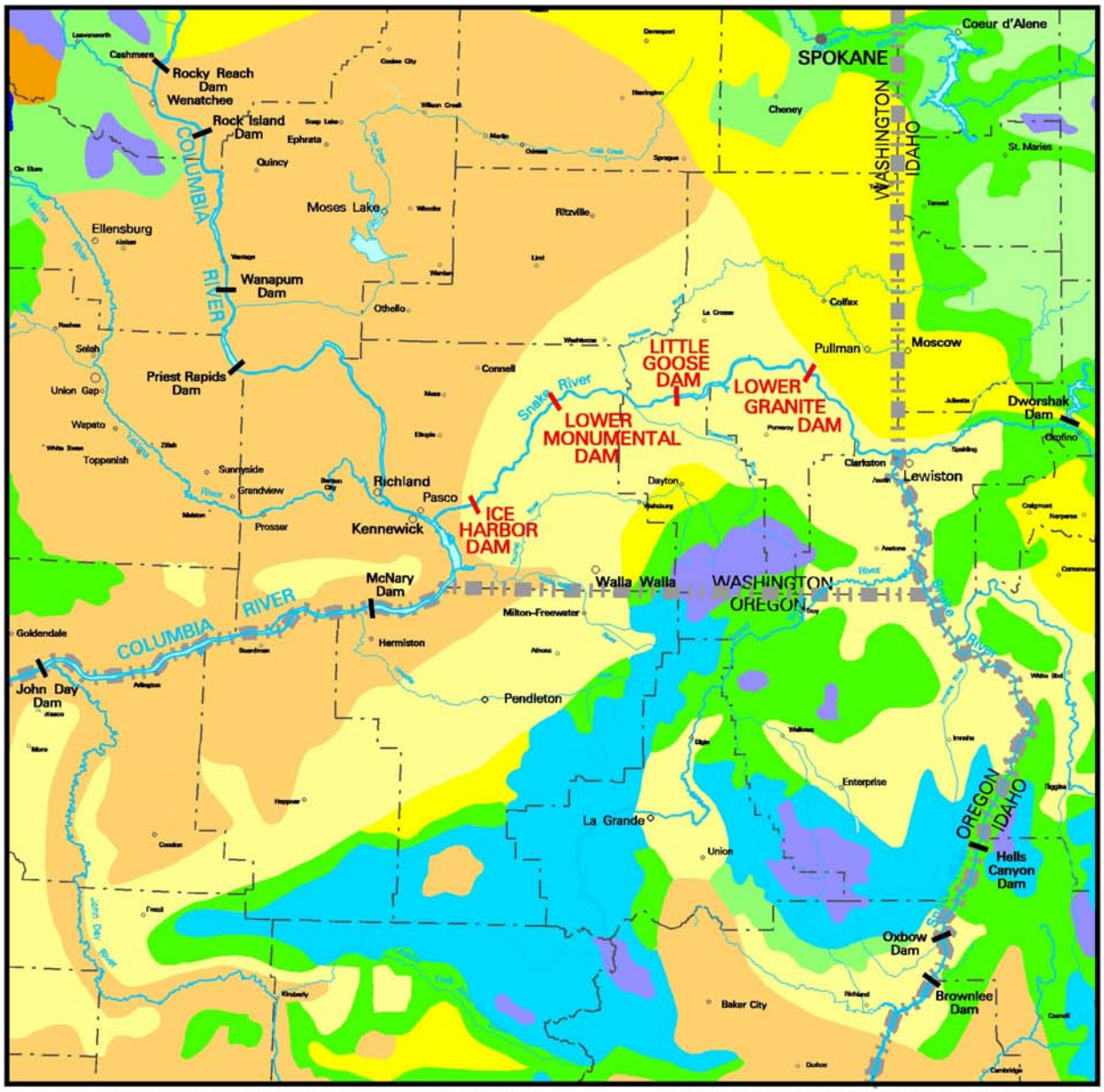
Many wetlands have been modified, degraded, or destroyed over the last 100 years by land use practices and manipulation of hydrology. Human activities such as railroad construction, road construction, livestock grazing, and agricultural have adversely impacted vegetation in the study area. Regional vegetation is shown on Figure 4.6-1.

The construction of dams and impoundments reduced the native upland and riparian habitats within the study area. Emergent wetland types increased significantly after construction of dams and impoundments due to sedimentation and flooding of backwater areas (by approximately 350 acres—see Table 4.6-1). Approximately 13,772 acres were inundated by impoundment in the reservoirs (Table 4.6-1). Currently, the study area contains approximately 18,150 acres of upland habitat, 1,800 acres of riparian habitat, and 963 acres of wetland habitat (including ponds).

Table 4.6-1. Acreages of Habitat Types within the Boundaries of the Lower Snake River Project Based on Cover Type

	Area (Acres)		
Habitat Type	**Pre-project (1958)**	**Post-impoundment (1995)**	**Change**
Upland			
Cropland and Pasture	4,643.3	307.1	(4,336.2)
Grassland	13,258.7	9,406.4	(3,852.3)
Forbland and Planted Grassland	1,915.7	650.5	(1,265.2)
Shrub-steppe	7,674.3	5,331.7	(2,342.6)
Exposed Rock and Rock Talus	3,096.4	2,453.5	(642.9)
Total Upland Habitat	*30,588.4*	*18,149.2*	*(12,439.2)*
Riparian			
Mesic Shrub	837.3	752.1	(85.2)
Palustrine Forest	710.8	459.1	(251.7)
Palustrine Scrub-shrub	1,736.6	592.3	(1,144.3)
Total Riparian Habitat	*3,284.7*	*1,803.5*	*(1,481.2)*
Wetland			
Palustrine Emergent	9.9	353.2	343.3
Palustrine Open Water (ponds)	293.7	609.4	315.7
Total Wetland Habitat	*303.6*	*962.6*	*623.0*
Reservoir/River	*19,464*	*33,236*	*13,772*
Total Project Lands	***53,640.7***	***54,151.3***	***510.6***

Source: USFWS (1991) and cover typing completed by USFWS and Corps in 1995



Source: "Potential Natural Vegetation of the Conterminous U.S." by A.W. Kuchler, 1964

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NEEDLELEAF FOREST
- Western Ponderosa
- Douglas Fir
- Cedar – Hemlock – Pine
- Grand Fir – Douglas Fir
- Western Spruce – Fir

GRASSLANDS
- Fescue – Wheatgrass
- Wheatgrass – Bluegrass
- Alpine Meadow and Barren

SHRUB & GRASSLAND COMBINATION
- Sagebrush – Steppe

KM 25 0 MILES 7.5 15 30

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

125,000 ACRES

1 : 1,900,800

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.6-1.

REGIONAL VEGETATION

4.6.1.1 Riparian Communities

The riparian zone lies adjacent to streams and rivers and is influenced by the stream and its associated groundwater (Malanson, 1993). This includes areas with woody vegetation, which are too dry to be classified as wetlands, sand and gravel bars, wet meadows, flood-scoured areas, and other stream-related habitats and vegetation. Riparian areas serve as important wildlife habitat and are integral to the function of river aquatic ecosystems, wind shelters for residences, and locations for recreational activities.

The extent and type of riparian vegetation occurring in the study area depend on water availability. Water availability (e.g., precipitation) increases with elevation from downstream to upstream ranging from approximately 9 to 15 inches. Greater precipitation in the upstream area facilitates a richer band of riparian vegetation in the side draws and shallow pockets across the canyon slopes in the upper half of the study area. Also, north-facing slopes retain more moisture than other slopes and often have more diverse vegetation and more extensive woody vegetation.

Before any impoundments were constructed on the lower Snake River, there were approximately 3,285 acres of riparian vegetation (Table 4.6-1, Figure 4.6-2). This habitat was composed of riparian forest, palustrine scrub-shrub, and mesic shrubland. Typical riparian forest included black cottonwood, white alder, black locust, and netleaf hackberry. Mesic shrubland occurred in side draws and areas with at least seasonal springs and seeps. Species typical of these areas included netleaf hackberry, douglas hawthorn, chokecherry, and willows. Additionally, riparian areas included forbland composed of species such as teasel, curly dock, and water hemlock. Much of this vegetation was found in discontinuous bands along the main river at the bottom of the canyon or in the side canyons associated with seeps and springs.

Currently, approximately 1,804 acres of similar habitat types occur in varying proportions (Table 4.6-1, Figure 4.6-3). Species composition has also changed somewhat reflecting intrusion of invasive species such as Canada thistle, false indigo, black locust, and Russian olive. Both Russian olive and black locust were used as part of the original mitigation plantings. The invasion is primarily from these plantings.

Several factors have contributed to the lack of development of extensive riparian areas along the lower Snake River. The steep shorelines along the project reservoirs and areas of the shoreline covered in riprap are primarily responsible for limiting development of riparian communities. Furthermore, extensive grazing (Lewke and Buss, 1977), the expansion of railroads, and the gradual inundation of the river bottom by dams have also limited riparian vegetation to narrow vegetation corridors and backwater areas. These particular changes have reduced the extent of many of the woody plant communities such as cottonwood, willow, and white alder that once characterized the riparian zone. In addition to riparian vegetation that remained above the newly established water line, riparian vegetation has been artificially recreated through the use of irrigation on 11 Habitat Management Units (HMUs) scattered throughout the reach. (see Section 2.1.1.8, Lower Snake River Fish and Wildlife Compensation Plan and Section 4.6.2, Wildlife).

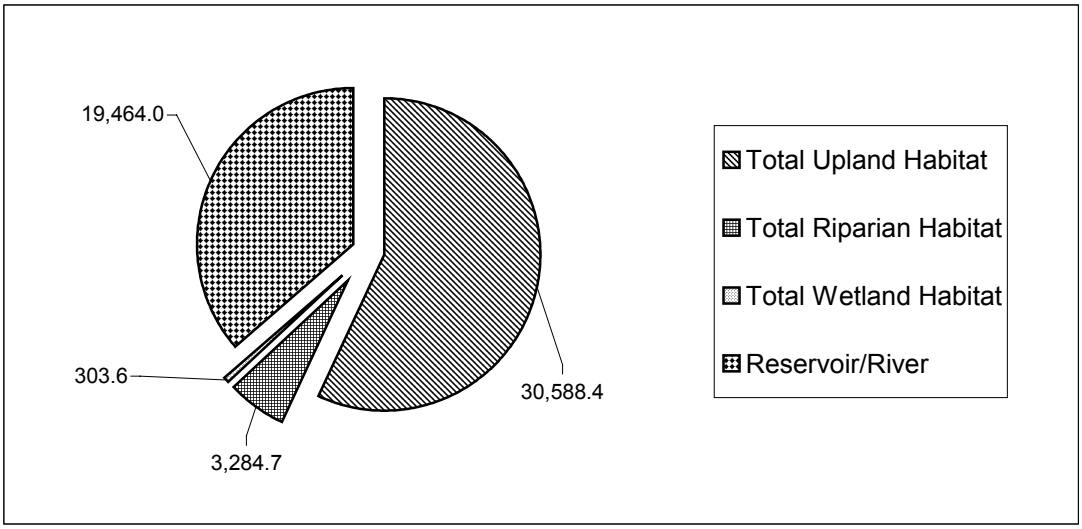


Figure 4.6-2. Pre-project (1958) Acreage of Vegetation Types in the Study Area

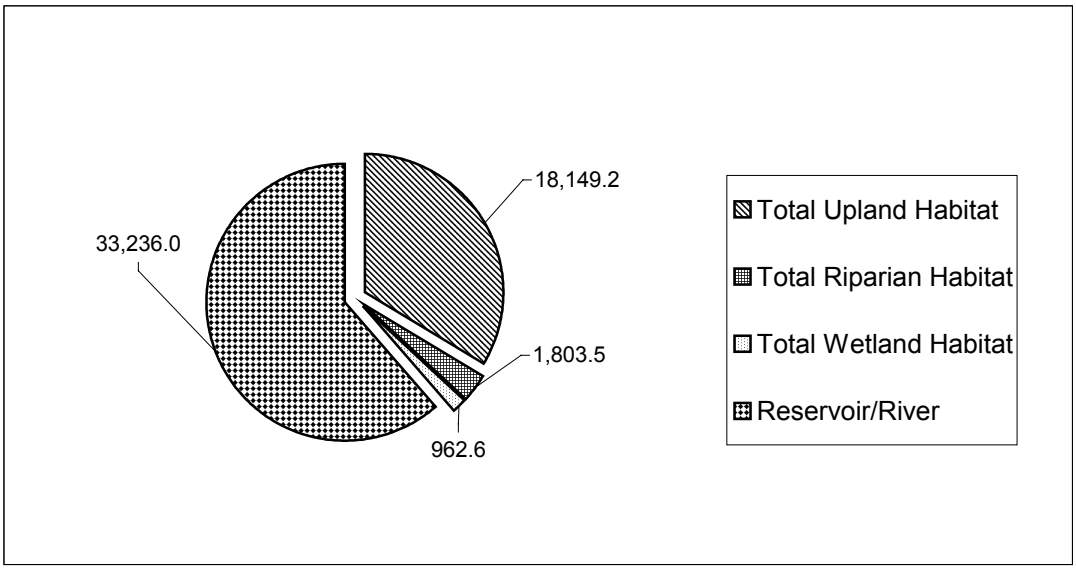


Figure 4.6-3. Current (1995) Acreage of Vegetation Types within the Study Area

4.6.1.2 Emergent Wetland Community

In contrast to riparian habitats, which usually have water saturated soils during flood events, wetlands generally occur where groundwater saturates the surface layer of soil during a portion of the growing season, often in the absence of surface water. This water remains at or near the surface of the substrate for periods of sufficient duration and frequency to induce the development of characteristic vegetative, physical, and chemical conditions (16 USC Sec.440b Title 16, ch. 64).

Wetlands along the river and inside stream deltas serve a variety of physical and biological functions including: wildlife habitat (waterfowl, big game, furbearers, etc.), fish breeding and foraging habitat, nutrient/sediment trapping, flood control, and recreation.

The amount and occurrence of emergent wetland vegetation has increased since the four dams were constructed, from about 10 acres in 1958 to 353 acres currently (Table 4.6-1, Figure 4.6-3). Additionally, numerous small pockets of wetland vegetation, less than one-half acre in size (not mapped due to small size), exist in small impoundments behind roads and railroads and small embayments. Vegetation is dominated by cattail and softstem bulrush with some rushes and sedges. The increase in emergent wetland communities is likely due to several factors: 1) abundant slack water which causes sediments carried into reservoirs to accumulate and create good conditions for wetland vegetation development, especially at the mouths of tributaries; 2) several embayments and backwaters which also allow wetland development; 3) drawdowns which allowed wetland vegetation to establish; and 4) runoff and seeps from nearby irrigated HMUs.

4.6.1.3 Upland Community

The upland vegetation in the study area is typical of steppe communities in the Columbia Basin Province, which are dominated by rabbitbrush, cheatgrass, and remnant bunchgrasses and forbs. Prior to reservoir construction, much of the upland habitat had been degraded by overgrazing with livestock. Also, some vegetation had been removed to facilitate farming and orchards. Pockets of native grassland vegetation (bluebunch wheatgrass-Sandberg's bluegrass community) remained on very steep slopes and other areas inaccessible to grazing; otherwise, much of the native vegetation had been replaced with cheatgrass. Approximately 12,439 acres of upland vegetation were inundated by the four reservoirs (Table 4.6-1).

Currently, 18,149 acres of upland habitat exist within the study area (Table 4.6-1). Grassland represents the largest habitat type present within the study area and includes approximately 9,406 acres. Topographic relief increases from the lower to upper end of the reach reflecting increasing proportions of rock cliff and talus slopes. Fencing of project lands has eliminated cattle grazing on some plant communities (mostly grassland), encouraging re-establishment of some of the native plants. Shrub-steppe habitat present in the study area includes approximately 5,332 acres. Characteristic vegetation of this habitat includes big sagebrush, gray rabbit brush, and cheatgrass.

Currently, about 307 acres of agricultural land (i.e., cropland and pasture) are present in the study area. Included in this habitat type are lands being managed specifically for wildlife that include a mixture of alfalfa, grass pastures, and food plots. The food plots are primarily small patches of crops which are rotated between corn, sunflower, and grain sorghum. Wheat and millet are also used sometimes in the food plots.

4.6.2 Wildlife

The study area for wildlife resources encompasses the four reservoirs along the lower Snake River as well as the wetland, riparian, and upland habitats within the canyon of the river (see Section 4.6.1, Vegetation, and Figures 4.6-4a through d). The study area contains some of the most important wildlife habitat remaining in eastern Washington because most of the upland areas outside the canyon are intensively cultivated for crops such as wheat, barley, and lentils. Asherin and Claar (1976) identified 87 species of mammals and 257 species of birds that occur in the vicinity of the lower Snake River. Although the canyon has been intensively grazed in the past, particularly between the 1880s and late 1930s (Asherin and Claar, 1976), upland vegetation in the canyon is still important for the maintenance of healthy populations of wildlife, particularly upland game bird species such as pheasant, chukar, and quail.

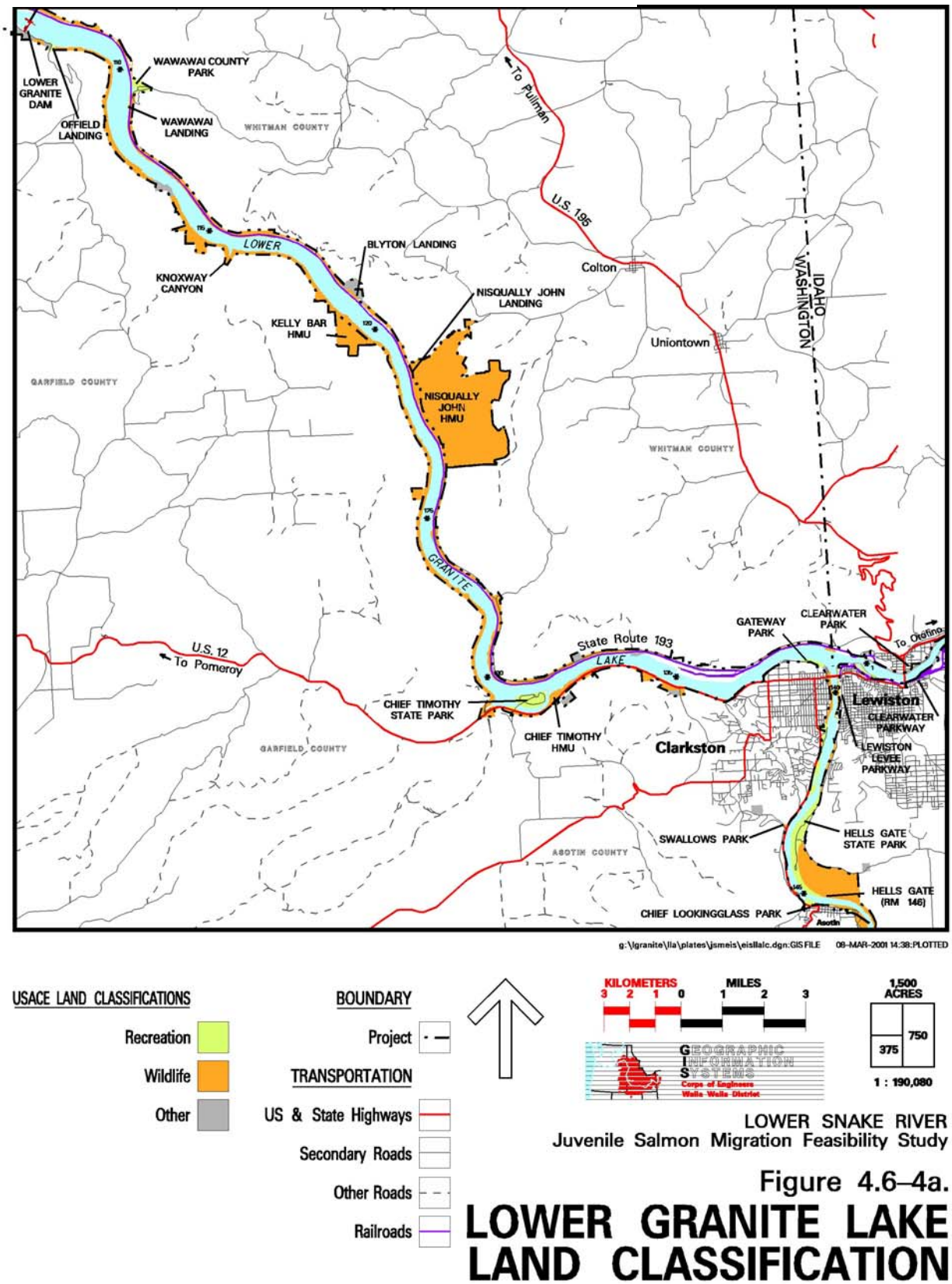
Inundation of the lower Snake River following dam construction between 1962 and 1975 eliminated approximately 45 percent of the woody riparian habitat present along the pre-impoundment river (Asherin and Claar, 1976; Appendix L, Lower Snake River Mitigation and History and Status). The remaining riparian habitat is now highly discontinuous and dominated by exotic species such as Russian olive (see Section 4.6-1, Vegetation).

Some riparian habitats have been restored through the establishment of HMUs along the river (Figures 4.6-4a through d). Thus, wildlife generally associated with riparian habitats tends to be concentrated in these HMUs and in the natural vegetation along the major tributaries, such as the Tucannon and Palouse rivers.

Current wildlife resources are described below according to the following major groups of terrestrial species that exist in the study area: game birds, waterfowl, shorebirds, colonial-nesting birds, raptors, other non-game birds, big game animals, small mammals, furbearers, amphibians and reptiles, and listed threatened or endangered species. These groups were chosen to facilitate the results of this analysis with the results of the existing Habitat Evaluation Procedures (HEP) that have been undertaken for the Lower Snake River Fish and Wildlife Compensation Plan. These groups are not intended to be exclusive. They are simply intended to provide basic species groupings for the purposes of discussion.

4.6.2.1 Current Terrestrial Mitigation and Habitat Evaluation Procedures

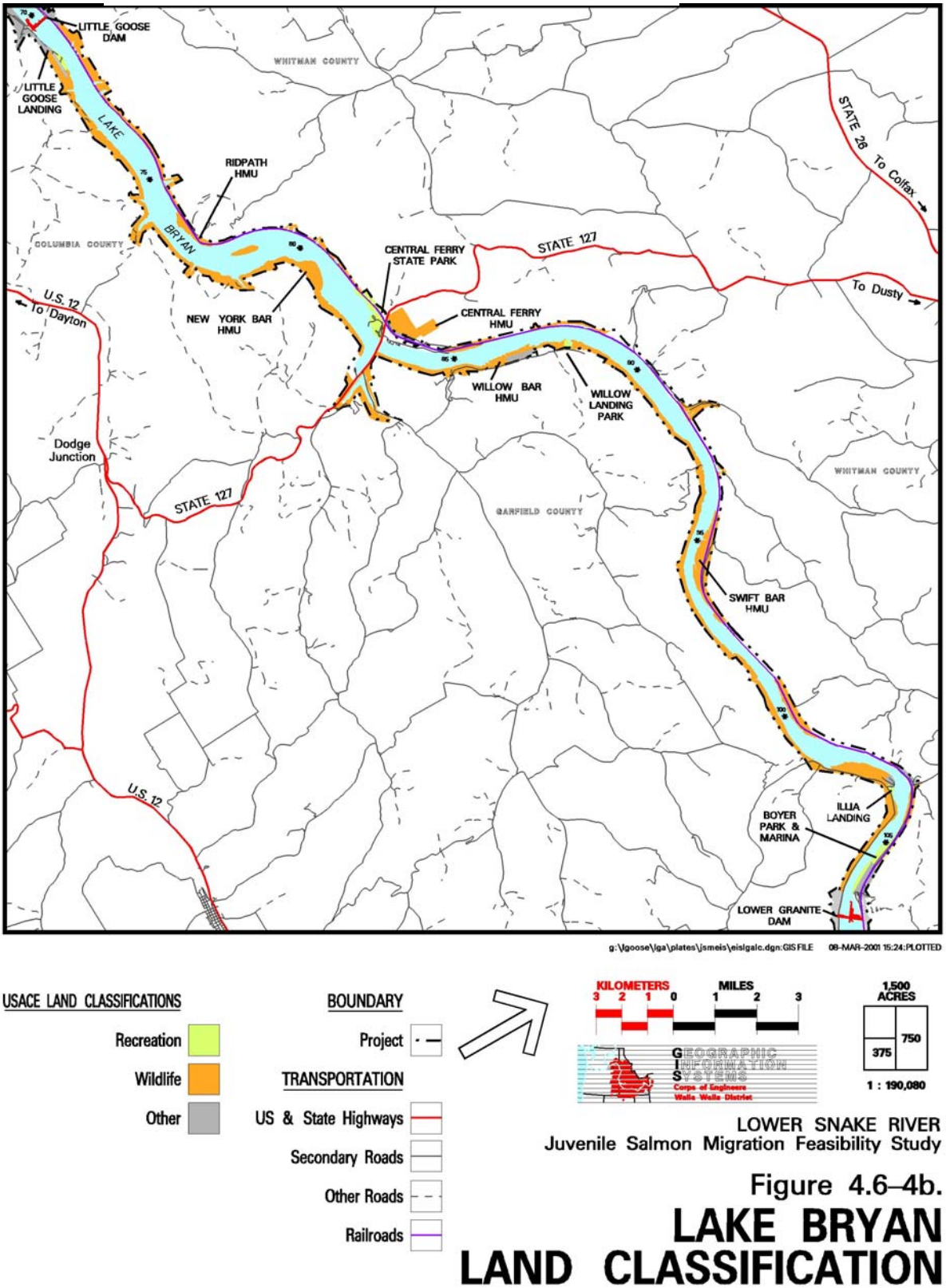
The Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan) was developed to compensate or mitigate for fish and wildlife losses from constructing the four lower Snake River reservoirs (see Section 2.1.1.8, Lower Snake River Fish and Wildlife Compensation Plan). Other terrestrial mitigation in Idaho was covered in a separate agreement (see Appendix L, Lower Snake River Mitigation History and



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

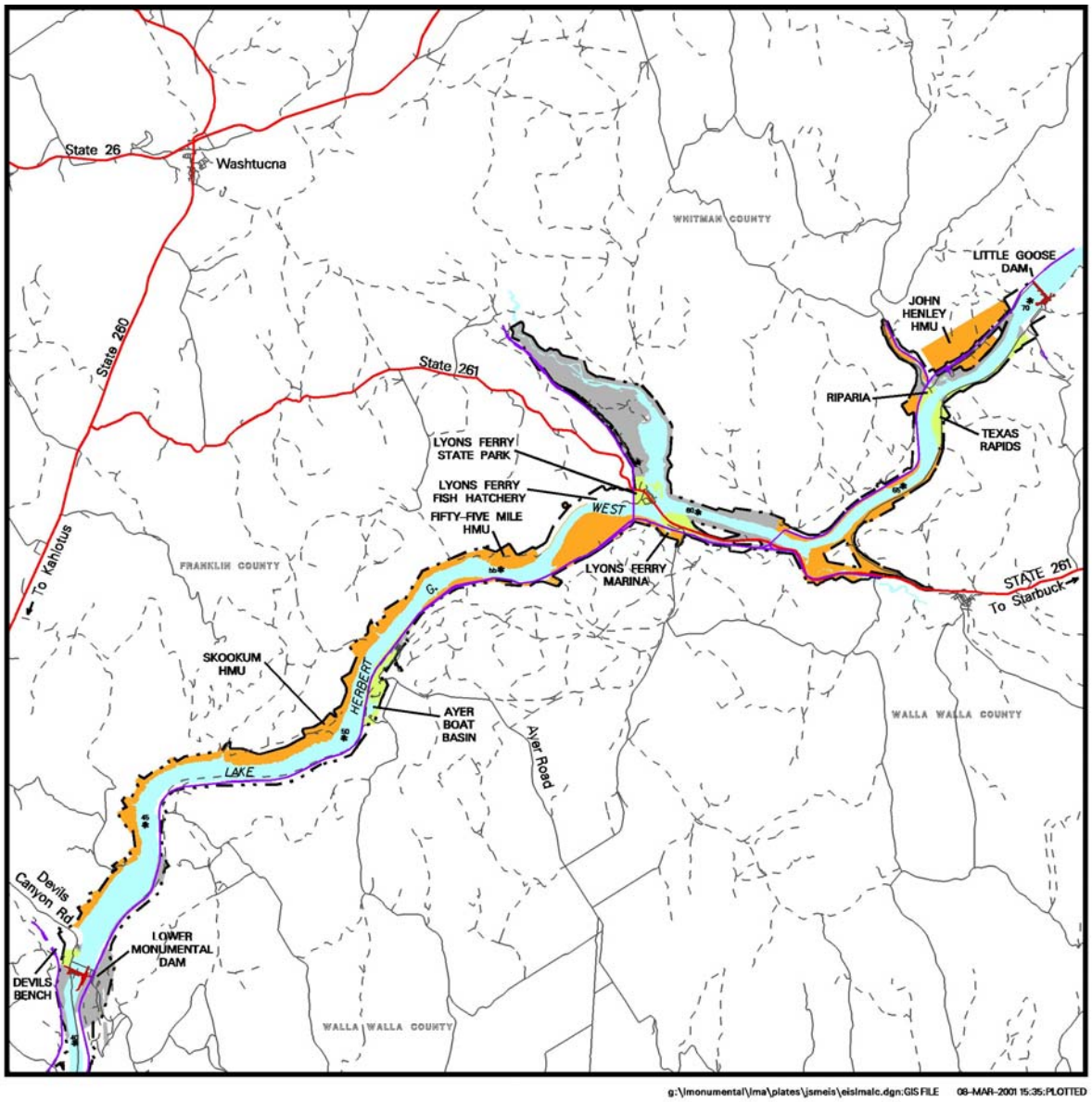
Figure 4.6–4a.

LOWER GRANITE LAKE LAND CLASSIFICATION



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.6–4b.
LAKE BRYAN LAND CLASSIFICATION



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USACE LAND CLASSIFICATIONS

- Recreation
- Wildlife
- Other

BOUNDARY

- Project

TRANSPORTATION

- State Highways
- Secondary Roads
- Other Roads
- Railroads

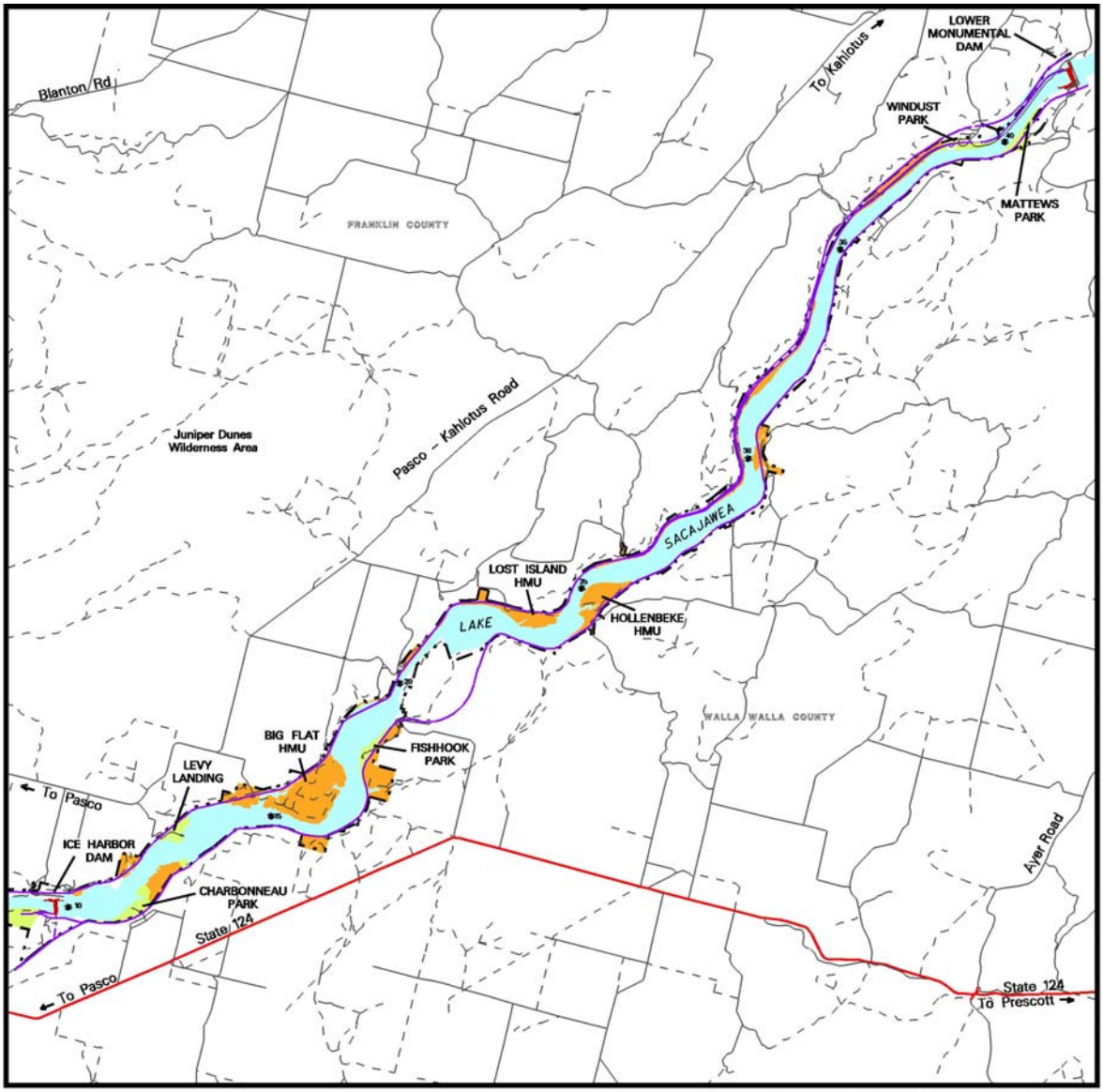
KILOMETERS 3 2 1 0 MILES 1 2 3

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1,500 ACRES
750
375
1 : 190,080

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.6–4c.
LAKE WEST LAND CLASSIFICATION



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USACE LAND CLASSIFICATIONS

- Recreation
- Wildlife
- Other

BOUNDARY

- Project

TRANSPORTATION

- US & State Highways
- Secondary Roads
- Other Roads
- Railroads

KILOMETERS 3 2 1 0 MILES 1 2 3

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1,500 ACRES
750
375

1 : 190,080

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.6–4d.

LAKE SACAJAWEA LAND CLASSIFICATION

Status). Initially, mitigation goals were defined by animal numbers and hunter-use days. However, concerns arose over use of this method for determining compensation (USFWS, 1991). Subsequently, it was determined that a habitat-based method should be used to establish compensation goals and measure compensation progress. This was formalized in a Letter of Agreement (LOA) signed by the Corps, USFWS, and Washington Department of Wildlife (now the Washington Department of Fish and Wildlife [WDFW]) in 1989. These agencies agreed to use a modified HEP method.

HEP is a species-based habitat analysis procedure, that normally involves representatives from several agencies or other groups. The USFWS, Corps, and WDFW were all actively involved in this procedure. HEP assesses the value of a given habitat for certain selected species over the life of the project. The species evaluated are selected either to represent entire groups of species (for example, river otter was chosen to represent furbearers), because of some special value they have in the area (for example, popular game birds), or to evaluate a certain habitat type. The evaluation species that were chosen included 12 birds and mammals, including: downy woodpecker, yellow warbler, marsh wren, song sparrow, western meadowlark, California quail, ring-necked pheasant, chukar, mallard, Canada goose, mule deer, and river otter. Appendix L, Lower Snake River Mitigation History and Status identifies the species group or habitat type represented by each of these species and provides more detail on the HEP methodology.

Terrestrial wildlife habitat mitigation is divided into several programs. These include Lower Snake River Project land (which involves lands immediately adjacent to the reservoirs) development program; the purchase of additional lands and easements; and the game farm program. The Lower Snake River Project lands have been developed using a combination of dryland and irrigation techniques. The Corps has purchased additional lands and easements in southeast Washington, and has begun developments on them (Figure 2-5, Chapter 2). These developments include food plots, pastures, grass meadows, and shrub and tree plantings to improve habitat for both game and non-game wildlife species. The game farm alternative is a program where the WDFW sets up lease agreements with landowners in southeast Washington to improve ring-necked pheasant habitat on their lands (see Appendix L, Lower Snake River Mitigation History and Status for more detail).

4.6.2.2 Game Birds

The major game bird species occurring in the study area include ring-necked pheasant, California quail, chukar, and mourning dove, of which only the mourning dove is native (Asherin and Claar, 1976; Rocklage and Ratti, 1998). These game birds are relatively common throughout the study area, extending from the riverside to the upland areas. Chukars use a wide variety of habitats in the study area. Oelklaus (1976) found that chukars use Douglas hackberry, smooth sumac, and poison ivy stands along the Snake River extensively. Shrub and talus areas are important for nesting (USFWS, 1995). Cheatgrass and agricultural grains are important for foraging (Galbreath and Moreland, 1953; Christensen, 1970). Access to water is probably the most limiting factor for chukar distribution in the study area (Galbreath and Moreland, 1953).

Ring-necked pheasants depend on permanent shrub and tall herbaceous cover that is maintained on irrigated lands in the study area. They are often found in the irrigated HMUs foraging on food plots.

The California quail has experienced more habitat loss than the other species as a result of inundation by the Lower Snake River Project. This species has an estimated loss of 18,861 habitat units (HUs) that remain uncompensated since dam construction and mitigation development. This outstanding mitigation need exceeds the amounts for any other single wildlife species or group in the study area. In comparison, the pheasant and chukar have approximately 2,118 and 877 HUs still uncompensated, respectively. The pheasants and quail tend to be found most often in the irrigated HMUs, such as Swift Bar HMU, where their populations are supported by food plots of various crops like sunflower, grain, and corn as well as permanent water sources called "guzzlers." Of a total of 62 HMUs scattered along the Snake River from Ice Harbor Dam to the upper extent of the Lower Granite pool, 10 are subject to intensive management. Within these 10 intensively managed HMUs, approximately 960 acres of food plots, meadows, and woody vegetation plots are under irrigation.

4.6.2.3 Waterfowl

Over 30 species of waterfowl have been documented to occur in the study area (Lewke and Buss, 1977; Asherin and Claar, 1976; Rocklage and Ratti, 1998). Although impoundment of the river has not significantly changed the species composition of waterfowl along the river (the most abundant species are still Canada goose, mallard, common goldeneye, and American wigeon), it has affected the abundance and occurrence of these species both negatively and positively. In general, the increase in consistent slack water has provided more loafing and resting sites, but has eliminated feeding and nesting sites by removing riparian vegetation. However, the increase in abundance of cereal grain fields both in HMUs along the river and in the adjacent uplands has provided a consistent source of food, particularly for mallards and Canada geese. Of the four reservoirs, Ice Harbor usually has the most waterfowl (see Appendix M, Fish and Wildlife Coordination Act) probably due to its protection as a waterfowl preserve. HEP analysis has demonstrated that approximately 2,060 HUs of uncompensated losses for Canada geese exist along the river, compared to 52 HUs of compensation exceeding losses for mallards (see Appendix L, Lower Snake River Mitigation History and Status).

Much of the management focus on waterfowl along the lower Snake River has been for Canada geese. Therefore, much more is known about the population status of this species than any other single species. Canada goose nesting has been documented on cliffs, on islands, and on artificial nesting structures along the river. Surveys conducted between 1974 and 1987 on the lower Snake and Columbia Rivers have found that over 80 percent of Canada goose production was supported on Badger, Foundation, and New York islands on the Columbia River (Corps., 1988). New York Island alone has averaged 70 to 80 nests over the years, but numbers have declined in recent years. Foundation and Badger islands averaged 80 to 100 nests each year. Island nesting on the lower Snake River produced about 125 nests in 1996. The surveys also found an average of 88 nests per year in all four reservoirs, compared to a pre-impoundment average of 220 (Yocum, 1961). This reduction in nest production

can be attributed to the inundation of over 50 islands larger than 5 acres by the reservoirs. Cliff nesting appears to be an increasing trend since impoundment (see Appendix M, Fish and Wildlife Coordination Act Report), probably in response to loss of predator-free island nesting sites. Artificial nest structures along most of the HMUs have regular annual use. In 1996, goose tubs (large nest boxes elevated above river level on poles) produced 45 nests on the lower Snake River. Total lower Snake River nesting currently is about 200 nests per year.

4.6.2.4 Shorebirds

Shorebirds are relatively uncommon breeders along the lower Snake River (Smith et al., 1997); their use of the reservoirs is limited by the small amount of sandbars and mudflats available (USFWS, 1991; Asherin and Claar, 1976). At least one study has shown that use of shorelines by shorebirds on reservoirs and natural lakes in the intermountain west is closely associated with the availability of exposed mudflats (Taylor and Trost, 1992). Potential suitable habitat for shorebird breeding in the vicinity of the study area includes Lake Kahlotus and the McNary Wildlife Refuge, as well as Foundation, Badger, and Crescent Islands on the Columbia River (Smith et al., 1997). Pre-impoundment, only killdeer and spotted sandpiper were seen along the sand and gravel bars of the river with any regularity (see Appendix M, Fish and Wildlife Coordination Act Report). Asherin and Claar (1976) only noted four species in Lower Granite Reservoir prior to inundation. Recent surveys (Rocklage and Ratti, 1998) found killdeer, spotted sandpiper, and common snipe in the area during the breeding season, lesser and greater yellowlegs in the fall, and killdeer and long-billed curlew in the spring. The most abundant species observed by Asherin and Claar (1976) in the study area was the American avocet. Asherin and Claar (1976) observed 28 American avocets during the spring of 1974. The most abundant shorebird species observed by Rocklage and Ratti (1998) was the killdeer. Fifty-eight individuals of this species were observed in the spring season. The HEP analyses did not address shorebirds.

4.6.2.5 Colonial-nesting Birds

Colonial-nesting birds include marine species such as gulls, caspian tern, and double-crested cormorant, but also inland species such as great blue heron and cliff and bank swallows. No known rookeries for any of these species occur on the lower Snake River, with the exception of several sites listed as "possible" breeding sites in the *Breeding Bird Atlas of Washington State* (Smith et al., 1997). Apparently, the double-crested cormorant bred along the river pre-impoundment, but has not been recorded since inundation (Weber and Larrison, 1977). Several of these species breed on the large islands at the mouth of the Snake River (in the vicinity of McNary Wildlife Refuge), but the lack of islands and mature riparian forest as well as fluctuating water levels has probably kept these species from breeding along the reservoirs of the lower Snake River. Both black-crowned night herons and great blue herons have been observed foraging in shallow water areas and in agricultural areas in the study area. Two other species that do occur in the vicinity of the study area are white pelican and double-crested cormorant. White pelicans have had a small nesting colony (20 to 40 nests) on Crescent Island since at least 1994 (Ackerman, 1994). This is the only known nesting population of white pelicans in Washington state and

they are a state-listed endangered species. These birds are occasionally seen in the shallow water areas in the study area, most often near Ice Harbor Dam on the western edge of the study area. Double-crested cormorants have nested on Foundation Island in the McNary pool since at least 1988 with a colony size of between 5 and 125 nests (USFWS, 1997). This species is also occasionally observed foraging in the study area, often in Dalton Lake at Big Flat HMU.

Significant colonies of cliff and bank swallows occur at a number of locations along the river. Bank swallows are usually present wherever there are exposed cutbanks suitable for nesting that are consistently above water level. Cliff swallows nest both on steep rock faces and in the dam structures themselves. The HEP analyses did not address colonial-nesting birds.

4.6.2.6 Raptors

The study area supports a diverse raptor population. Some of the species that have been documented include northern harrier, Swainson's hawk, red-tailed hawk, American kestrel, ferruginous hawk, prairie falcon, and golden eagle. Several of these species, including prairie falcon, golden eagle, kestrel, and Swainson's hawk, nest on cliffs and rocky crevices in the study area (Smith et al., 1997; Asherin and Claar, 1976; WDFW, 1999a). Others, including the ferruginous hawk, nest and forage in the open grasslands and shrubby draws (WDFW, 1999a). Rocklage and Ratti (1998) documented 17 species of raptors in the study area, including 209 individuals of 12 species during the breeding season. Of these 209 individuals, over 80 percent were one of three species: red-tailed hawk (45 percent), American kestrel (21 percent) and northern harrier (14 percent).

Asherin and Claar (1976) found 14 raptor species along the lower Snake River, with one species, burrowing owl, not reported by Rocklage and Ratti (1998). Asherin and Claar (1976) found 225 individuals, with American kestrel (43 percent) and red-tailed hawk (44 percent) the most common species in the study area.

Lewke and Buss (1977) documented species including Cooper's hawk, northern harrier, red-tailed hawk, rough-legged hawk, kestrel, and great horned owl in the vicinity of Lower Granite Reservoir. Asherin and Claar (1976) did not observe three of these species (rough-legged hawk, Cooper's hawk, and great horned owl) in the vicinity of the Lower Granite reservoir. The HEP analyses did not address raptors.

4.6.2.7 Other Non-Game Birds

There is some evidence that bird species richness along the lower Snake River has declined from pre-impoundment conditions. Of 61 total bird species found by Dumas (1950), 12 were not reported by a recent study (Rocklage and Ratti, 1998). These species include the black-chinned hummingbird, veery, red-eyed vireo, solitary vireo, American redstart, Brewer's blackbird, and fox sparrow. Most of these species are associated with riparian forest habitat (Smith et al., 1997). It is possible that some of these species are not currently found along the river because of the lack of mature riparian forest and the predominance of exotic species such as Russian olive (USFWS, 1997).

Several studies (USFWS, 1997; Brown, 1990) have shown that native willow habitat provides both better foraging and nesting habitat for most bird species. This may be partially explained by the more diverse shrub and tree composition of native riparian areas compared to the low diversity Russian olive habitat (USFWS, 1997; Geupel et al., 1993).

Asherin and Claar (1976) found riparian habitats to have the highest bird species richness and the most individuals during winter along the lower Snake River. Riparian habitats in Washington have been identified as priority areas for monitoring, research, and management of neotropical migratory birds (NTMB) (Andelman and Stock, 1994). Eighty-nine species of NTMB have been recorded along the lower Snake River (see Appendix M, Fish and Wildlife Coordination Act Report), including most of the species identified as experiencing long-term declines in Washington, such as the ferruginous hawk, golden eagle, killdeer, eastern kingbird, barn swallow, golden-crowned kinglet, gray catbird, solitary vireo, orange-crowned warbler, yellow warbler, Wilson's warbler, and chipping sparrow (Andelman and Stock, 1994).

Rocklage and Ratti (1998) observed a total of 92 bird species during the breeding season within the study area. Within the various habitats along the river, the HMUs (consisting primarily of riparian shrub habitat) had higher bird species richness during both the breeding season and the fall than the woody drainages leading into the reservoirs. The suitability of the woody drainages for foraging and nesting may be limited by their narrow width and their degradation by intensive cattle grazing. Therefore, despite the lack of mature riparian habitat on the HMUs, they still provide important habitat for riparian bird species. In particular, the irrigated HMUs provide important habitat. For example, Rocklage and Ratti (1998) found 10 species of birds in the irrigated HMUs that were absent from the non-irrigated HMUs. The availability of food plots on the HMUs also probably offsets some of the negative habitat value of the non-native habitat. The improvement in habitat quality in the HMUs, and along the lower Snake River in general, is further evidenced by comparing the results of this study with those of Asherin and Claar (1976). Rocklage and Ratti (1998) detected 24 more bird species along the Snake River from Lower Monumental Dam to Clarkston, Washington during summer, 40 more in fall, and 14 more in spring.

The HEP analyses addressed six non-game bird species, which represented six different cover types. The HEP analyses reveal that the value of the habitat provided on compensation lands for three of the six species, including the marsh wren, song sparrow, and western meadowlark (as measured in habitat units), exceeds the losses incurred by the inundation habitat by the reservoirs (Appendix L, Lower Snake River Mitigation History and Status). These species represent emergent wetland, mesic shrubland, and shrub-steppe grassland cover types, respectively.

Very little emergent wetland habitat existed pre-impoundment (Appendix L, Lower Snake River Mitigation History and Status), and impoundment actually created more of this habitat type than existed before impoundment. Shrub-steppe grassland and mesic shrubland cover types have both benefited from development of purchased compensation lands.

The following species and their habitats have uncompensated losses: downy woodpecker (riparian forest), song sparrow (riparian forest understory), and yellow warbler (scrub-shrub wetland). Of these three species, the yellow warbler has the largest deficit (710 HUs) and the song sparrow has the least uncompensated losses (15 HUs). The biggest deficit, therefore, is with cavity-nesting species and species that rely on native riparian shrub and tree communities. In order to thrive in this region, the yellow warbler needs native willow/cottonwood and the downy woodpecker needs native riparian forest (with some decadence).

4.6.2.8 Big Game Mammals

Mule and whitetail deer are the two most common big game species found along the lower Snake River. Other species that have been observed along the river but that are considered uncommon to rare include elk, bighorn sheep, black bear, moose, and mountain lion. An estimated 1,800 mule and white-tailed deer inhabited the study area prior to inundation (WDG, 1984). The WDFW estimated that inundation reduced the carrying capacity of the study area by 1,200 deer (Corps, 1975). Aerial winter deer counts conducted by the Corps and WDFW between 1978 and 1988 along the four reservoirs found an average of 3,547 deer per year or an average of 9.2 deer per square mile (Corps, 1990). Mule deer made up approximately 80 percent of this population, with whitetail deer making up the remaining 20 percent. During this time, deer densities gradually increased, with a net increase of over 3,000 deer by 1988. The Corps (1990) suggests that this means that the study area recovered to its pre-project carrying capacity. This increase is at least partly due to the development of habitat in the HMUs and the exclusion of livestock from much of the study area.

Suitable habitat for deer in the study area mainly serves as wintering range, with the deer making seasonal and daily migrations out of the canyons to forage in the surrounding cultivated land. While in the study area, deer use a wide variety of habitats, including shrub and brush for cover and fawning and grassland for foraging. There is some evidence that greater precipitation and higher habitat diversity along the upper two reservoirs provide more stability for deer populations than habitats downstream (Corps, 1990).

Habitat development in irrigated HMUs (e.g., Skookum, 55-Mile) has provided some higher quality habitat in Ice Harbor and Lower Monumental Reservoirs. Furthermore, HMUs could be considered excellent habitat for fawning as they provide dense shrub habitat for cover, food plots for foraging, and close proximity to water (Thomas, 1979). It is unknown if mule or white-tailed deer use existing islands as fawning habitat in the study area. Only New York Island may provide suitable cover for fawning although there has been no evidence of deer use in the last 15 years. Currently, the winter deer range provided by the HMUs is considered to be low to moderate quality, based on HEP analysis (USFWS, 1991). Nonetheless, the most recent HEP analysis available (see Appendix L, Lower Snake River Mitigation History and Status) demonstrates that current compensation habitat in the study area for the big game species group (which is based on the mule deer model) outweighs pre-dam habitat losses by approximately 534 HUs. Notably, epizootic hemorhagic disease has recently caused severe mortality in the white-tailed deer population,

although estimates of deer numbers lost are not currently available and losses are expected to be short term in nature.

4.6.2.9 Small Mammals

Eleven small mammal species have been observed in the study area, with two additional species likely present. These species include the deer mouse, western harvest mouse, Great Basin pocket mouse, house mouse, long-tailed vole, montane vole, northern pocket gopher, vagrant shrew, Merriam's shrew, bushy-tailed woodrat, and Ord's kangaroo rat (Rocklage and Ratti, 1998; Johnson and Cassidy, 1997; Asherin and Claar, 1976; Fleming, 1981). Pre-impoundment data from a study done on the Lower Granite Reservoir (Lewke and Buss, 1977) found seven species, of which the deer mouse made up the majority of captures (93 percent). Asherin and Claar (1976) found only deer mice at the Lower Granite Reservoir site prior to impoundment. Overall, deer mice made up 70 percent of the total numbers of small mammals trapped in their 1974 study. Post-impoundment studies have found similar results. Rocklage and Ratti (1998) found six species, with deer mouse composing 74 percent of total captures. Notably, some evidence suggests that small mammals prefer native riparian habitat to other habitat. Asherin and Claar (1976) found the highest species diversity in their study in the native cattail and shrub willow habitat types. One species, vagrant shrew, is known to be dependent on riparian areas (Johnson and Cassidy, 1997; Appendix M, Fish and Wildlife Coordination Act Report).

Six species of bats have been documented in the study area and five more are suspected to occur there based on habitat suitability, their range, and their occurrence in the vicinity (Johnson and Cassidy, 1997; Mack et al., 1994, Asherin and Claar, 1976). Documented species include the Yuma myotis, western pipistrelle, pallid bat, small-footed myotis, California myotis, and Townsend's big-eared bat (Asherin and Claar, 1976; Johnson and Cassidy, 1997).

Other species of bats that may also be present include the long-legged myotis, long-eared myotis, fringed myotis, hoary bat, and big brown bat (Johnson and Cassidy, 1997; Asherin and Claar, 1976). The Yuma myotis, long-legged myotis, long-eared myotis, small-footed myotis, fringed myotis, and Townsend's big-eared bat are all listed as species of concern by the USFWS (USFWS, 1998a). The Townsend's big-eared bat is also a candidate for state listing (WDFW, 1999b).

Although the known or suspected species of bats in the study area use a wide variety of habitats, there are some trends. Townsend's big-eared bat is thought to be dependent on caves or mines for both winter and summer roosting (Perkins and Levesque, 1987; Philpott, 1997). It preys primarily on moths and seems to require still lakes, ponds, or pools to obtain water, as it flies low and laps water with its tongue (Perkins and Schommer, undated). Most of the other species use a wider range of locations, including caves, mines, trees, buildings, bridges, dams, and rock crevices as roost sites (Philpott, 1997; Christy and West, 1993). Bats have been known to roost in the dams in the study area. At least one species, the western pipistrelle, is closely associated with the steep canyon walls and rock crevices in the study area and utilizes these habitats for roosting (Johnson and Cassidy, 1997). This observation is consistent with behavior of western pipistrelles in southern Arizona

and southwestern New Mexico (Hayward and Cross, 1979). Most of these species will forage in a wide variety of habitats, including arid grassland, shrubs, trees, and rocky areas (Johnson and Cassidy, 1997).

At least one species, Yuma myotis, is closely associated (more so than any other species) with water, and tends to forage close to the surface of the water (Johnson and Cassidy, 1997; Maser, 1998).

4.6.2.10 Furbearers

Furbearing mammals that have been documented in the study area include bobcat, coyote, raccoon, red fox, striped skunk, beaver, river otter, mink, and muskrat (Asherin and Claar, 1976; Johnson and Cassidy, 1997; Mack et al., 1994). Coyote and raccoons are the most common terrestrial species, and beaver is the most common aquatic furbearer.

Asherin and Claar (1976) observed four species of terrestrial furbearers (bobcat, coyote, raccoon, and striped skunk) and three species of aquatic furbearers (beaver, river otter, and muskrat). They concluded that aquatic furbearer abundance was low along the lower Snake River. Asherin and Claar (1976) also conducted scent station surveys along the lower Snake River in 1974, but unfortunately they were not conducted in the Lower Granite Reservoir site so no comparison to natural river conditions can be made. These surveys produced similar results to the direct observations, with raccoon and coyote the most common species observed. Asherin and Claar (1976) also noted that the aquatic furbearers were more abundant in those study segments with more extensive riparian habitat such as McNary Wildlife Refuge and Brownlee Reservoir.

Although it is likely that some of these species were never abundant (Asherin and Claar, 1976), inundation by the reservoirs probably eliminated much of the riparian habitat that was important for foraging and denning in many of the furbearers. In particular, muskrat and mink seem to have declined (WDG, 1984).

HEP analysis demonstrates that current compensation habitat in the study area for furbearers exceeds losses by approximately 866 HUs (see Appendix L, Lower Snake River Migration History and Status). The HEP analysis for furbearers was based on the model for the river otter. One of the reasons why compensation has exceeded losses is that riprap placed along the river for bank stabilization is considered to provide suitable denning habitat for otters (USFWS, 1995).

4.6.2.11 Amphibians and Reptiles

Sixteen species of amphibians and reptiles have been documented in the study area (Asherin and Claar, 1976; Loper and Lohmann, 1998; Corps, 1976). Asherin and Claar (1976) found 11 species of herptiles along the lower Snake River during surveys in 1974. These included five amphibian and six reptile species. The most commonly occurring species were the Pacific tree frog, bullfrog, western yellow-bellied racer, and Great Basin gopher snake. Furthermore, of the vegetation types sampled, the ones most closely associated with water had the greatest relative

abundance of amphibians. In particular, native willow and emergent wetland habitats had the greatest species diversity (Asherin and Claar, 1976).

A recent 2-year study by Loper and Lohman (1998) found five amphibian and eight reptile species in the study area. Species found in this study but not in Asherin and Claar's (1976) study were long-toed salamander, western toad, night snake, and painted turtles. Asherin and Claar (1976) found the Columbia spotted frog and Great Basin spadefoot toad, which were not found by Loper and Lohman (1998). Although Asherin and Claar (1976) did not find those four species in the study area, they did find them in other study segments. Thus, it might be expected that they could have dispersed into the study area, or, since Asherin and Claar (1976) only employed visual surveys, they were simply not detected.

Although the Columbia spotted frog is common in much of the Palouse region, it is generally absent from the lower Snake River area (Loper and Lohman, 1998; Johnson and Cassidy, 1997). Similarly, the Great Basin spadefoot toad is considered a common resident of the Columbia River Basin, even though it was not discovered during the Loper and Lohman (1998) study (Johnson and Cassidy, 1997). Loper and Lohman (1998) observed the western painted turtle at only one site—the pond on the Chief Timothy HMU. Asherin and Claar (1976) only found this species at Hat Rock State Park on the Columbia River. Other species that may occur within the study area, but were not seen in either study, include: tiger salamander, northern leopard frog, short-horned lizard, sagebrush lizard, rubber boa, and the ringneck snake (Loper and Lohman, 1998; Johnson and Cassidy, 1997; Asherin and Claar, 1976).

Unlike Asherin and Claar (1976), Loper and Lohman (1998) found no increased abundance of amphibians or reptiles with riparian areas. They found that, in general, species richness and abundance were low at both riparian and upland sites. Some of the reasons behind this pattern may include the relative young age of the recovering riparian fringe beside the existing reservoirs; the isolation of suitable riparian habitat into discrete patches along the river (i.e., HMUs); and fluctuating water levels in the reservoirs that prevent the consistent occurrence of litter, debris, pools, and vegetation that these species could use for breeding, resting, and forage (Loper and Lohman, 1998). These conclusions are supported by studies on amphibians in other dammed river systems (Lind et al., 1996; Jones, 1988).

4.6.3 Species with Federal Status

The Endangered Species Act (ESA) (16 USC 1536), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the preservation of the ecosystems upon which they depend. Section 7(a) of the ESA requires Federal agencies to consult with the USFWS and the NMFS, as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitat.

Section 7(c) of the ESA and the Federal regulations on endangered species coordination (50 CFR § 402.12) also require that Federal agencies prepare biological assessments of the potential effects of major construction actions on listed or proposed endangered species and critical habitat.

There are 10 potentially affected species that have Federal status under the ESA as threatened or endangered (Table 4.6-2). These species are described below in Section 4.6.3.1, Threatened and Endangered Plant Species, and Section 4.6.3.2, Threatened and Endangered Wildlife Species.

4.6.3.1 Threatened and Endangered Plant Species

Five plant species with Federal status—water howellia, McFarlane's four-o'clock, Ute ladies' tresses, Howell's spectacular thelypodium, and basalt daisy—may potentially occur in the study area. Water howellia, McFarlane's four-o'clock, and Ute ladies' tresses are Federally listed as threatened, Howell's spectacular thelypodium is proposed to be listed, and the basalt daisy is a candidate for Federal listing.

Water Howellia

Water howellia, a Federally threatened species, is a small annual aquatic plant that is usually found in wetlands associated with glacier pothole ponds and former river oxbows (USFWS, 1994a). Generally this species is found in isolated seasonal ponds or river oxbows that may be abandoned or hydrologically linked to adjacent river systems. These seasonal wetland habitats usually exhibit some drying during the growing season, although some of the ponds may retain water throughout the year (USFWS, 1994a). This seasonal drying is critical to the phenology of this species, which reproduces solely from seeds that require air to germinate (USFWS, 1994a). Historically, howellia occupied a large area of the Pacific Northwest, extending from northern California to Washington and Montana. Currently, there are only 107 known populations. Most of these populations are concentrated in two regions—Spokane County, Washington and the Swan River drainage in northwestern Montana, where 46 and 59 individual populations are located, respectively (USFWS, 1994a). The closest population to the study area is approximately 60 miles north in Spokane County, Washington (USFWS, 1994a). The USFWS has not completed a recovery plan for this species at this time. These individual populations are considered to be vulnerable to disturbance and possible extirpation due to a variety of threats, including drainage of wetlands due to farming, damage from intense grazing, timber harvesting, residential development, and competition from exotic species (particularly reed canary grass) (USFWS, 1994a).

McFarlane's Four-o'clock

McFarlane's four-o'clock, a Federally threatened species, is known to occur only at sites on the lower Snake, Salmon, and Imnaha rivers, all upstream of the lower Snake River project in Hells Canyon, which is about 30 miles from the study area (USFWS, 1996). It is apparently restricted to talus slopes in canyonland corridors where the climate is regionally warm and dry with precipitation occurring mostly in winter and spring (USFWS, 1996). Exotic plant species, particularly cheatgrass and yellow star-thistle, as well as intense livestock grazing pose serious threats to this species (USFWS, 1996). The USFWS has completed a recovery plan for this species.

Table 4.6-2. Threatened and Endangered Plant and Animal Species Potentially Occurring within the Study Area

Common Name	Scientific Name	Status[1/]	Primary Habitat Association	Occurrence
Plants				
Water howellia	*Howellia aquatilis*	Threatened	Small isolated ponds and river oxbows	Possible
McFarlane's four-o'clock	*Mirabilis macfarlanei*	Threatened	Grassland dominated by bluebunch wheatgrass	Possible
Ute ladies' tresses	*Spiranthes diluvialis*	Threatened	Wetland and riparian areas	Possible
Howell's spectacular thelypodium	*Thelypodium howellii var. spectabilis*	Proposed	Wet alkaline meadows	Possible
Basalt daisy	*Erigeron basalticus*	Candidate	Cliff crevices in basaltic canyons	Possible
Animals				
Bald eagle	*Haliaeetus leucocephalus*	Threatened	Nests mainly in tall, dead-topped conifers or snags near large bodies of water; in winter, forages along major river systems in Washington and Oregon	Documented in winter; no known breeding occurrences
Oregon spotted frog	*Rana pretiosa*	Candidate	Shallow emergent wetlands associated with lakes and streams	Possible
Gray wolf	*Canis lupus*	Endangered	Restricted to remote wilderness areas free of human disturbance with abundant prey	Possible
Grizzly bear	*Ursus horribilis*	Threatened	Remote, mountainous areas with low-level human disturbance	Possible
Canada lynx	*Lynx canadensis*	Threatened	Lodgepole pine stands on north facing slopes 1,400 to 2,180 meters in elevation	Very unlikely but species could pass through area

1/ Status from USFWS species list (USFWS 2000 Biological Opinion)
Source: Foster Wheeler Environmental Corporation (1999)

Ute Ladies' Tresses

This perennial orchid is listed as Federally threatened. It has been documented in southeastern Idaho along the upper Snake River and in northern Washington. It is found in wetland and riparian areas, including spring habitats, mesic to wet meadows, river meanders, and floodplains, which are typically inundated early in the growing season but dry out later in the year (USFWS, 1992). This species may be adversely affected by modification of its habitat associated with livestock grazing, vegetation removal, excavation, construction activities, stream channelization, and other actions that alter hydrology or vegetation. The USFWS has not approved a recovery plan for this species.

Howell's Spectacular Thelypodium

This herbaceous biennial is proposed for listing and occurs in wet alkaline meadows in valley bottoms, usually near the boundary between upland and the wet meadow in association with woody shrubs. The species is currently known to exist in five populations in Baker and Union County, Oregon, all of which are within 13 miles of the town of Haines, Oregon (USFWS, 1999). The closest population is approximately 100 miles from the study area. Major threats to this species include competition from exotic species such as teasel and thistle, conversion of suitable habitat to agriculture, and the use of herbicides and pesticides (USFWS, 1999). The USFWS does not have an approved recovery plan for this species.

Basalt Daisy

This herbaceous perennial is a candidate for Federal listing. It is a local endemic found only in cliff crevices in basaltic canyons at low elevations in Yakima County, Washington. The nearest known population is approximately 90 miles from the study area. Suitable habitat for this species is restricted to vertical basalt exposures. There are some potentially suitable vertical basalt cliffs for this species in the study area. Basalt cliffs make up a major portion of the approximately 2,400 acres of exposed rock and talus that currently exists in the project area (Table 4.6-1).

4.6.3.2 Threatened and Endangered 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, grizzly bear, and Oregon spotted frog, and Canada lynx are not known to occur, but could potentially occur in low numbers. All five species are described below.

Bald Eagle

Suitable habitat for the threatened bald eagle includes areas with large trees for roosting or nesting that are close to large bodies of open, ice-free water with a good prey base of fish and waterfowl (USFWS, 1986). Bald eagle nesting territories are usually associated with marine or freshwater shorelines where there are stable

populations of fish and/or waterfowl for prey (USFWS, 1986). Nests are usually located in uneven-aged, multi-storied stands with old growth components (Anthony et al., 1982). Nest trees usually provide an unobstructed view of, and are usually within 1 mile of, a nearby water body (Anthony et al., 1982). Live mature trees with deformed tops and snags are often selected. Similarly, large trees or snags with strong branches and open structure in the vicinity of foraging areas are often selected for perch trees (Garrett et al., 1993; Anthony et al., 1982). No bald eagle nests are documented along the reservoirs. The nearest known nest and winter concentration sites are on the Columbia River bordering the Hanford Reservation.

Wintering birds are regularly seen in the study area, although sightings are not abundant. They are present in the study area between November and March. Wintering bald eagles are primarily associated with open water near concentrated food sources. Communal winter roost sites consist of concentrations of eagles within 1 mile of large bodies of water or along large rivers (Anthony et al., 1982). These sites are usually large pockets of old growth along a feeder stream to the large lake or Class I river. Large cottonwoods and conifers are the preferred tree species for use during winter (USFWS, 1997; USFWS, 1986; Stalmaster, 1976).

Midwinter bald eagle surveys by the Corps in 1990 reported 10 eagles on the lower Snake River. These birds are probably dependent on waterfowl and fish, as are eagles at the Hanford Reach of the Columbia River (Fitzner and Hanson, 1979). Wintering bald eagles are more common in the middle and upper Snake River. The lack of mature cottonwood and black locust trees along the margins of the reservoirs probably limits the ability of bald eagles to successfully perch and forage along the lower Snake River.

Oregon Spotted Frog

The Oregon spotted frog is a candidate for Federal listing. It is native to the Pacific Northwest (Leonard et al., 1993). It was recently differentiated from a close relative, the Columbia spotted frog.

The Oregon spotted frog is closely associated with shallow, emergent wetlands associated with lakes, ponds, and slow-moving streams. Historically, this species was common in the lowlands of Puget Sound and the Willamette Valley, but its range has been reduced by almost 90 percent due to loss of wetlands from agriculture and development (McAllister and Leonard, 1997; Hayes, 1997). Of 11 known historic localities in Washington, the Oregon spotted frog has only been found at one, in Thurston County. Two new populations have been found in Klickitat County. No populations are known to occur near the study area. The major threats to this species include predation by exotic species, mainly bullfrog, continued destruction of potentially suitable wetland habitat, overgrazing, and residential development (McAllister and Leonard, 1997).

Gray Wolf

Endangered gray wolves have two main life requisite requirements: 1) an abundance of ungulate and alternative prey species, and 2) isolation from human disturbance.

Wolves will take a variety of prey species, but the bulk of their prey (over 90 percent by weight) is composed of ungulates, mainly deer, elk, and moose (USFWS, 1987). Also, wolves are sensitive to human disturbance, particularly near their denning and rendezvous sites. Factors such as road density have been shown to be important indices of levels of disturbance that wolves can tolerate (Mladenoff et al., 1995).

In 1995, a non-essential, experimental population of gray wolves was reintroduced in the rugged, mountainous terrain of central Idaho. The status of this population allows individuals to be managed in such a way as to avoid conflicts with land uses outside the designated introduction area (USFWS, 1994b). This initial population consisted of 35 adult wolves, which were released in three different locations in the central Idaho wilderness. According to the latest update from the Snake River Basin Office of the USFWS, which is based on wolf locations obtained during aerial surveys between October 2 and 21, 1998, this initial population has reproduced successfully.

There are now 12 known wolf packs in central Idaho, of which 10 successfully reproduced in 1998 (USFWS, 1998c). The total number of wolves in Idaho related to the reintroduction effort, based on radio telemetry and visual documentation, is estimated at 122. The number of wolves in the state could be slightly larger due to transient and dispersing wolves from Canada and Montana. These results are significant for the wolf recovery effort because it is the first year Idaho has met its recovery goal of maintaining 10 breeding packs for 3 consecutive years.

The closest known wolf activity to the study area is in the headwaters of the North Fork of the Clearwater River and along the Salmon River south of Elk City, Idaho, which are both approximately 100 miles from Lewiston, Idaho. As recently as February 1999, a lone female gray wolf dispersed from central Idaho into eastern Oregon, a distance of some 200 miles. This included crossing the Snake River. There have been no sightings of wolves closer to the study area, but given that lone wolves can have home ranges of more than 1,000 square miles (USFWS, 1987), it is conceivable that they could occur in the study area. However, this is unlikely given the relatively high level of human activity and high road density in the study area.

Grizzly Bear

The threatened grizzly bears have three main habitat requirements: 1) a wide range of high-energy foods during all seasons, including both herbaceous and animal sources; 2) dense forest cover; and 3) suitable denning locations in remote, steep areas away from human disturbance (USFWS, 1993). Grizzly bear movements are primarily influenced by the annual availability of food. They tend to move to lower elevations early in the year and move to higher elevations as herbaceous food sources are available (USFWS, 1993).

The grizzly bear persists in very low numbers in Idaho. Two small populations persist in the Selkirk and Cabinet/Yaak ecosystems of extreme northern Idaho. The USFWS observed only one female bear with cubs of the year in 1997 in the Selkirks, and three females with cubs in 1997 in the Cabinet/Yaak area. Also, bears will wander into Idaho from Yellowstone National Park. All of these areas are at least 150 miles from the study area.

Historically, grizzly bears were abundant in the drainage of the Clearwater River and into the Selway-Bitteroot Mountains up to the turn of the century (USFWS, 1998b). However, hunting, trapping, predator control, and the decline of anadromous fish runs led to the virtual extinction of the grizzly in central Idaho by the 1950s. The last confirmed grizzly bear occurrences were of individuals killed in the Bitterroot Mountains in 1932 (Moore 1984, 1996).

The wilderness areas of central Idaho (Frank Church River of No Return, Selway-Bitterroot, and Gospel Hump) are being considered by the USFWS as one of six recovery zones identified in the Grizzly Bear Recovery Plan (USFWS, 1993) that could potentially support viable populations of the bear. The USFWS is currently in the process of reviewing and incorporating public comments on the draft Bitterroot Grizzly Bear EIS that analyzes, in detail, the existing conditions and potential impacts of reintroducing grizzly bears to the Bitterroot Ecosystem. The Selway-Bitterroot Wilderness is approximately 100 miles (to Lewiston, Idaho) from the study area. If bears were reintroduced into this wilderness, it is conceivable that they could occur in the study area given that grizzly bears will range over wide areas. However, it is unlikely that they would occur in the study area given the high level of human activity and the lack of suitable food resources.

Canada Lynx

The Canada lynx was listed as threatened.

In the West, verified occurrences of lynx have been reported from Washington, Oregon, Montana, Idaho, Wyoming, Colorado, Utah, and Nevada (McKelvey et al., 1999a, draft). Over 130 verified records of lynx exist in Washington, most of them from the north Cascades, Okanagan Highlands, and northeastern corner of the state (McKelvey et al., 1999a, draft). However, records for Washington do exist from the central and southern Cascades and in the Blue Mountains (Koehler and Aubry, 1994). Currently, the range of the lynx in Washington is considered to include most of these areas, with the exception of the Blue Mountains. The USFWS has concluded that a resident lynx population exists in Washington (USFWS, 1998d). The WDFW has estimated the current lynx population in the state of Washington at between 100 and 200 individuals (WDFW, 1993).

The distribution and abundance of the Canada lynx is closely tied to that of its primary prey, the snowshoe hare. However, it is widely accepted that lynx population levels in Washington (and other areas in the southern limits of the lynx range) do not fluctuate as compared to populations in Canada because snowshoe hare cycles are not as pronounced in southern latitudes (Koehler and Aubry, 1994; Koehler, 1990; McKelvey et al., 1999b). Studies by McKelvey et al. (1999b, draft) from north-central Washington indicate that lynx are strongly associated with lodgepole pine stands on north-facing aspects between 1,400 and 2,150 meters in elevation. These authors found that this pattern of habitat use by lynx also corresponds to habitat types with the greatest abundance of snowshoe hare. Other habitat variables that are important to lynx include dense, mature conifer forest with large woody debris suitable for denning, and travel corridors between populations. These corridors can

be a variety of habitat types, but are usually some type of dense deciduous or conifer stands (Koehler and Aubry, 1994).

The major threats to this species are continued large-scale fragmentation of suitable conifer forest habitat due to timber harvest and development, trapping (which is not allowed in Washington), and interspecific competition, particularly from coyote, bobcat, and cougar (Koehler and Aubry, 1994; USFWS, 1998a; Buskirk et al., 1999).

No suitable habitat for this species exists in the study area. It is very unlikely that this species would occur in the study area, but recent observation from the Blue Mountains of Oregon (USFWS, 1998d) and historic records from Idaho demonstrate that transient lynx could pass through the study area.

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4.7 Cultural Resources

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Cultural resources in the Snake River Basin are a rich source of information about prehistoric and historic human use and occupation of the study area dating back over 11,000 years. Cultural and historic resources can be generally categorized into one of the following three groups: historic sites, prehistoric archaeological sites, and traditional cultural properties. The information provided in this section is primarily derived from Appendix N, Cultural Resources, and Appendix D of the SOR FEIS (BPA et al., 1995).

4.7.1 Cultural Resource Definition

Known cultural resources in the Snake River Basin consist of traditional cultural properties, as defined by Parker and King (1989), and as identified by an affected living community, as well as archaeological sites. Other cultural resources include the remains of historic settlement and development activities of Euro-Americans, Asians, and other non-Native cultures over the past 200 years. Federal agency responsibilities concerning cultural resources are defined in law, primarily by the National Historic Preservation Act (NHPA), Archaeological Resources Protection Act (ARPA), Native American Graves Protection and Repatriation Act (NAGPRA) and American Indian Religious Freedom Act (AIRFA). As defined in Section 301(5), the term *historic property* means "any prehistoric district, site, building, or object included in, or eligible for inclusion on the National Register, including artifacts, records, and material remains related to such a property or resource."

Prehistoric archaeological sites are typically represented by open campsites; pit house (a semi-subterranean dwelling) villages; rockshelters; rock art (petroglyphs/pictographs); lithic (stone) quarries and workshops; burial grounds and cemeteries; and isolated rock cairns, pits, and alignments. Historical sites are denoted by structures, buildings, and objects that represent activity influenced by Euro-Americans. These include the remains of farms, towns, trading posts, mining sites, military forts, burial sites, abandoned settlements, and transportation and industrial facilities.

Contemporary Native Americans recognize archaeological sites as important resources, but also emphasize their interests in traditional cultural properties. Native American traditional cultural properties, as a class of cultural resources, may include a broad range of features from the natural environment and sacred world. Traditional cultural properties are places and resources composed of both cultural sites and natural elements significant in contemporary traditional social and religious practices, which often help preserve traditional cultural identities. For example, certain distinctive shapes in the natural landscape, features in a tribe's cultural geography, habitats for culturally significant food and medicinal plants, traditional fisheries, sacred religious sites and places of spiritual renewal may constitute traditional cultural properties. Some tribes assert that the Snake River itself is a traditional cultural property. The following discussion of cultural resources focuses on tangible resources such as sites and artifacts. Native American values are discussed in Section 4.8, Native American Indians, and Section 5.7, Native American Indians.

4.7.2 Cultural Resource Significance

The significance of a historic property is defined in the NHPA and is based upon a site's eligibility for listing in the National Register of Historic Places (NRHP). Under Section 106 of the NHPA, Federal agencies are required to take into account the effects of their undertakings on all historic properties included in or eligible for the NRHP (i.e., "significant" historic properties). Eligibility criteria for listing on the NRHP relates to the quality of preservation of a site and its contents, location, integrity of setting and materials, and association with particular ethnic groups or historically known individuals and events. Except under rare circumstances, a property must be at least 50 years old to be eligible for nomination to the NRHP.

A particular site's setting and/or contents are essential to scientists' efforts to examine research questions about the past. Common research themes include cultural history, cultural process, and human adaptations in response to environmental change. Certain cultural sites are significant because they may represent a specific time period. Marmes Rockshelter on Lake West and Windust Caves on Lake Sacajawea are examples of significant sites that contain evidence of some of the earliest human occupants in the lower Snake River canyon. These occupants are believed to have lived between 9,800 and 10,200 years ago.

Many archaeological sites are points of recreational or educational interest for the public through interpretation of their historical and scientific significance. Archaeological sites are also important to the heritage of regional Native American groups, whose primary interest lies with protection rather than investigation.

4.7.3 Prehistory

During the earliest period of human occupation, over 8,000 years before present (BP), people in the general region of the Lower Snake River Project are believed to have foraged for a wide variety of food resources located in different topographic zones. The time between 8,000 and 4,500 years BP witnessed a warming trend and a shift toward more use of plant foods and aquatic resources including salmon and freshwater clams. From 4,500 to 2,500 years BP, people residing in the study area developed pit house villages and further intensified their use of plant and aquatic foods (e.g., river clams).

From 2,500 to 250 years BP, the number of pit house village sites expanded further as did the use of salmon and plant foods. The bow and arrow was also introduced during this time. The last 250 years coincide with the historic and ethnographic period from the acquisition of the horse by native peoples in the early Eighteenth Century to their displacement to reservations in the late Nineteenth Century, and the settling of the area by Euro-Americans.

At the time the Euro-Americans arrived in the Pacific Northwest, they found numerous Native American groups living throughout the Columbia River Basin. The large geographic distribution and the diversity of dialects represented in the languages are evidence for the long presence of native peoples in the region. The lower Snake River was occupied by numerous bands of Native Americans who spoke dialects of the Cayuse, Northeast Sahaptin, and Nez Perce languages. Political organizations consisted of loosely associated villages of family groups, each village with its own general territory and leadership. While these bands were fairly distinctive, they shared similar customs and languages, and jointly used major subsistence and trade markets. Native bands also formed a larger southern Plateau Culture Area society through economic and political alliances.

Middle Columbia and lower Snake River bands shared subsistence-based economies supported by hunting, fishing, and foraging. These practices required families to make annual seasonal migrations throughout their homelands and to places elsewhere within the region. People harvested foods as they became ready and participated in a trade network involving other bands. It is estimated that as much as one-third of the southern Plateau Area peoples' annual diet may have come from aquatic resources such as salmonid fish species. Food plants may have supplied an additional 50 percent of their annual food supply, with game and huckleberries making up much of the remaining amount (Hunn, 1990).

4.7.4 Historic Period

European and American influence began in the early 1700s when European trade items were transported into the Snake River Basin. The first contact between Euro-Americans and Native Americans in the region occurred in 1805 with the arrival of the Lewis and Clark Corps of Discovery. The Lewis and Clark Corps of Discovery followed the course of the lower Snake River, traveling through the homelands of the Nez Perce, Palus, Cayuse, and Walla Walla tribes/bands (Coues, 1893). The Lewis and Clark expedition was followed by other expeditions, that further explored the region and established trading operations. Missionaries arrived in the 1830s, soon to be followed in the 1840s by increasing numbers of settlers coming west.

In 1855, treaties establishing area reservations were signed between the United States and many of the Plateau Culture Area tribes/bands. Gold was discovered in Idaho in the 1860s, leading to a rush of settlers into the area. Further settlement was based on extensive dryland wheat farming. This was the era of the steamboat. Between 1855 and 1880, conflicts arose between non-Native American settlers and local tribes, resulting in several wars. Federally recognized tribes were required to relinquish part of their homelands. However, through treaty negotiations, these tribes legally retained certain

pre-existing rights that allow them to fish at usual and accustomed areas, and hunt, gather, and graze livestock on open and unclaimed lands.

The 1880s brought construction of railroads and continued settlement. The 1900s have seen the damming of the Snake River, expansion of urban developed areas and agricultural lands, increased recreation, navigation of the river, the development of major irrigation projects, and continued growth in the region.

4.7.5 Identified Historic and Archaeological Sites

There are approximately 375 known archaeological sites within the four reservoirs of the Lower Snake River Project, some of which are partially or completely inundated. The known sites are both prehistoric and historic and range in age from the earliest period of human occupation to recent times. Identified prehistoric sites include villages, fishing sites, burials, rock art (pictographs and petroglyphs), storage pits, and temporary camps. Historic sites include homesteads, mining sites, forts, towns, farmsteads, and trading posts.

Two archaeological districts (Windust Caves and Palouse Canyon) and three sites (45FR50, 45FR272, and 10NP151) are listed in the NRHP. In addition to NRHP status, Marmes Rockshelter is also a designated National Historic Landmark. 45FR50 and the Palouse Canyon Archaeological District are both located within Lake West. The Windust Caves Archaeological District/45FR272 and 10NP151 are located by Lake Sacajawea and Lower Granite Lake, respectively. Many other cultural resources at the reservoirs are potentially eligible for NRHP nomination, but have not been thoroughly evaluated or nominated.

In summary, the NRHP sites and districts at the four lower Snake River reservoirs include:

Ice Harbor Dam, Lake Sacajawea
- Windust Cave Archaeological District (listed)
- 45FR272 (listed)

Lower Monumental Dam, Lake West
- Palouse Canyon Archaeological District (listed)
- 45FR50

Little Goose Dam, Lake Bryan
- No sites currently listed or determined eligible

Lower Granite Dam, Lower Granite Lake
- 10NP151 (listed)
- Archaeological sites 45-WT-78/79 (determined eligible)

Most scientific information generated about cultural resources found in the Snake River System has been the result of archaeological studies associated with the construction of Federal dams in the study area. A comprehensive archaeological survey has been done for all reservoirs. Evaluation of all known sites associated with Lake Sacajawea and Lake West will be completed in FY01. Evaluation of known sites associated with Lake Bryan and Lower Granite Lake will be completed in FY02. The Corps routinely works with Native American Indian tribes and others to inventory and manage cultural resources found in the study area.

4.8 Native American Indians

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This section discusses the Native American Indian tribes and bands whose interests and/or rights may be affected by the proposed Federal actions in the FR/EIS. This discussion includes the following tribes and bands:

- Confederated Tribes of the Umatilla Indian Reservation
- Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation
- Nez Perce Tribe of Idaho
- Confederated Tribes of the Colville Indian Reservation
- Wanapum Band
- Confederated Tribes of the Warm Springs Reservation of Oregon
- Shoshone-Bannock Tribes of the Fort Hall Reservation
- Shoshone-Paiute Tribes of the Duck Valley Reservation
- Burns Paiute Tribe of the Burns Paiute Indian Colony
- The Spokane Tribe of the Spokane Reservation.
- Coeur d'Alene Tribe
- Kalispel Indian Community of the Kalispel Reservation
- Kootenai Tribe of Idaho
- Northwestern Band of the Shoshoni Nation.

Each of the tribes listed above is unique. However, many tribes are intertwined through blood line; by cooperative pursuit of salmon and other food; through religion; shared languages; and similar treaties. Some of these tribes and Indian communities are some distance from the Snake River drainage.

The tribes and American Indian communities considered to be most directly influenced by the proposed alternatives include four tribes with treaties signed by the United States government and one non-Federally recognized Indian community. The four treaty tribes are the Confederated Tribes of the Umatilla Indian Reservation (Umatilla), the Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation (Yakama), the Nez Perce Tribe (Nez Perce) of Idaho, and the Confederated Tribes of the Colville Indian Reservation (Colville). The non-Federally recognized Indian community most likely to be affected is the Wanapum Indian community (Wanapum). Three of these tribes are directly addressed in a report on tribal circumstances prepared for this FR/EIS by Meyer Resources, Inc. in association with the Columbia River Inter Tribal Fisheries Commission (CRITFC) (Meyer Resources, 1999).[1]

The Tribal Circumstances report presents information that represents the viewpoints of the four CRITFC tribes—the Nez Perce, Yakama, Umatilla, and the Confederated Tribes of the Warms Springs Reservation of Oregon (Warm Springs)—together with the Shoshone-Bannock Tribes of the Fort Hall Reservation (Shoshone-Bannock). These five tribes are referred to as the "study tribes" in the remainder of this document. Three of these study tribes—the Nez Perce, Yakama, and Umatilla—are among those believed by the Corps to be most likely affected by the proposed alternatives. The Shoshone-Bannock, as well as the Shoshone-Paiute of the Duck Valley Reservation (Shoshone-Paiute), may be affected to the degree that fish passage through the lower Snake River hydropower facilities affects tribal access to harvestable levels of Snake River salmon stocks within their ceded lands. Similar effects may be assessed for the Warm Springs to the extent that their fisheries may be changed by Snake River fish passage conditions, as well as the associated implications for fishing pressures on their tribal fisheries. The Colville and the Wanapum were not part of the Meyer Resources report, but are known to have comparable cultures and interests in the health/availability of aquatic resources and habitats as the five study tribes listed above. Therefore, the findings presented in the Tribal Circumstances report and summarized in the following section and Section 5.7 are likely to be broadly representative of the Colville and Wanapum. These tribes and Indian Communities have close cultural and economic links to the salmon.

The six other tribes listed above—the Burns Paiute Tribe of the Burns Paiute Indian Colony of Oregon, the Kalispel Indian Community of the Kalispel Reservation, the Kootenai Tribe of Idaho, the Northwestern Band of the Shoshoni Nation of Utah, the Coeur d'Alene Tribe, and the Spokane Tribe of the Spokane Reservation—are not expected to be affected by the proposed alternatives as their "areas of interest" and/or ceded lands do not lie within the project area or within its zone of influence.

In addition, as discussed in Section 3.5.4 of Appendix I, Economics, it is not anticipated that the proposed alternatives would significantly contribute to ocean treaty fisheries or affect those tribes, such as the Makah, Quinault, and/or Quileute, with ties to marine resources. Possible effects could, however, occur if access to ocean treaty fish with

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[1]This report entitled *Tribal Circumstances and Impacts of the Lower Snake River Projects on The Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes* is available on the Corps' website at: http://www.nww.usace.army.mil. This report is referred to as either the Tribal Circumstances report or Meyer Resources (1999a) throughout this document.

origin elsewhere were limited through management efforts designed to constrain ESA-listed stocks.

4.8.1 Overview

Native cultures within this region developed over thousands of years. By the early 19th century, these cultures had developed numerous different languages and dialects, and a variety of effective life ways for living in the unique environments of the Pacific Northwest. A variety of significant natural resources and habitats such as riverine, lake, or other aquatic environments supported their subsistence-based economies. These subsistence-based economies were in turn bolstered by established trade, political and social networks, and alliances that connected the region's different cultures. In these societies, villages harvested local resources and hosted inter-band resource/trade centers in their own lands through mutually beneficial agreements and exchange systems.

The formation of Federally recognized tribes in the mid-19th century placed these different cultures together on reservation lands often located outside of a band's homeland. Those families that chose to remain within their homelands often did so by opting to acquire Indian allotments or, in a few cases, by remaining in off-reservation villages. Traditional cultural practices, such as harvesting foods and medicines, observing native religions and ceremonies, speaking native language dialects, and living in extended families, continued throughout the 19th and 20th centuries, although this lifestyle became increasingly fragmented as people became acculturated and communities adapted to local non-Indian ways.

Reservation communities continue to be the predominate place of residence for the descendants of lower Snake River native peoples. Their tribal governments remain their primary form of representation in family and community life, even though local and state governments share responsibilities for these citizens. As part of agreements made when the tribes ceded lands to the U.S. Government, tribes typically retained rights to hunt, fish and gather, and to graze livestock on unclaimed land. In addition, tribes and American Indian communities maintain cultural values in both natural and cultural resources managed by the Corps in and along the lower Snake River. Numerous aquatic, plant, and wildlife species retain cultural significance to Amerian-Indian tribes (e.g., salmonids, lamprey, sturgeon, whitefish, sculpin, deer, cous, Indian carrots, chokecherries, and tules).

4.8.1.1 Tribal Summaries

This section provides an overview of the 14 tribes identified at the beginning of this section.

Confederated Tribes of the Umatilla Indian Reservation (CTUIR)

The "Treaty with the Walla Walla, Cayuse, and Umatilla Tribes," subsequent Treaties, and the CTUIR Constitution form the basis for formal recognition of the tribes' inherent sovereignty. The tribal government's off-reservation treaty rights are recognized in Article 1 of the treaty. Congress ratified this treaty in 1859 and a reservation was established encompassing 254,699 acres in what has become northeastern Oregon. The size of the reservation was reduced through subsequent congressional acts and today

consists of 89,350 acres of trust and allotted lands. The tribes rejected the Indian Reorganization Act in 1935 by tribal referendum. However, a Constitution and By-laws were adopted in 1949. The tribal governing body consists of a General Council and a Board of Trustees. The Board of Trustees is a nine-member council that sets tribal policy and makes final tribal decisions. The Board of Trustees members are elected together in a single election for 2-year terms. All Board of Trustees members, except the chairperson, participate in tribal commissions and committees and thereby oversee tribal business. Tribal headquarters are in Mission, Oregon.

The bands represented by the confederated bands of the CTUIR were affiliated with the southern Plateau Cultural Area. English, Sahaptin dialects, and the Nez Perce language are spoken by tribal citizens. Major religious affiliations include traditional Indian religions and Christian denominations.

Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation

In 1855, the "Yakama Treaty" established the Yakama Nation and a reservation in what is now south-central Washington. Pre-treaty lands included about a quarter of the modern State of Washington. Other binding treaty documents include the Agreement of January 13, 1885, Executive Order November 21, 1892; and Executive Order 11670. A number of land ownership changes have resulted in the current 1.2-million-acre reservation. As a point of interest, the spelling of Yakama was changed from Yak[i]ma back to the original spelling in the Treaty of 1855 by a vote of the Tribal Council on January 24, 1994. In 1999, the tribal government also indicated a preference to be known as the Yakama Nation.

The Tribal Council is the governing body and is comprised of 14 members. The General Council elects Tribal Council members in elections held every 2 years wherein half of the Tribal Council is elected to 4-year terms. The Tribe's democratic government is regulated by General Council and Tribal Council resolutions. The Tribe rejected the Indian Reorganization Act in 1935. The Tribe has a self-determination form of government and operates under traditional laws, ordinances, and resolutions as opposed to having a constitution. The Tribal Council oversees tribal business through eight standing committees and seven special committees. The General Council meets annually for an extended period of time to provide direction to the Tribal Council. The Tribal Headquarters are in Toppenish, Washington.

The Yakama Nation includes peoples of the southern Plateau Cultural Area. Religious affiliations include traditional Indian religions and belief systems, and Christian denominations. Languages spoken on the reservation include English, and numerous dialects of Sahaptin, Chinookan, and Salish.

Nez Perce Tribe

The "Nez Perce Treaty" of June 11, 1855 and subsequent treaties, acts, agreements, and proclamations established the legal status of the Nez Perce Tribe. A reservation of 7.7 million acres was established in 1855. In 1863, the reservation was re-established with 780,000 acres. The present reservation is 750,000 acres between the Clearwater and Snake Rivers in Idaho. The Tribe rejected the Indian Reorganization Act in 1935 by

tribal referendum. A Constitution and By-laws were originally adopted in 1927. The Tribe is self-governing under a Constitution, which was adopted in 1958 and revised in 1961. The Nez Perce Tribe Executive Council (NPTEC) is the Tribe's primary governing authority and they meet formally twice a month. The Tribe's governing body (composed of tribal membership) is the general council and they meet twice a year. The general council elects three of the nine NPTEC members every year in September. There is no provision under the Nez Perce Council to hold special General Council meetings. Tribal Headquarters are in Lapwai, Idaho.

The Tribal government encompasses tribes and bands of the Nez Perce People (Ni-mii-puu) who are associated with the southern Plateau Cultural Area. Major religious affiliations include Christian denominations and traditional Indian religions and belief systems. English and Sahaptin Nez Perce language dialects are spoken.

Confederated Tribes of the Colville Indian Reservation

The basis for formal Federal recognition of the Tribe and its inherent sovereignty was established through the "Nez Perce" and "Yakama" Treaties of June 9, 1855. The Executive Order of April 9, 1872—which was superseded by Executive Orders of March 6, 1879, February 23, 1883, March 6, 1880, and May 1, 1886; Agreements of May 9, 1891, July 1, 1892, December 1, 1905, and March 22, 1906; and the Act of June 20, 1940—all helped refine the Colville Tribe's relationship with the U.S. Government.

The Colville Reservation was established on April 9, 1872 in north-central Washington. Modifications to the reservation size, status, and location in later years resulted in the present 1.4-million-acre reservation in north-central Washington. The basis of the Tribe's off-reservation rights and interest is derived from the Yakama and Nez Perce Treaties of 1855, Article 3 and a 1891 Agreement, Article 6. It is through the Yakama Treaty that members of the Palus band moved onto the Colville Reservation in the late 19th century. The Colville Tribe asserts rights and interests in ceded lands of the Palus people along the lower Snake River.

The Colville Tribe did not adopt the Indian Reorganization Act of 1934, but did establish a constitutional form of government with a Business Council in 1938. The Tribe's Business Council membership is elected from four reservation districts comprised of two groups of seven council members that are elected to four-year terms in staggered biennial elections. The chair and vice-chair Business Council positions are filled through elections held by its Executive Committee, while all other positions are elected by the entire Business Council membership. The General Council meets bi-annually to provide direction to the Business Council. The Colville Tribes have operated under a tribal self-determination agreement with the Bureau of Indian Affairs since 1995 that has integrated BIA staff positions with the Tribe's. Colville Tribal Headquarters are located in Nespelem, Washington.

The Confederated Tribes of the Colville Indian Reservation (CTCIR) represent people of the Plateau Cultural Area. Interior Salish, Sahaptin, and English are spoken by the Tribal population. Religious affiliations include traditional Indian religions and Christian denominations.

Wanapum Band

The Wanapum Band, a traditional Indian community, lives within their native homeland at Priest Rapids along the middle Columbia River. The community is comprised of a longhouse and families who follow traditional social, subsistence and religious customs while adapting to modern societal, and economic demands. The Wanapum believe their Creator gave them the land as a sacred trust and would not take it from them. The families at Priests Rapids maintain their sacred responsibility and are advocates for their ancestral homeland. The Wanapum have not left their homeland because of the sacred trust and their responsibilities as they have been handed down to them from their elders.

Confederated Tribes of the Warm Springs Reservation of Oregon

In 1855, the sovereignty of the Confederated Tribes of the Warm Springs Reservation was recognized in the "Treaty with the Tribes of Middle Oregon." (The "Treaty with the Tribes of Middle Oregon of 1865" was later negated by the U.S. Government.) Today the Warm Springs Reservation, in central Oregon, consists of 640,000 acres, 480,196 acres of which are Tribal-owned.

The Tribes adopted the Indian Reorganization Act in 1935 and a Constitution and By-laws in 1938. The Tribes have an elected Tribal Council and various Tribal committees and boards. The Tribes are self-governing. Tribal Headquarters are in Warm Springs, Oregon.

People represented on the Reservation are of the Plateau and Great Basin Cultural Regions. Languages spoken by Tribal members include English, Chinookan, Sahaptin, and Shoshonean (Northern Paiute). Major religious affiliations include traditional Indian religions, traditional belief systems, and Christian denominations.

Shoshone-Bannock Tribes of the Fort Hall Reservation

The Treaty with the Eastern Shoshoni Tribe of 1863 and several subsequent treaties, acts, and agreements form the basis for the sovereignty of the Tribes. The Treaty reservation was originally established at 1.8 million acres. The present reservation encompasses 544,000 acres in southeast Idaho adjacent to the Caribou National Forest. The Tribal governments for the Shoshone and Bannock peoples operate under a Constitution and By-laws adopted in 1977, the Land Use Ordinance, the Big Game Code, the Law and Order Code, inherent sovereignty, customs, and traditions. The legislative body is the elected Fort Hall Business Council.

The Shoshone-Bannock Tribes comprise one Federally recognized Tribe that includes two distinct groups—the Northern or Snake River Shoshone, and the Bannocks. Major religious affiliations include Christian denominations, the Native American Church, and traditional beliefs. Languages spoken include English, Shoshone, Bannock, and other dialects.

Shoshone-Paiute Tribes of Duck Valley Reservation

The Executive Order of April 16, 1877 set aside the Duck Valley Reservation for several Western Shoshoni bands that traditionally lived along the Owyhee River of southeastern Oregon, southwestern Idaho, and the Humbolt River of northeastern Nevada. Later, Paiute from the lower Weiser country of Idaho and other Northern Paiute families joined

the Shoshoni on the reservation. The reservation was expanded in 1886 to 500,000 acres to include a Northern Paiute group (Paddy Cap's Band), who arrived in 1884 following their release from the Yakama Reservation. The current reservation is 294,242 acres. The entire reservation is owned by the Tribe, forming a contiguous block of property located partially in southern Idaho and northern Nevada.

The Tribe adopted a Constitution in 1936 in conformance with the Indian Reorganization Act of 1934. The Tribe is one of the original 17 tribes that achieved a self-governing status having shed Bureau of Indian Affair's supervision. The Tribe has General Council meetings of adult Tribal members and a six-member elected Tribal Council. Tribal Headquarters are in Owyhee, Nevada.

Western Shoshone and Northern Paiute people are represented on the reservation. Traditional religious beliefs and Christian denominations form the Tribe's primary religious affiliations.

Burns Paiute Tribe of the Burns Paiute Indian Colony

Members of the Walpapi Band of the Northern Paiute signed the treaty with the "Snake" band in 1865. The Tribe signed a treaty with the U.S. Government in December 1868; Congress failed to ratify it. The Executive Order of March 1872 established the Malheur Indian Reservation and recognized the Burns Paiute Indians. However, in 1883 another Executive Order dissolved the reservation and the Tribe lost Federal recognition. The 1.8-million-acre Malheur Indian Reservation was terminated and the land was made public domain. The 1887 Indian Allotment Act allowed for 160 acres to each Tribal head of household. The Burns Paiute Tribe is located in eastern Harney County, Oregon. Tribal Headquarters are in Burns, Oregon. In 1972, the United States transferred title to 762 acres to the Burns Paiute and established the Burns Paiute Reservation through Public Law 92-488.

The current reservation consists of 771 acres, and another 11,786 acres of allotments are owned by Tribal members. An additional 360 acres are held in trust and administered for the Tribe by the Bureau of Indian Affairs. The Tribe is self-governing. A Tribal Council of seven elected members was established by the Tribe in 1988.

The peoples represented by the Tribe are of the Great Basin Cultural Region consisting of the northern division of the Paiute peoples. The original homeland of the Northern Paiute peoples included southeast Oregon, most of northwestern Nevada, and a portion of southwest Idaho. Northern Paiute and English are spoken by the Tribe. Major religious affiliations include traditional Indian religions and denominations of Christianity.

The Spokane Tribe of the Spokane Reservation

The Executive Order of January 18, 1881 and subsequent agreements and acts form the basis for the Tribe's sovereignty. The first reservation was also established in 1881 in northeast Washington. Today the reservation is comprised of 137,002 acres of fee, allotted, and trust lands. The Tribe approved a Constitution in May 1951, establishing a Business Council. Today, a general election chooses a five-member General Council which then elects members to the Business Council. At least once a year adult Tribal

members meet to advise the General Council. The Tribe is self-governing. Tribal headquarters are in Wellpinit, Washington.

People represented by the Tribe are of the Northern Plateau. Major religious affiliations are Christian denominations, primarily Catholic. English and Interior Salish are spoken by the Tribe.

Coeur d'Alene Tribe

In 1867, an entity called the Coeur d'Alene Reservation was created for the Coeur d'Alene, Kalispel, Spokane, Sanpoil, and Colville "bands." The Coeur d'Alene never moved to that reservation. In 1873, a 592,000-acre reservation was created for the Coeur d'Alene Tribe by Executive Order. In following years, the reservation area was reduced, lands ceded, and portions removed from the reservation. Today's reservation consists of 345,000 acres in northern Idaho.

Tribal government is under a constitution originally approved on September 2, 1949. The Tribal Council is the legislative body. Tribal Headquarters are in Plummer, Idaho.

People represented by the tribe are of the Plateau Cultural Region and are of the Coeur d'Alene, Spokane, and San Joe River Tribes and Bands. In 1842, a Catholic mission was established by Father Pierre DeSmet near St. Maries for the tribe. Today, religious affiliations include traditional Indian religions and denominations of Christianity. Interior Salish and English are spoken by the Tribal peoples.

Kalispel Indian Community of the Kalispel Reservation

The Tribe's inherent sovereignty was recognized through an agreement with about half of the Kalispel Tribe in an Executive Order dated April 21, 1887. In 1904, another Executive Order established a reservation for the Tribe. However, the U.S. Government wanted to move the Kalispel to the Flathead Reservation. A second 4,630-acre reservation was established in northeastern Washington on March 23, 1914. Today, the reservation is about 4,550 acres. A Tribal Constitution and Charter was originally adopted on March 24, 1938. In addition to the Constitution, Tribal Council resolutions create Tribal law. The Tribal Headquarters are in Usk, Washington.

People from Tribes and bands of the "People of the Pend Oreille" are represented on the Reservation. These people are of the Plateau Cultural Region. Major religious affiliations include Christian denominations, primarily Catholic. English and Interior Salish dialects are spoken.

Kootenai Tribe of Idaho

The Treaty with the Flathead, Kootenai, and Upper Pend d'Oreilles of July 16, 1855 established the Tribe's sovereignty. Some Kootenai living in the vicinity of the Canadian border did not move to the reservation when the Flathead Reservation in Montana was established. A group of Kootenai families living near Bonners Ferry were recognized by the U.S. Government in 1894. By 1972, a reservation existed of approximately 2,683 acres. Today's reservation is approximately 1,300 acres. The Tribe adopted a Constitution in 1947. In addition to the Constitution, the Tribe is regulated by a code of conduct. Tribal Headquarters are in Bonners Ferry, Idaho.

The Kootenai people were composed of two groups: Upper and Lower. Major religions followed by the Tribe include denominations of Christianity and traditional belief systems. Languages spoken are English and Kitunahan dialects.

Northwestern Band of the Shoshoni Nation

The Northwestern Band of the Shoshoni Nation's legal status is based on the Treaty of Box Elder of June 30, 1863 and subsequent Acts and Agreements. By 1900, many of the Northwestern Band resided on the Fort Hall Reservation. Others resided in Utah and Idaho communities. The tribe did not accept the Indian Reorganization Act of 1934. In 1989, the Tribe acquired the 187 acres of land that constitute the present Reservation in north-central Utah. Other nearby land parcels are held in trust by the Bureau of Indian Affairs. A Constitution was approved on August 24, 1987. The Tribe is self-governing, with a General Council of all adult enrolled Tribal members and an elected Tribal Council. Tribal headquarters are in Brigham, Utah.

The Northwestern Band of Shoshoni include the Weber Utes, Northwestern Shoshoni, and other Shoshoni people from the Lemhi area of southeastern Idaho. Traditional religions and denominations of Christianity are the major religious affiliations. Tribal members speak Shoshone and English.

4.8.2 Tribal Resources

Tribes and traditional Indian communities continue to have rights and interests in the lands and resources managed by the Federal government. For example, tribal rights and interests pertain to lands a tribe ceded to the U.S. Government and to certain rights to hunt, fish and gather, and graze livestock. In addition, tribes maintain cultural values in both natural and cultural resources located in and along the lower Snake River. Numerous aquatic, plant and wildlife species retain cultural significance to tribes (e.g., salmonids, lamprey, sturgeon, whitefish, sculpin, deer, cous, Indian carrots, chokecherries, and tules). For additional information concerning the tribal view of natural and cultural resources, see Appendix N, Cultural Resources, Appendix Q, Tribal Consultation/Coordination, and the Tribal Circumstances report (Meyer Resources, 1999). Land and salmon are discussed below.

4.8.2.1 Land

As indicated in Section 4.8.1.1, the tribes of this area historically retained more land than they currently own. Current reservation locations and approximate boundaries are marked on Figure 4.8-1. This FR/EIS does not enter the debate concerning historical land transfers except to the extent needed to determine the direct, indirect, and cumulative impacts to the tribes from the alternatives being studied in this FR/EIS. Summary data regarding the present day reservations of the five tribes addressed in the Tribal Circumstances report are provided in Table 4.8-1. Details on the land purchased by the Corps to build the dams and disposal options are described in Appendix K, Real Estate, and summarized in Section 5.11. Tribal perspectives are provided in the Tribal Circumstances report (Meyer Resources, 1999) and summarized in the tribal section of Appendix I, Economics.

Table 4.8-1. Study Tribe Reservations and Enrolled Populations

Tribes	Reservation	Total Acres	Indian-Owned Acres	Non-tribal Owned Acres	Tribal Enrollment
Nez Perce	Nez Perce	na	108,000	na	3,000
Shoshone-Bannock	Fort Hall	544,000	1/	1/	3,700
Shoshone-Paiute	Duck Valley	293,700	2/	2/	1,003
Yakama Nation	Yakama Indian Reservation	1,379,725	1,126,445	253,280	9,601
Umatilla	Umatilla Indian Reservation	292,744	95,136	197,608	2,087
Warm Springs	Warm Springs	643,000	641,110	2,102	1,683 3/

1/ About 3 percent of the reservation is owned fee simple by Indians. No other data are currently available.
2/ Nearly all reservation lands are owned by Indians. No other data are currently available.
3/ This is the 1972 population total. No other data are provided in the Tribal Circumstances report.
na - not currently available
Source: Meyer Resources, 1999

4.8.2.2 Salmon

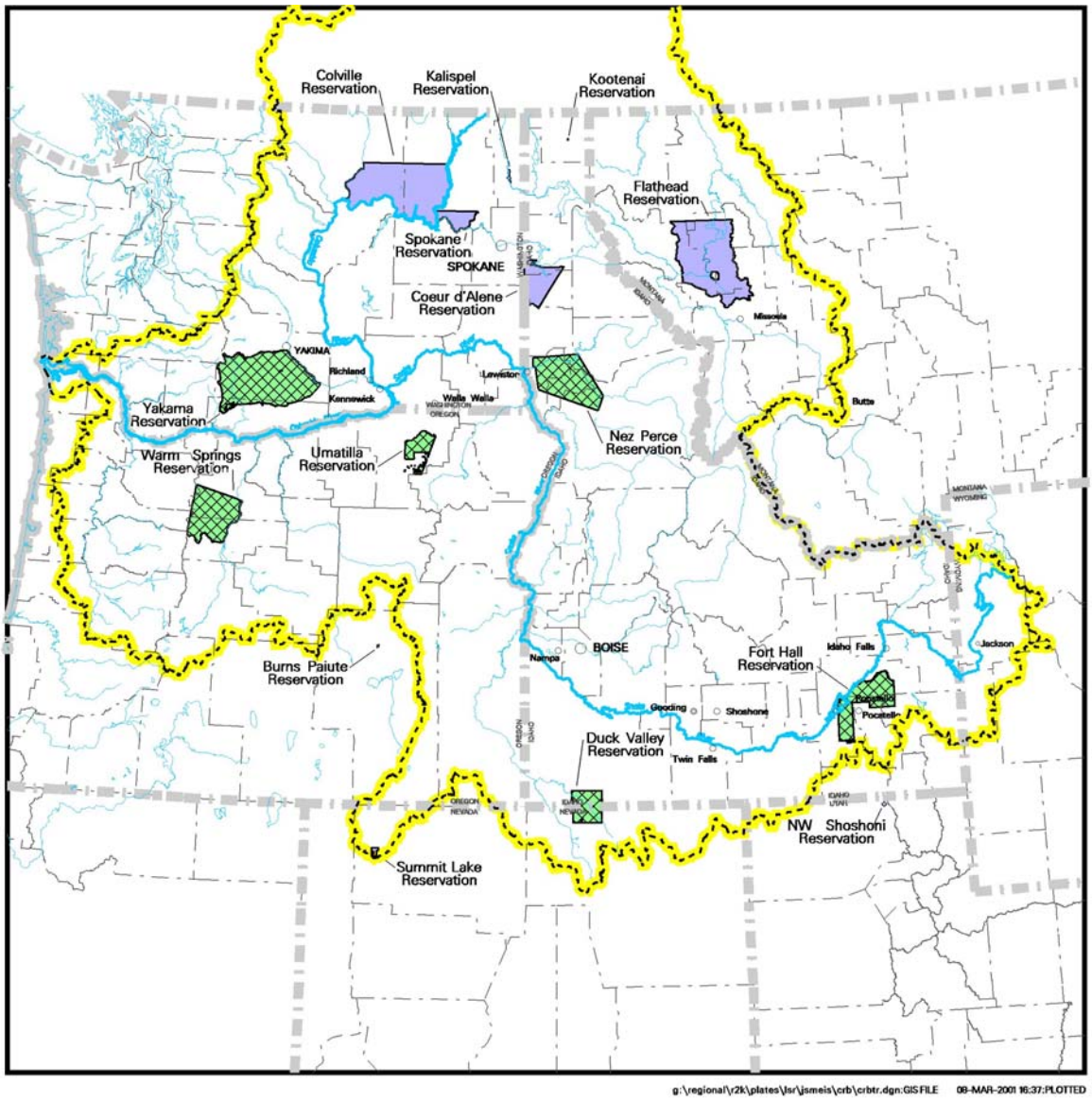
The decline in salmon has impacted the harvest practices of many people, including the tribes. Although it is generally conceded that numerous factors have contributed to the decline in salmon and Pacific lamprey harvest, the tribes believe that if the dams were removed, they would have a better chance for future increased harvest.

The Tribal Circumstances report includes data and cultural information with regard to the salmon's role in tribal societies. Estimates of salmon populations, rates of decline, and future runs are provided in Appendix A, Anadromous Fish, and Sections 4.5 and 5.4, Aquatic Resources of the FR/EIS.

In the process of complying with the ESA, the Federal agencies have implemented actions specifically designed to benefit salmon. This focus is consistent with treaty and trust responsibilities.

4.8.3 Current Tribal Circumstances

The Tribal Circumstances report states that the study tribes cope with high poverty, unemployment, and death rates. It also provides a tribal perspective with regard to the comparison of present wellbeing of tribes and their non-tribal neighbors. Summary demographic and economic information drawn from this report is presented in Table 4.8-2. While the tribes are generally uncomfortable with statistical treatment of tribal issues, these data allow some degree of comparability and evaluation.



BOUNDARIES

Columbia River Basin

State

County

TRIBAL RESERVATIONS

Study Tribes

Other Basin Tribes

KM 100 50 0 MILES 50 100

1,000,000 ACRES

1 : 76,032,000

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.8–1.
TRIBAL RESERVATIONS

Table 4.8-2. Relative Circumstances of the Five Tribal Circumstances Report Tribes

Socioeconomic Indicator [1/]	Nez Perce	Shoshone-Bannock	Yakama Indian Nation	Umatilla	Warm Springs	ID	OR	WA
Families in Poverty (%)	29.4	43.8	42.8	26.9	32.1	9.7	12.4	10.9
Unemployment[2/]								
U.S. Census (%)	19.8	26.5	23.4	20.4	19.3	6.1	6.2	5.7
BIA (%)	62.0	80.0	73.0	21.0	45.0			
Per Capita Income ($000s)	8.7	4.6	5.7	7.9	4.3	11.5	13.4	14.9

[1/]The data presented in this table are taken directly from the Tribal Circumstances report (Table 41). See the tribe by tribe sections in that report for further information.

[2/]Census data (U.S. Bureau of the Census–1990 Census of Population: Social and Economic Characteristics, American Indian and Alaska Native Areas) and BIA data (U.S. Bureau of Indian Affairs, 1995. Indian Service Population and Labor Force Estimates) are both included because census data is more rigorous but tends to overestimate employment. BIA numbers are less rigorous but more likely indicative of tribal circumstances, particularly over winter months.

Source: Meyer Resources, 1999

4.8.4 Government to Government

The sovereign status of Indian tribes has long been recognized. Principles outlined in the Constitution, treaties, Federal statutes, regulations, and executive orders continue to guide national policy towards Indian nations. Working within a government-to-government relationship with Federally recognized Indian tribes, agencies consult, to the extent practicable and permitted by law, with Indian tribal governments; assess the impact of agency activities on resources; ensure that tribal interests are considered before the activities are undertaken; and remove procedural impediments to working directly with tribal governments on activities that affect the rights of the tribes.

This relationship recognizes that tribal governments are sovereign entities with rights to set their own priorities, develop and manage tribal resources, and be involved through the consultation process in Federal decisions or activities which have the potential to affect these rights. The development of this FR/EIS has included efforts to obtain tribal views of agency responsibilities or actions related to this study, in accordance with provisions of treaties, laws and executive orders, as well as principles lodged in the United States Constitution. Several tribal chairs/leaders have met with Corps commanders/leaders with regard to this study. The Corps has also reached out, through designated points of contact, to involve tribes in collaborative processes designed to facilitate information exchange and consideration of various viewpoints. Tribal members have also participated or attended regional forums or meetings where these issues were discussed.

Numerous documents address Federal responsibilities and policies toward tribes. The Corps' Native American Policy is set forth in the February 1998, Lt. General Joe N. Ballard, *Memorandum for Commanders, Major Subordinate Commands and District Commands: Policy Guidance Letter No. 57, Indian Sovereignty and Government-to-Government Relations with Indian Tribes.* Treaty rights and trust responsibilities are

derived and interpreted through statutes, regulations, executive orders, and, court cases, as well as individual treaties.

Appendix N, Cultural Resources, and Appendix Q, Tribal Consultation/Coordination, address the Corps' work toward fulfilling its unique relationship with and obligations to Native American tribes and Indian peoples. The tribal impacts of the alternatives under consideration are being evaluated using many resources including the Tribal Circumstances report and associated sections in Appendix I, Economics; Appendix N, Cultural Resources; Appendix Q, Tribal Consultation/Coordination; and other comments received throughout the study process. The potential effects of the proposed alternatives are discussed in Section 5.7, Native American Indians.

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4.9 Transportation

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The Columbia and Snake Rivers have always been major transportation corridors for humans. As the only near sea-level passage through the Cascades, the Columbia River has consistently provided a key linkage from the ocean to the eastern interior portions of the Pacific Northwest. Oceangoing vessels historically sailed upriver to Vancouver, Washington and Portland, Oregon and then up the Willamette River to Oregon City. When gold was discovered in Idaho in 1862, steamers began traveling from The Dalles, Oregon to Lewiston, Idaho. Navigation between the Columbia and Snake Rivers became possible with construction of the Cascades and Dalles-Celilo canals in 1896 and 1915, respectively. Today the Columbia and Snake Rivers provide a major water transportation route and the river valleys are used extensively as road and rail transportation corridors.

4.9.1 Navigation

4.9.1.1 Navigation Facilities

The Columbia-Snake Inland Waterway is a 465-mile-long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake Rivers. The waterway provides inland waterborne navigation up and down the river from Lewiston, Idaho to the Pacific Ocean. This system is used for commodity shipments from inland areas of the Northwest and as far away as North Dakota. The navigation system consists of two segments: the downriver portion, which provides a deep-draft shipping channel, and the upriver portion, which is a shallow-draft channel with a series of navigation locks.

The deep-draft portion of the navigation system consists of a 40-foot-deep by 600-foot-wide channel that extends up the Columbia River from the Columbia Bar (RM 3.0) to

Vancouver, Washington (RM 105.6). This channel, maintained by the Corps, is used extensively by oceangoing vessels that transport products and commodities to and from national and international markets. Major import-export terminals are located adjacent to the channel at the Columbia River ports of Vancouver, Longview, and Kalama in Washington, and Portland and Astoria in Oregon.

The shallow draft portion of the waterway is a Corps-maintained channel and system of locks that extends from Vancouver, Washington to Lewiston, Idaho. The channel extends up the Columbia River from Vancouver, Washington (RM 106) to Richland, Washington (RM 345) and from the mouth of the Snake River (Columbia River RM 325) to Lewiston, Idaho (Snake River RM 141). This channel has a minimum authorized depth of 14 feet at the MOP elevations of each of the upriver dams. The authorized channel upriver from Vancouver, Washington to The Dalles, Oregon is 27 feet deep by 300 feet wide but is only maintained to a depth of 17 feet from Vancouver to the Bonneville Dam and to a depth of 14 feet from Bonneville to The Dalles. The authorized channel extending 276 miles from The Dalles to Lewiston is 14 feet deep by 250 feet wide.

The shallow draft portion of the Columbia-Snake Inland Waterway accommodates tugs, numerous types of barges, log rafts, and recreational boats and connects the interior of the basin with deep water ports on the lower Columbia River. Barges and other river traffic need minimum water depths to navigate successfully. River navigation occurs year-round and does not vary by season. Dam operators regulate water releases and maintain reservoir levels to provide minimum navigation depths throughout the year.

Each of the eight mainstem dams maintains a system of locks with sufficient water depth at MOP to allow vessels to pass. These locks provide hydraulic lifts of up to 110 feet in elevation. A summary of the lock characteristics of the eight mainstem dams is provided in Table 4.9-1. In addition to the overall lift, the operating range of a navigation lock is determined by the depth of the sills at the upriver and downriver ends of the lock. The Snake River dams have upriver and downriver sill depths of 15 feet. The Corps does not charge lock fees.

Table 4.9-1. Lock Characteristics of the Columbia-Snake River System

River/Lock	River Mile	Year Opened	Age in 2000 (Years)	Chambers (Feet)		
				Width	Length	Lift
Columbia River						
Bonneville (Main)	146	1993	7	86	675	65
Bonneville (Aux.)[1/]	146	1938	62	76	500	65
The Dalles	190	1957	43	86	675	88
John Day	215	1968	32	86	675	110
McNary	292	1953	47	86	675	83
Snake River						
Ice Harbor	9.7	1961	38	86	675	105
Lower Monumental	41.6	1969	31	86	650	103
Little Goose	70.3	1970	30	86	668	101
Lower Granite	107.5	1975	25	86	674	105

1/ Bonneville's first lock, constructed in 1938 to hold two barges and one tugboat at a time, was replaced by a new, larger lock completed in 1993. The new lock can hold five-barge tows, which gives it the same capacity as the seven upriver dams
Source: DREW Transportation Workgroup, 1999, Table 3-2; Corps, 1999c

4.9.1.2 Ports

The presence of the Columbia-Snake River Inland Waterway has led to the development of a sizable river-based transportation industry in the region. Riverside facilities managed by port districts and various other public and private entities are located on the pools created by the system of dams and locks. Fifty-four port and other shipping operations provide transportation facilities for agricultural, timber, and other products. There are 22 port barge-loading facilities located along the shallow draft portion of the waterway. All of the ports on the lower Snake River have grain-handling capability.

4.9.1.3 Shipping Operations

Barge transportation of commodities accounts for the majority of commercial shipping activity on the shallow-draft portion of the Columbia-Snake Inland Waterway. Commodities are transported through the waterway system on non-powered barges propelled by tugboats. Typical operations involve a tow, ranging from one to five barges, pushed by a single tugboat.

Transportation firms operating in this portion of the river system in 1995 are presented in Table 4.9-2. Eight companies accounted for 89 percent of all the shallow-draft vessels operating on this portion of the waterway in 1995. The remaining 11 percent (22 shallow-draft vessels) were distributed among 13 different companies. Tidewater Barge Lines, Inc., the largest operator, operated 72 vessels and accounted for 51.6 percent of all commodities transported by shallow-draft vessels on the Columbia and Snake Rivers in 1995 (Table 4.9-2).

Table 4.9-2. Barge Transportation on the Shallow–Draft Portion of the Columbia-Snake Inland Waterway in 1995

Company	Total Vessels Operated	% of Total Vessels	Tons (000s)	% of Total Tons	Trips	% of Total Trips
Tidewater Barge Lines. Inc.	72	36.4	5.588.5	51.6	2.674	34.1
James River/Western Transportation	36	18.2	1,268.7	11.7	2,305	29.4
Shaver Transportation Co.	14	7.1	1,150.5	10.6	368	4.7
Brix Maritime Co.	24	12.1	886.2	8.2	1,290	16.5
Bernert Barge Lines	14	7.1	519.2	4.8	364	4.6
SDS Lumber Co.	5	2.5	310.4	2.9	125	1.6
Ross Island Sand and Gravel Co.	6	3.0	54.5	0.5	121	1.5
Sause Brothers Ocean Towing Co.	5	2.5	41.1	0.4	11	0.1
Other Companies (13)	22	11.1	1,001.2	9.3	577	7.4
Total	**198**	**100**	**10,820.3**	**100**	**7,835**	**100**

Source: DREW Transportation Workgroup, 1999, Table 3-4

In addition to barge transportation, commercial shipping operations include some passenger service. Three cruise lines operate four tour boats between Portland and Clarkston in spring and fall. Week-long tours regularly depart Portland, travel upriver to Clarkston, and then return to Portland. These tours are generally scheduled from the beginning of April through the first week of June, and again from September through the first half of November.

4.9.1.4 Commodity Movements

Columbia River Deep-Draft Channel

The Columbia River serves an extensive region that covers much of the western United States. Within the region, a variety of commodities, foodstuffs, and other products are produced. Agricultural products, particularly grains, such as wheat and barley, dominate regional waterborne commerce. In addition, corn, which is produced outside of the region, represents a significant volume of shipments from export terminals on the lower Columbia River. Other regional industries that use water to transport products include aluminum, pulp and paper, petroleum products, logs, and other wood products. In terms of volume, wheat and corn represent the major share of total commodities shipped on the deep-draft segment of the Columbia River channel. Other products include automobiles, containerized products, logs, petroleum, chemicals, and other miscellaneous products. Countries involved in the region's export trade are Japan, Korea, Taiwan, and other Pacific Rim countries.

Columbia-Snake Inland Waterway

Products shipped on the shallow-draft segment of the river system consist principally of grain, wood products, logs, petroleum, chemicals, and other agricultural products. Bulk shipments make up much of the waterborne traffic on the upstream channel. A number of commodities, principally non-grain agricultural, food products, and paper products, are shipped via container. Approximately 97 percent of downriver-bound container shipments are destined for Portland, Oregon, with the remainder going to Vancouver, Washington. Historically, the bulk of upriver barge shipments have been made up of petroleum products.

Analysis of data from the Waterborne Commerce Statistics Center (WCSC) and the Corps' Lock Performance Monitoring System (LPMS) showed that commodities from 37 commodity groups were shipped on the waterway in both 1996 and 1997. These commodity groups were aggregated into five groups for the purposes of this analysis—grain, petroleum products, wood chips and logs, wood products, and other. Shipments from 1992 to 1996 are shown in Table 4.9-3.

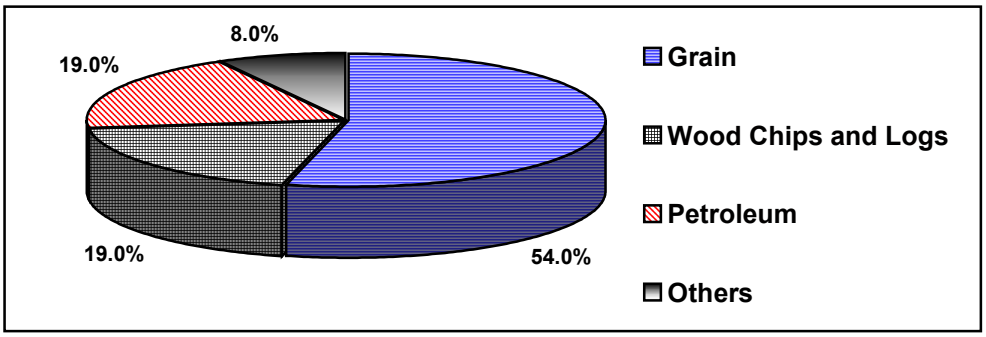
Table 4.9-3. Tonnage of Shipments by Commodity Group on the Shallow Draft Portion of the Columbia-Snake Inland Waterway from 1992 to 1996

Commodity Group	Thousand Tons				
	1992	**1993**	**1994**	**1995**	**1996**
Grain	4,612.9	4,902.3	5,671.4	5,883.3	5,710.4
Petroleum Products	1,567.1	1,746.1	1,693.1	2,164.6	2,023.2
Wood Chips and Logs	1,837.3	2,130.8	2,056.4	1,779.2	1,281.9
Wood Products	61.3	44.7	63.1	73.4	28.1
Other	1,224.7	761.9	615.3	626.9	629.6
Total	**9,303.3**	**9,585.8**	**10,099.3**	**10,527.4**	**9,673.2**

Source: Waterborne Commerce Statistics Center (WCSC), New Orleans, LA, and Corps' Lock Performance Monitoring System (LPMS)

Three of these groups—grain, petroleum products, and wood chips and logs—accounted for about 91 percent of the total tonnage transported. The relative contribution of these

groups is highlighted in Figure 4.9-1. Grain alone accounted for about 54 percent of the total average annual tonnage transported over this period.

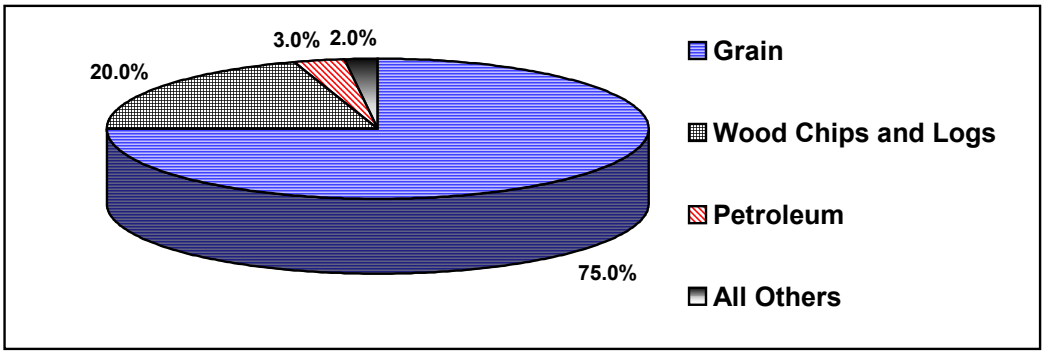


Source: DREW Transportation Workgroup, 1999, Table 4-6

Figure 4.9-1. Average Annual Tonnage Transported on the Shallow-Draft Portion of the Columbia-Snake Inland Waterway by Commodity Group, 1992 through 1996

Lower Snake River

Commodity movement on the lower Snake River is dominated by grain, with wheat and barley making up about 75 percent of the average annual tonnage passing through Ice Harbor lock between 1992 and 1996 (Figure 4.9-2). Wood chips and logs, and wood products accounted for 20 percent and petroleum products accounted for another 3 percent, with the remaining 2 percent composed of a variety of products including other farm products, chemicals, and sand and gravel. Table 4.9-4 provides a summary of the annual tonnage by commodity passing through Ice Harbor lock for 1987 through 1996.



Source: DREW Transportation Workgroup, 1999

Figure 4.9-2. Average Annual Tonnage Transported on the Lower Snake River above Ice Harbor Dam by Commodity Group, 1992 through 1996

The Columbia-Snake Inland Waterway from Lower Granite pool through McNary Dam handled cumulative totals of approximately 6.7 million tons in 1990, 7 million tons in 1991, and 6.7 million tons in 1992. This included upbound and downbound cargo originating at the Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary reservoirs (Corps and NMFS, 1994). Since 1980, cumulative cargo volumes have ranged from approximately 5 to 8 million tons per year. Tonnage using at least a portion of the Snake River segment, as measured by the figures for Ice Harbor, averaged about 3.8 million tons per year from 1980 through 1990. This average increased slightly to about 3.9 million tons per year from 1991 through 1996. The following discussion addresses shipments of grain, wood products, and petroleum products in turn.

Table 4.9-4. Tonnage by Commodity Group Passing through Ice Harbor Lock 1987-1996 (in thousand tons)

Commodity[1/]	1987	1988[2/]	1989[2/]	1990	1991	1992	1993	1994	1995	1996[3/]	10 Year Average
Grain	2,906	3,981	2,532	3,109	3,241	2,612	2,706	3,135	3,471	2,821	3,051
Wood Chips and Logs[4/]	507	446	365	346	449	561	899	968	925	558	602
Petroleum	117	105	115	108	106	108	129	137	144	95	116
All Others	96	127	203	166	159	80	57	74	82	85	113
Total	**3,626**	**4,659**	**3,215**	**3,729**	**3,955**	**3,361**	**3,791**	**4,314**	**4,622**	**3,559**	**3,883**

1/ All figures are rounded to the nearest 1,000.
2/ Large movements of 1.2 million tons in 1988 and 1.4 million tons in 1989 have been omitted because they appear to have been one time movements and would significantly skew the "All Other" category that they were classified in (DREW Transportation Workgroup, 1999.
3/ Ice Harbor lock was out-of-service from January 1 through March 9 while the downriver lift gate was being replaced.
4/ The data presented here for the Wood Chips and Logs commodity group also includes the Corps' Wood Products commodity group. Wood Chips and Logs comprised 92 percent of the combined total in 1995.
Source: DREW Transportation Workgroup, 1999, Table 4-7

Grain

In general, downriver tonnage is typically more than nine times the volume of upriver tonnage. This volume difference is primarily because of the large movements of grain bound for lower Columbia River export terminals. Typical downriver barge operations involve one barge of general cargo or wood chips moved in a tow with two or more grain barges. Without the large grain movements, it is likely that either rates for transporting other cargoes would be substantially higher or barge service would be unavailable. Origin/destination data for wheat and barley indicate that virtually all barge traffic originating above Ice Harbor lock moves from one of the Snake River ports of Lewiston (Clearwater River), Clarkston, Wilma, Almota, Central Ferry, Garfield, Lyons Ferry, Windust, or Sheffler to the ports of Portland, Vancouver, or Kalama on the lower Columbia River. Wheat and barley cargoes are subsequently transferred to deep-draft vessels for export. Between 1987 and 1996, barge shipments of wheat and barley originating above Ice Harbor lock ranged from 2,532,000 tons in 1989 to 3,981,000 tons in 1988, with an annual average of 3,051,000 tons (Table 4.9-4).

Approximately 22 percent of grain transported on the lower Snake River originates in Idaho (Table 4.9-5). About 86 percent of this total is loaded onto barges at Lower Granite with the remaining 14 percent loaded at Little Goose. Grain grown in

Washington accounts for approximately 69 percent of total lower Snake River grain shipments, with 53 percent of this total loaded onto barges at Little Goose. Approximately 26 percent of Washington grain shipments are loaded onto barges at Ice Harbor, with the remaining 21 percent divided between Lower Granite (15 percent) and Lower Monumental (6 percent). Shipments from Montana and North Dakota account for approximately 6 and 3 percent of total grain shipments transported on the lower Snake River, respectively, with less than one percent of shipments originating in Utah. Wallowa County, Oregon provides the remaining one percent of annual lower Snake River grain shipments (Table 4.9-5).

Table 4.9-5. Grain Shipments on the lower Snake River by State of Origin and Reservoir (in bushels)

	Lower Granite		Little Goose		Lower Monumental		Ice Harbor		Total	
Reservoir	**Bushels (000s)**	**% of Reservoir Total**	**Bushels (000s)**	**% of Reservoir Total**	**Bushels (000s)**	**% of Reservoir Total**	**Bushels (000s)**	**% of Reservoir Total**	**Bushels (000s)**	**% of Total**
Idaho	23,480	49	3,910	8	0	0	0	0	**27,390**	**22.2**
Oregon	1,180	2	0	0	0	0	0	0	**1,180**	**1.0**
Washington	12,880	27	44,570	92	5,210	100	22,050	100	**84,710**	**68.6**
Montana	6,780	14	0	0	0	0	0	0	**6,780**	**5.5**
North Dakota	3,270	7	0	0	0	0	0	0	**3,270**	**2.6**
Utah	140	0	0	0	0	0	0	0	**140**	**0.1**
Bushels by Reservoir	**47,730**	**100**	**48,480**	**100**	**5,210**	**100**	**22,050**	**100**	**123,470**	**100.0**
% by Reservoir		**38.7**		**39.3**		**4.2**		**17.9**		

Source: DREW Transportation Workgroup, 1999, Tables 5-2 through 5-5

Note: These data are based on a survey of grain elevators on the lower Snake River. This survey was designed to establish grain origin and movement patterns for a "representative year" of operations. In some cases the data were obtained for May 1997 through April 1998. In other cases facility operators provided adjustments to data compiled for the Columbia River System Operation Review EIS but no actual new data. As a result, these data are representative of current conditions but cannot be directly associated with a particular year.

Wood Products

Annual shipments of wood products, chips, and logs, the second largest commodity group using the Snake River above Ice Harbor lock ranged from 346,000 tons in 1990 to 968,000 tons in 1994, with an annual average of 602,000 tons from 1987 to 1996 (Table 4.9-4). The Corps classifies commodities on each barge traveling up and down the Columbia-Snake Inland Waterway by commodity group. Lumber, logs, wood chips, pulp, and paper products are included in the wood products commodity group summarized here. Logs and wood chips comprised approximately 92 percent of wood products shipped on the lower Snake River in 1995 (DREW Transportation Workgroup, 1999).

Based on data compiled in the Corps annual and monthly Lock Tonnage Reports for 1980 through 1995, the majority of wood products travel downriver and movements tend to occur throughout the year. Wood products typically enter the Columbia-Snake Inland Waterway at the Lower Granite reservoir and travel downriver through the four lower Snake River dams, with no tonnage added or removed until McNary pool. Additional wood products are often added at McNary pool. These patterns suggest that wood

products transported on the lower Snake River are typically harvested in the eastern regions of the Pacific Northwest, delivered by truck or rail to the Lower Granite or McNary pools, and then barged downriver for processing, shipment to other states, or international export (Lee and Casavant, 1996). Upriver movements of wood products tend to be concentrated in the Columbia River portion of the waterway and are typically offloaded at McNary pool, with a relatively small portion of total tonnage continuing up the Snake River to the Lower Granite reservoir (Lee and Casavant, 1996).

Petroleum Products

The majority of petroleum product shipments, the third largest commodity group transported on the lower Snake River, originate in the Portland area and move upriver to a terminal at Wilma on the Lower Granite reservoir. Petroleum products account for approximately 80 percent of all upriver commodity movements above Ice Harbor lock (Corps and NMFS, 1994). Annual petroleum product shipments ranged from 95,000 tons in 1996 to 144,000 tons in 1995, with an annual average of 116,000 from 1987 to 1996 (Table 4.9-4). Upriver movements of petroleum products generally occur throughout the year but movements of gasoline, jet fuel, and kerosene tend to be higher from March through September, with increased demand coinciding with spring planting and fall harvesting seasons. Upriver shipments of distillate, residual, and other fuel oils are also steady throughout the year, but tend to peak in September during harvest. The majority of upriver petroleum product shipments on the Columbia-Snake Inland Waterway are unloaded at McNary pool for distribution by truck and rail. The remaining portion is typically left on barges and transported up the Snake River to the Lower Granite reservoir (Lee and Casavant, 1996).

4.9.1.5 Upper River Navigation

The 465-mile-long Columbia-Snake Inland Waterway ends at the head of the Lower Granite reservoir. River reaches upriver of Lower Granite reservoir are used for various types of navigation, with recreation uses the most common. Many types of motorized and non-motorized pleasure craft are used by private boaters on the Snake and Clearwater rivers above the Lower Granite reservoir. Commercial tour, guiding, and transportation services also exist in some locations, particularly on the Hells Canyon reach of the Snake River upriver from Lewiston.

4.9.2 Railroads

Railroads provide another mode of commodity transport within the Columbia Basin. Grain moved to export elevators via rail is normally delivered by truck to country elevators where it is loaded on rail cars. Rail transportation consistently accounted for over half of the total annual receipts of wheat and barley at Columbia River export houses from 1981 through 1997. Direct truck transportation averaged approximately 2 percent of the total over the same period. The remaining shipments of wheat and barley were transported by barge. Summary data for 1990 through 1997 are presented in Table 4.9-6.

Table 4.9-6. Receipts of Wheat and Barley at Columbia River Export Houses by Mode of Transportation (in thousands of bushels)

	Rail		Barge		Truck		Total
Year	**Bushels**	**Percent**	**Bushels**	**Percent**	**Bushels**	**Percent**	**Bushels**
1990-91	254,514	57.3	179,528	40.4	10,505	2.4	**444,547**
1991-92	251,942	59.6	162,067	38.4	8,406	2.0	**422,415**
1992-93	267,143	61.6	155,888	36.0	10,456	2.4	**433,487**
1993-94	317,299	61.9	185,589	36.2	9,353	1.8	**512,241**
1994-95	315,989	63.0	176,540	35.2	9,282	1.8	**501,811**
1995-96	343,136	59.4	227,163	39.3	7,564	1.3	**577,863**
1996-97	258,778	55.0	203,353	43.2	8,055	1.7	**470,186**

Source: Casavant and Lee, 1998

Wheat and barley represent a significant portion of total rail grain traffic moving through the region, but more than half of this grain traffic involves corn, most of which originates from Nebraska, Minnesota, or South Dakota. Rail grain traffic has remained relatively constant at the Port of Portland over the past decade. Traffic has increased at the Port of Vancouver. Grain is no longer exported from the Port of Longview. In the Puget Sound region, rail grain traffic has declined at the Port of Seattle and fluctuated significantly at the Port of Tacoma.

The most dramatic regional change in rail grain traffic has been the increasing volume of long-haul midwestern corn moved to the Columbia River Port of Kalama. Most of the major Columbia River ports with deep-water access unload grain arriving by barge and rail car and transfer it to deep-water vessels for shipment to export markets. The existing storage and rail car and barge unloading capacities at these facilities are identified in Table 4.9-7.

Table 4.9-7. Existing Rail and Barge Grain Unloading Capacities at Columbia River Deep Water Ports

Company	Port Location	Operating Storage Capacity (Bushels)	Receiving Facilities	Rail Car Unload Capacity (Tons)	Barge Unload Capacity (Tons)
United Harvest	Vancouver, WA	4,230,000	barge, rail	14,000	10,000
Louis Dreyfus	Portland, OR	1,500,000	barge, rail	3,000	7,000
Cargill (Irving Elevator)	Portland, OR	1,500,000	barge, rail, truck	5,500	10,000
Cargill	Portland, OR	7,500,000	barge, rail, truck	5,500	7,000
Columbia Grain	Portland, OR	4,000,000	barge, rail, truck	10,000	10,000
United Harvest	Kalama, WA	6,000,000	barge, rail, truck	7,000	7,000
Kalama Export	Kalama, WA	2,000,000	barge, rail	40,000	12,000
Total		**26,730,000**		**85,000**	**63,000**

Source: DREW Transportation Workgroup, 1999, Table 3-1

Based on origin-destination relationships for commodities shipped on the Columbia-Snake Inland Waterway, the areas potentially affected by the proposed action are primarily the grain growing areas of Washington, Oregon, Idaho, Montana, and North Dakota. These areas are served by the Burlington Northern-Santa Fe Railroad (BNSF), the Union Pacific Railroad (Union Pacific), and several shortline operations including the Camas Prairie Railroad, which serves Idaho and Washington, and the Montana Rail Link, which serves Idaho and Montana. Regional railroads are shown in Figure 4.9-3.

In Washington, BNSF and Union Pacific have an agreement to jointly manage the mainline track from Seattle to Portland. From Vancouver, Washington, the BNSF line runs along the northern side of the Columbia River through the Tri-Cities to Spokane. It continues north to Sandpoint, Idaho, then runs southeast to Missoula, Montana and on into the Midwest. BNSF has crossings into Oregon at Portland, Wishram, and Wallula. The Union Pacific line runs along the southern side of the Columbia River from Portland to Hinkle, Oregon, then runs south to Boise and on into the Midwest. Both BNSF and Union Pacific provide extensive trackage in all four states.

The Camas Prairie Railroad is a joint venture operated cooperatively by BNSF and Union Pacific. Camas Prairie tracks originating at Revling and Kamiah in Idaho, pass through Lewiston, Idaho to connect with Riparia, Washington on the Lower Monumental reservoir. Montana Rail Link provides service from Sandpoint, Idaho to Garrison, Montana (Corps and NMFS, 1994).

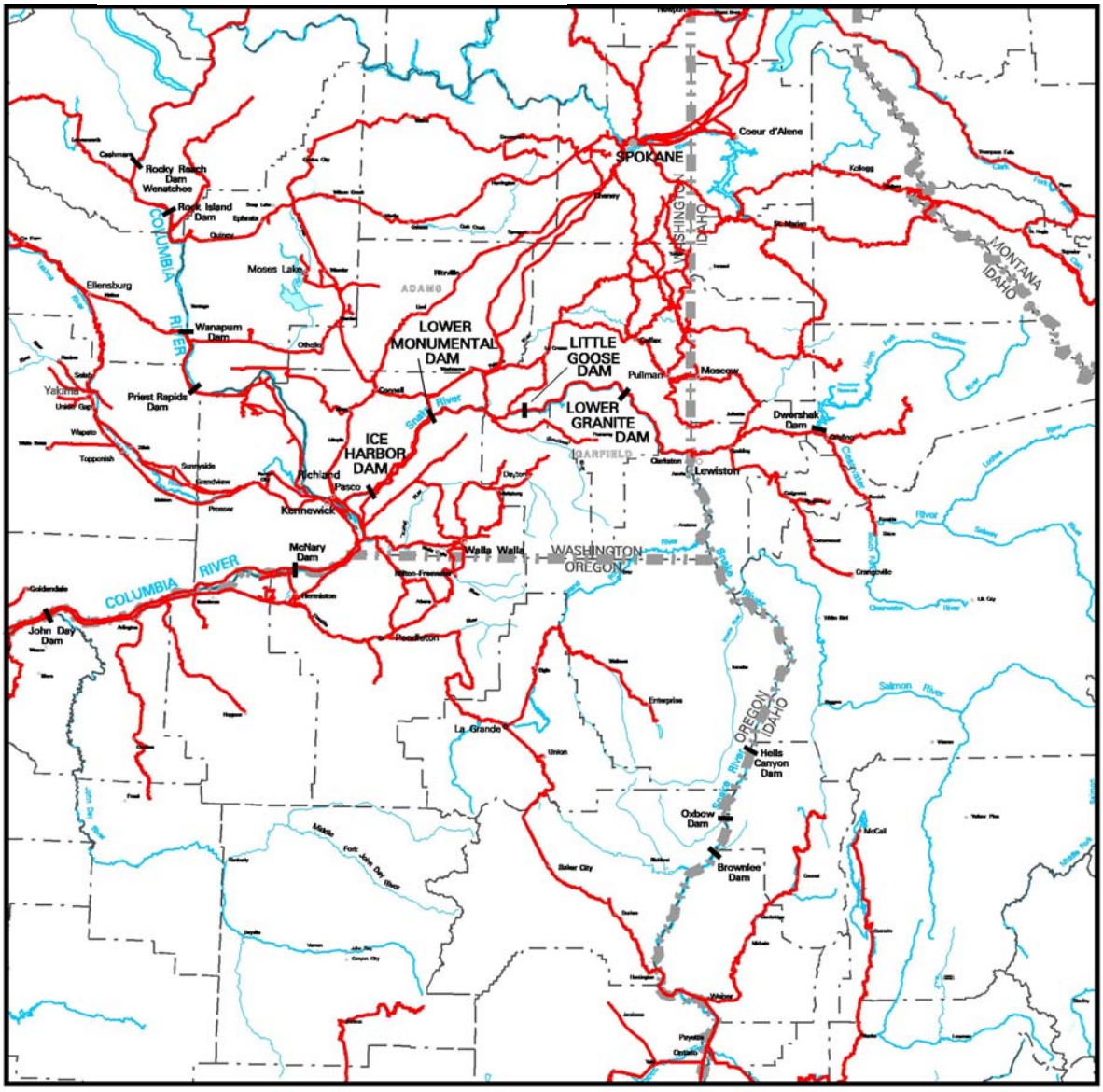
4.9.3 Highways

Trucks are also used for commodity transport, particularly for the movement of petroleum and chemical products to inland destinations. Trucks are also used in conjunction with other modes of transportation. This section provides a discussion of current truck transportation patterns for eastern Washington grain shipments and an overview of potentially affected local and regional highways.

4.9.3.1 Eastern Washington Grain Shipments

Wheat and barley comprise approximately 75 percent of the total tonnage transported on the lower Snake River. A significant portion of this wheat and barley is harvested in eastern Washington and transported by truck to lower Snake River ports, especially the ports of Windust and Almota on the Little Goose reservoir. At these ports, wheat and barley shipments are transferred to barge and transported downriver. These existing patterns are discussed here to provide more detailed insight into potentially affected traffic patterns and highway maintenance costs. Highway access to the nine lower Snake River ports is limited. Therefore, other commodities transported by truck to lower Snake River ports likely converge on the same primary routes as wheat and barley shipments.

Eastern Washington wheat and barley, harvested in July and August, is usually transported by truck to elevators or river ports, which serve as short- and long-term facilities, transfer stations, and points of consolidation. Grain stored in elevators is subsequently trucked to river ports for barge shipment to Portland (61 percent), shipped via rail directly to Portland (23 percent), or trucked to another elevator for rail transport to Portland (13 percent) (Newkirk et al., 1995). Upbound products arriving at river terminals are typically transported to their final destinations by truck.



Special Note: Railroads may not all be operational or currently in use.

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RAILROADS

BOUNDARIES

State

County

KM 40 20 0 MILES 20 40

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

160,000 ACRES

1 : 2,534,400

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.9–3.

REGIONAL RAILROADS

Detailed information concerning eastern Washington grain elevator location, capacity, handling and storage rates, and transportation modal usage was obtained through a survey of grain elevators conducted in 1994 (Newkirk et al., 1995). Grain shipments from townships, or production areas, to river ports comprise 57 percent of grain-related truck miles, with township to elevator and township to elevator with rail comprising approximately 14 percent each (Jessup and Casavant, 1998). The ports of Windust and Almota account for 38 and 15 percent of wheat shipped by truck to river ports, respectively.

Approximately 28 percent of eastern Washington wheat transported by truck is moved to river ports at or below the Tri-Cities. Primary truck routes to these ports are State Routes (SRs) 21 and 263 (Port of Windust), SR 192 and 195 (Port of Almota), SR 127 (Port of Central Ferry), and SR 395 (ports at or below the Tri-Cities) (Jessup and Casavant, 1998). Truck shipments of barley follow a similar pattern with shipments converging on the primary corridors serving Snake River ports. However, a larger percentage of barley is transported by truck to the Tri-Cities, using Interstate 82 as well as SR 395. Ton-miles of eastern Washington grain shipments and associated existing annual infrastructure investments are presented in Table 4.9-8 by highway type.

Table 4.9-8. Eastern Washington Grain Shipments: Ton-miles and Highway Infrastructure Needs

Highway Type	Ton-miles	Percent of Ton-miles	Infrastructure Investment ($)	Percent
Interstate	29,053,431	6.7	58,089	0.8
State	309,597,521	71.1	3,096,555	44.0
County	96,983,339	22.3	3,879,296	55.2
Total	**435,634,291**		**7,033,940**	

Source: Jessup and Casavant, 1998 (Tables 7 and 34)

Data compiled by the DREW Transportation Workgroup (1999) suggest that grain shipments originating in Idaho tend to be transported by truck to Lewiston via SR 95.

4.9.3.2 Local and Regional Highways

The highway network serving the study area includes Federal, state, and county highways (Figure 4.9-4). Primary and secondary routes that could be affected by potential diversion of commodities from barge transportation are identified in Table 4.9-9. Alternative routes north of the lower Snake River pools are also identified. The majority of the links in the network tend to serve low traffic volumes (Corps and NMFS, 1994). Interstate 84 and some portions of SR 395 have four travel lanes. The majority of the remaining primary and secondary highways have two travel lanes. These highways generally serve rural areas with few large population concentrations.

The four lower Snake River dams serve as bridges across the river. Lower Monumental Dam connects Lower Monumental Road on the south side of the river with Devils Canyon Road on the north. Lower Granite Dam connects Lower Deadman Road on the south side of the river with Almota Road on the north. The closest alternate route to Lower Monumental Dam is Washington 261, which crosses the lower Snake River at Lyons Ferry. Washington 127, which crosses the river at Central Ferry, is the closest

alternate route to Lower Granite Dam. Ice Harbor and Little Goose Dams both have road crossings that appear to be used primarily by project operators and tourists. Although both the local population and visitors use the four dams to cross the river, they are not part of the highway system.

Table 4.9-9. Potentially Affected Highways

Highway	Segment/Location From	Segment/Location To
Primary Highways		
I-84	US 97 (Biggs)	Pendleton
I-82	I-84	US 395 (Pasco)
US 395/730	I-84	US 12
US 12	US 395 (Pasco)	Lewis County, ID
US 95	Lewis and Adams Counties, ID	
OR 11	I-84	WA state line
WA 14	US 97 (Maryhill)	I-82 (Plymouth)
WA 124	US 12 (near Pasco)	US 12 (Waitsburg)
WA 125	WA 125	OR state line
WA 193	US 12	Port of Wilma
Secondary Highways		
US 395	US 12 (Pasco)	WA 260 (near Mesa)
WA 260	US 395	WA 261
WA 261	WA 260	US 12
WA 127	US 12	Central Ferry
WA 129	US 12	OR state line
WA 397 (proposed)	US 395	Finley Industrial Park
Alternative Routes North from Snake River		
US 195	US 12	WA 26
WA 26	US 195	US 395
WA 260	WA 261	WA 26
WA 263 (proposed)	WA 260 (Kahlotus)	Windust

Source: Corps and NMFS, 1994

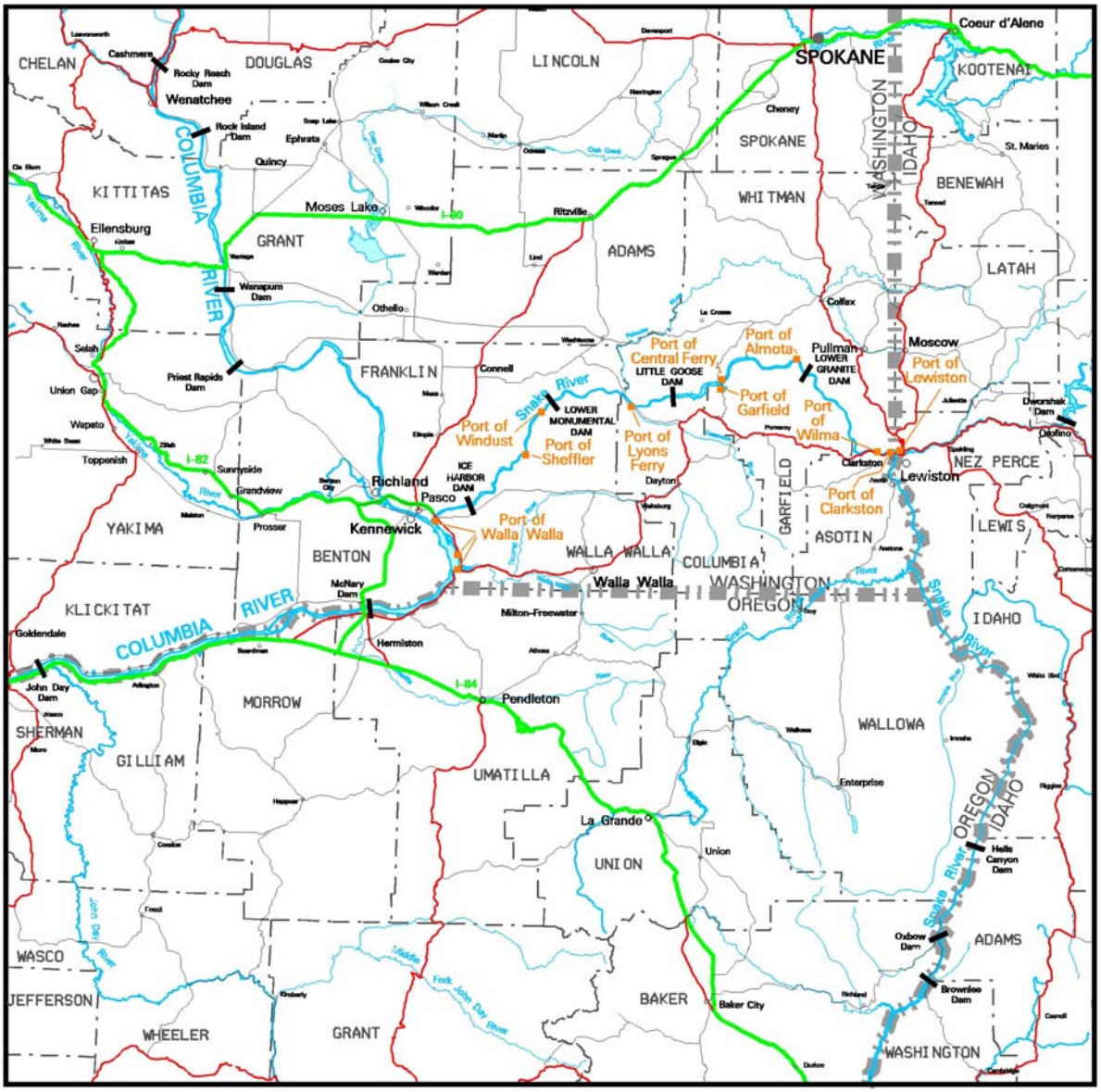

Figure 4.9–4.
ROADS, HIGHWAYS, AND PORTS

4.10 Electric Power

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4.10.1 Generation

The Columbia River and its tributaries are extensively developed for hydroelectric power, with over 250 Federal and non-Federal dams constructed since the 1930s. These include 30 major multiple use facilities built by Federal agencies on the Columbia River and its tributaries. These facilities fall into two major categories: storage and run-of-river projects. The purpose of storage reservoirs is to store water for use at a later time. The downstream effect of a storage facility is to adjust the river's natural flow patterns to conform more closely to water uses. These projects store spring runoff water which is gradually released for many river uses, including power, in late summer, fall, and winter when stream flows would ordinarily be low.

The hydraulic capacity at each storage facility is typically at least two times the average annual streamflow, allowing generating operations to provide additional power during high-flow periods. Run-of-river facilities, like the four lower Snake River dams, are developed primarily for navigation and hydropower generation. These dams have limited storage capacity and pass water at nearly the same rate that it enters the reservoir. Reservoir levels behind these dams vary only a few feet during normal operations.

Power generating operations follow a variety of cyclic patterns. Hydroelectric projects can increase or decrease their generation rapidly and are, therefore, usually operated to follow the peaks in power demand. Output levels typically vary significantly on a daily basis, with generation much higher during daylight hours than at night. On a weekly basis, power loads and generation tend to be considerably higher on weekdays than on weekends. The eight mainstem dams—the four lower Snake River dams and the McNary, John Day, The Dalles, and Bonneville Dams on the lower Columbia River—

tend to follow these daily and weekly cycles, causing reservoir levels to fluctuate frequently within the normal operating range.

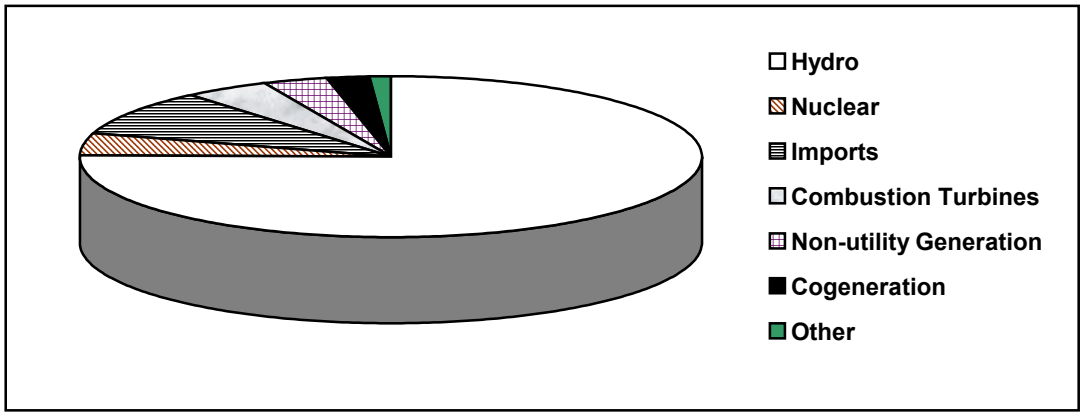
The four lower Snake River dams are currently operated in accordance with the Biological Opinions. The Corps operates Little Goose, Lower Monumental, and Ice Harbor Dams within one foot of MOP from approximately April 10 through August 31. Lower Granite Dam is operated within one foot of MOP from approximately April 10 through November 15. MOP elevations for Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams are 733 feet, 633 feet, 537 feet, and 437 feet mean sea level (msl), respectively. During the rest of the year, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams operate at elevations of 138 feet, 638 feet, 540 feet, and 440 feet msl, respectively. This operation restricts the daily and weekly operation of these dams to meet peak power demands.

Power demand is higher in the winter and lower during the spring and summer in most of the Pacific Northwest. During the winter, both storage and run-of-river projects are operated to provide peaking output during the high demand periods of the day. However, since river inflows are much lower during the winter than in the spring and early summer, operation is often limited to peak hours during the winter. The hydropower plants in the Pacific Northwest generate most of their energy in the spring and early summer during high runoff periods. Annual streamflow patterns also influence generation patterns. During years of relatively high runoff, hydroelectric plants are often operated at high levels in the spring to take advantage of the surplus water to generate additional energy. Power planners try to maximize hydroelectric production during the spring runoff period to avoid spilling water that can be used for power generation. This may involve deliberately keeping thermal plants inactive. As a result, hydropower generation may be significantly higher during the spring months than during the rest of the year. Maximum levels of generation occur at the four lower Snake River dams during the spring runoff period.

4.10.2 Regional Power Supply and Sales

BPA is the Federal agency responsible for selling the electricity generated at the Corps and BOR hydropower projects in the Pacific Northwest. From the revenues collected from the sale of electricity, BPA repays the Federal Treasury the costs associated with building and operating the Federal hydropower projects. If the four lower Snake River dams are breached, they will not produce any hydropower and BPA's revenue will be reduced. This section provides a brief summary of the sources of electricity generation in the Pacific Northwest and the nature of the power market.

The integrated system of 30 Federal hydroelectric facilities in the Columbia River Basin has a total installed nameplate generating capacity of about 19,600 megawatts (MW) (BPA, 1993). Hydropower (Federal and non-Federal), on average, accounts for approximately 60 percent of total regional energy needs and 70 percent of total electrical generating capacity. The remainder of the region's electricity comes from non-Federal hydroelectric facilities and from thermal resources, including coal-fired, nuclear, and gas-fired plants (Figure 4.10-1).



Source: BPA, 1997

Figure 4.10-1. Pacific Northwest Electric Generation by Resource Type

Summary information on Pacific Northwest electric generating facilities is presented in Table 4.10-1. Information is provided on sustained yield capacity, measured in MW, and firm energy, measured in annual average MW (aMW). Annual aMW is the average MW produced over an entire year (8,760 hours). For hydroelectric facilities, firm energy is the annual amount of energy that can be generated during an extreme low water year. The low water year of 1936-1937 is the baseline used to calculate the firm energy produced by the region's hydroelectric facilities. This year has been defined as the critical year for defining firm energy in many regional power planning studies.

Table 4.10-1. Pacific Northwest Electric Generating Resources

Resource Type	Sustained Peak Capacity (MW)	Firm Energy (aMW)
Hydro	25,887 (67%)	12,187 (57%)
Coal	4,521 (12%)	4,061 (19%)
Nuclear	1,162 (4%)	841 (4%)
Imports	2,296 (8%)	1,669 (8%)
Combustion Turbines	1,665 (4%)	753 (3%)
Non-utility Generation	1,166 (3%)	1,051 (3%)
Cogeneration	775 (2%)	675 (3%)
Other	264 (1%)	171 (1%)
Total	**38,436**	**21,408**

Source: BPA, 1997

4.10.2.1 Firm Sales

Publicly-owned utilities in the Pacific Northwest have first call or "preference" on power produced at Federal hydroelectric facilities. BPA has long-term firm power sales contracts with over 120 utilities, including municipalities, public utility districts, and rural cooperatives. BPA also sells firm power directly to other Federal agencies and some of the region's largest industries. These industries are known as direct service industries (DSIs). BPA supplied 15 DSI customers in 1995, 8 of which were aluminum companies (BPA, 1995). BPA's firm power sales contracts are long-term commitments that contain a guarantee to meet some or all of a customer's load requirements over a defined period. These contracts are based on estimates of the firm energy load-carrying capability (FELCC) of the system.

4.10.2.2 Nonfirm Sales

Nonfirm energy is power generated above the amount needed to meet firm power commitments. In most water years, stream flows are high enough to produce at least some nonfirm generation. In an average year, nonfirm generation may comprise 25 percent or more of total hydro system output. Nonfirm energy is generally sold with no guarantee of continuous availability and delivery can be terminated at very short notice. DSIs have first call on BPA's nonfirm energy. The remainder is sold to utilities in the Pacific Northwest and elsewhere.

4.10.2.3 Regional Exports

In wet years, the amount of hydropower generation can be significantly greater than under average or low-flow conditions and this energy can serve as a major portion of the energy exported from the Pacific Northwest region. In low water years, or during high demand periods within a year, energy is often imported into the region from other western states and Canada. The Pacific Northwest region is part of 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, managed by the Western Systems Coordinating Council (WSCC), extends over 1.8 million square miles and includes four major areas—the Northwest Power Pool Area, the Rocky Mountain Power Area, the Arizona-New Mexico Power Area, and the California-Southern Nevada Power Area—with varied geographic and climatic conditions. Changes in Pacific Northwest hydropower generation could affect the amount of energy bought and sold, and the amount of new generating facilities built, throughout this area.

In the past several years, the entire electrical industry has been undergoing drastic changes from a regulated industry of the past into a partially competitive industry. One of the most significant changes was a final rule issued by FERC in 1996 which required utilities that own, control, or operate transmission lines to file non-discriminatory open access tariffs that offer others the same electricity transmission service that they provide themselves. Open transmission access improves the flexibility to purchase electricity from generation facilities in the Pacific Northwest, the Pacific Southwest, and other WSCC areas. In early 1998, the State of California implemented significant legislation to set up a formal market system in which a wide range of wholesale buyers and sellers can contract for electricity sales. The hydropower generated in the Pacific Northwest is an integral part of the California power exchange, as well as an important regional export.

Transmission lines originate at generators at the dams and extend outward to form key links in the regional transmission grid. BPA owns and operates the transmission system, which consists of 14,787 circuit miles (BPA, 1995). The Pacific Northwest grid was designed to accommodate, and interact electrically with, existing generation sources, including the four lower Snake River hydroelectric facilities. The grid relies upon these and other fixed sources of generation to serve regional loads and move bulk power.

Nonfirm sales between the Pacific Northwest and other regions are mutually advantageous. In California, for example, Pacific Northwest nonfirm energy sales have traditionally allowed California utilities to shut down their relatively high cost oil- and gas-fired generating plants, reducing operating costs and pollution. Nonfirm export

sales, in turn, bring in revenues to the Pacific Northwest and help keep electricity rates in the region among the lowest in the United States.

4.10.3 Lower Snake River Facilities

4.10.3.1 Project Characteristics and Combined Capacity

Power generating facilities at the four dams are summarized in Table 4.10-2. Installed capacity ranges from 603 MW at Ice Harbor to 810 MW at Lower Granite, Little Goose, and Lower Monumental. The overload capacity, the maximum output that can be achieved, is 693 MW for Ice Harbor and 931 MW for each of the other three lower Snake River facilities.

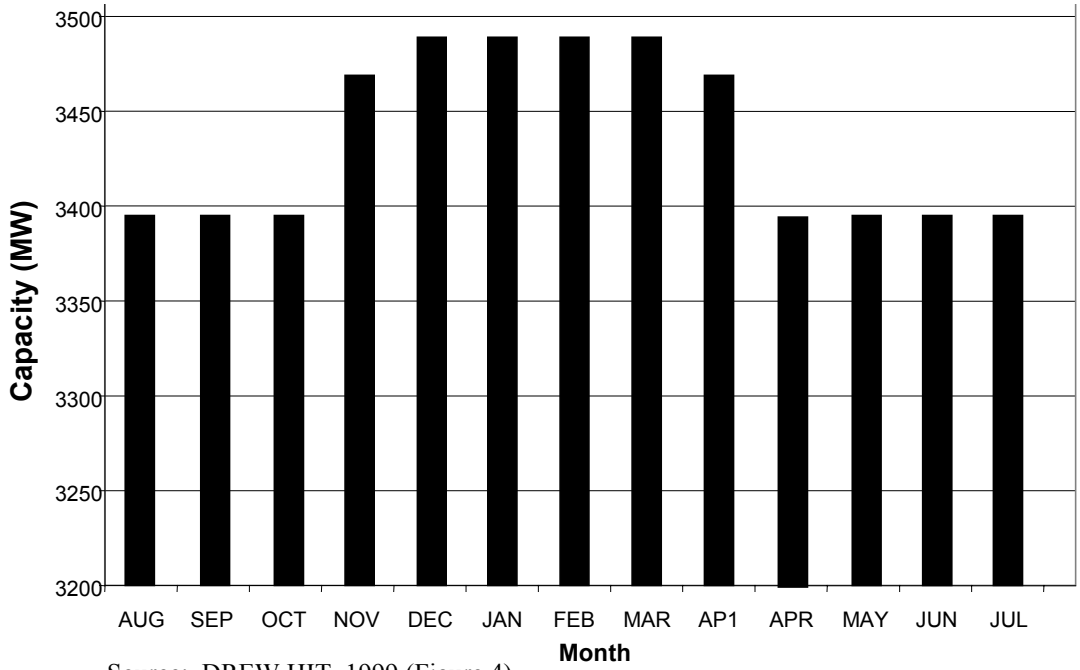
Table 4.10-2. Hydroelectric Power Plant Characteristics

	Lower Granite	Little Goose	Lower Monumental	Ice Harbor	Lower Snake Total
Number of Units	6	6	6	6	**24**
Nameplate Capacity Per Unit (MW)	135	135	135	3 (90) 3 (111)	
Total Nameplate Capacity (MW)	810	810	810	603	**3,033**
Overload Capacity (MW)	931	931	931	693	**3,486**
In-Service Date	1975 1978	1970 1978	1969 1970 1979	1961 1962 1975	
Average Annual Energy (aMW)	333	317	332	264	**1,246**
Plant Factor (%)	36	34	36	38	**36**

Source: DREW HIT, 1999 (Table 1)

The total nameplate peaking capacity of the four lower Snake River facilities is 3,033 MW (Table 4.10-2), which is approximately 15 percent of the peaking capacity at the Federal power system in the Pacific Northwest region and 7 percent of the total peaking capacity of all power facilities in the Pacific Northwest region. The four lower Snake River dams provide about 11 percent of the energy generated in the Federal power system in the Pacific Northwest region, and 5 percent of all energy generated in the Pacific Northwest region.

The monthly capacity of the lower Snake River dams is shown in Figure 4.10-2. The monthly amounts shown in this figure represent the maximum monthly generation of these projects under current operation. The projects do not always operate at these maximum outputs because there is insufficient water to do so for long periods of time. All four dams are run-of-river facilities with limited reservoir storage.



Source: DREW HIT, 1999 (Figure 4)

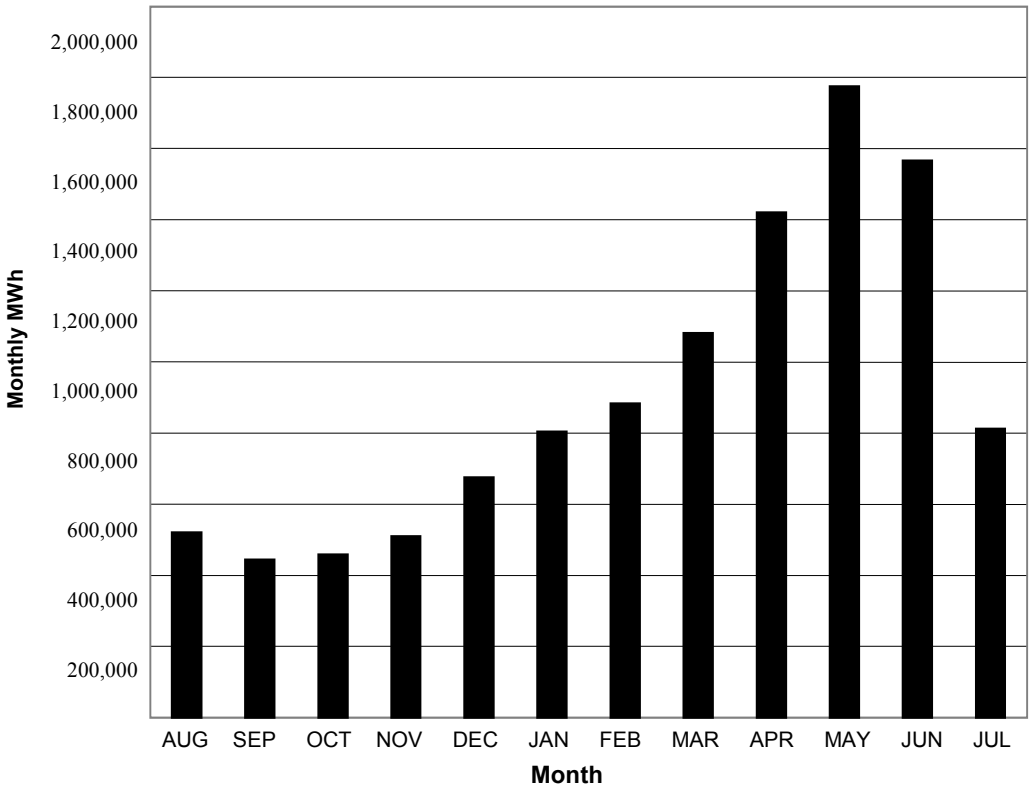
Figure 4.10-2. Combined Plant Capacity of the Four Lower Snake River Facilities

The lower capacity from April through October reflects the operation criteria established in the 1995/1998 Biological Opinions. The lower Snake River facilities are operated at their MOP during this period to increase migrating salmon and steelhead survival rates. Minimum pool operations reduce the power generating head and project capacity. The maximum output of each facility is further reduced because power turbine operations are restricted to within one percent of the peak efficiency level during this period.

4.10.3.2 Average Monthly Generation

Average monthly generation estimates for the four lower Snake River facilities are presented in Figure 4.10-3. These average monthly estimates, derived using the Corps' Hydro System Seasonal Regulation Program (HYSSR), are the averages of 60 individual annual estimates that were made using actual runoff data from the water years 1929 through 1988. The variation across months reflects both the run-of-river nature of these projects and the storage capability of the upstream storage reservoirs. Upstream reservoirs are able to store some of the high spring runoff but storage capacity is relatively small compared to the annual runoff amounts. As a result, generation in the spring period far exceeds generation during the rest of the year.

Average monthly generation is relatively low from August through March with high average generation amounts never occurring from August through December and rarely between January and March. The facilities are, however, frequently operated at high output levels to follow peak demand during the winter months, but the amount of water available is often too low to allow sustained periods of high output and, therefore, average monthly generation is relatively low.



Source: DREW HIT, 1999 (Figure 2)

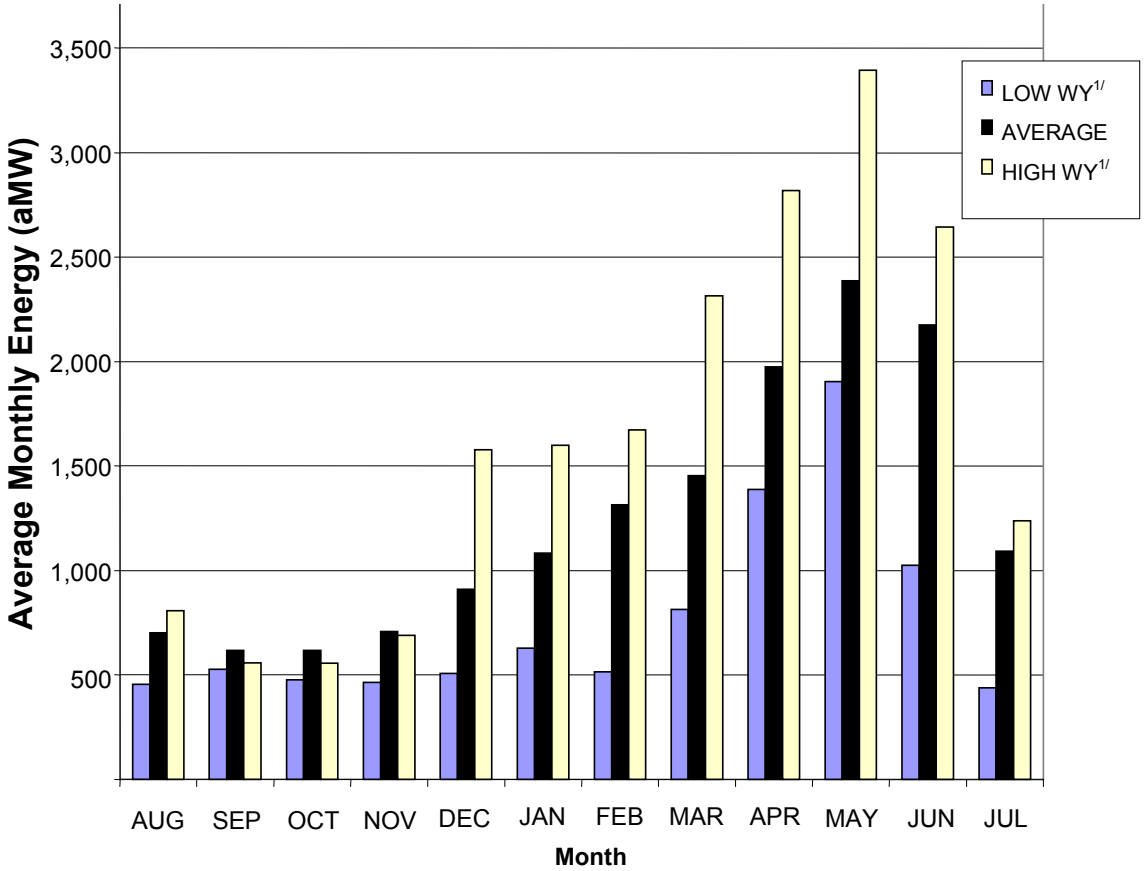
Figure 4.10-3. Average Monthly Generation by the Lower Snake River Facilities (combined)

4.10.3.3 Annual Generation

Actual monthly generation can vary significantly from year to year. Monthly generation amounts for the low water year of 1930-1931 and the high water year of 1955-1956 are compared with the 60-year average generation amounts in Figure 4.10-4. Variations from low water to high water years can be even more pronounced on a seasonal basis. In the summer months, for example, the average monthly generation of the lowest month is about 75 percent lower than the average summer monthly generation over the 60 water years of record. The highest summer monthly generation is about 160 percent larger than the monthly average. This range of variation is similar for the winter months, but considerably less during the fall and spring months.

4.10.3.4 Daily Generation and Ancillary Services

Hydropower generation at the four facilities is primarily determined by the amount of Snake River water arriving at Lower Granite because the four reservoirs have limited storage capacity and only minor tributaries flow into the reservoirs. These facilities do not have the capacity to store water on a seasonal, monthly, or even weekly basis. They can, however, shape the amount of generation throughout the day by adjusting the limited storage that is available within the top 3 to 5 feet of operating range.



Source: DREW HIT, 1999 (Figure 3)
1/ WY = Water Year

Figure 4.10-4. Annual Variation in Lower Snake River Project Average Monthly Generation

These adjustments are possible from November through March. The facilities operate within one foot of MOP for the remainder of the year in accordance with the 1995/1998 Biological Opinions.

Generation throughout the day is shaped to meet the power demand to the extent possible given the amount of water available and other operation constraints, such as spill and flow requirements. Operation during non-peak hours is typically low to allow much higher generation during peak demand periods. A minimal level of generation is required at each facility to serve the needs of the powerhouse and the dam.

The hydropower plants in the Pacific Northwest power system provide important services on an hourly basis that are generally known as ancillary services. The WSCC has established reserve requirements for all utilities. These reserves are needed to quickly respond to emergencies in the system, such as power plant or transmission line failure. Utilities are required to have both spinning and operating reserves. Spinning reserves must be synchronized with the power system and provide immediate response. Operating reserves must be available within 10 minutes. The quick start-up ability of hydropower units provides important spinning reserves to the WSCC system. Hydropower generation can be quickly adjusted up or down to give automatic generation control that provides the required frequencies in the transmission system. Hydropower

units may also be operated as a motor, in a condensing mode, to balance the needs of the transmission system. The four lower Snake River dams are connected to the Automatic Generation Control System, which regulates electricity generation at each dam, second-by-second, to keep the WSCC system's operating frequency as close to 60 seconds per cycle as possible.

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4.11 Water Supply

4.11 Water Supply 4.11-1
4.11.1 Irrigated Agriculture 4.11-1
4.11.2 Municipal, Industrial, and Other Water Uses 4.11-5

Water is withdrawn from the lower Snake River to support many uses. Irrigated agriculture is the dominant use, followed by municipal and industrial water supply, wildlife habitat enhancement, cattle watering, and recreational site irrigation. The following discussion focuses upon these lands and uses.

4.11.1 Irrigated Agriculture

The four lower Snake River reservoirs are bordered by the counties of Asotin, Columbia, Franklin, Garfield, Walla Walla, Whitman, and Nez Perce. According to the U.S. Census of Agriculture, approximately 19 percent of the 1,695,491 acres of agricultural land in these counties was irrigated in 1997 (Table 4.11-1). Almost 97 percent of these irrigated acres are located in Franklin and Walla Walla Counties, approximately 67 and 30 percent, respectively. Large river pumping stations in these two counties withdraw water for farm use from both the Columbia and Snake rivers out of the McNary and Ice Harbor pools, respectively.

Table 4.11-1. Agricultural Acreage in Southeast Washington Counties, 1997

County	Total Acres Harvested	Irrigated Land (acres)	Irrigated Land as a Percent of Total Acres Harvested by County	Irrigated Land by County as a Percent of Total Irrigated
Asotin	36,126	329	0.9	0.1
Columbia	109,607	3,565	3.2	1.1
Franklin	291,241	221,145	75.9	67.4
Garfield	114,645	693	0.6	0.2
Walla Walla	342,371	97,136	28.4	29.5
Whitman	801,501	5,469	0.7	1.7
Total	**1,695,491**	**328,337**	**19.4**	

Source: U.S. Census Bureau, 1997 (Agriculture)

Nearly all of the Snake River water used for agricultural irrigation comes from Ice Harbor. Since the construction of Ice Harbor in the 1960s, private entities have developed the infrastructure necessary to grow irrigated crops on lands adjacent to the reservoir in Franklin County (north side) and Walla Walla County (south side). Most of the lands irrigated by the lower Snake River are located in these counties. The Corps, in 1997/1998, identified the location of 33,933 acres of the approximately 37,000 acres irrigated from Ice Harbor Reservoir. Approximately 5,693 acres were located in Franklin County, accounting for approximately two percent of irrigated agriculture in that county. The remaining 28,240 acres accounted for approximately 30 percent of irrigated agricultural lands located in Walla Walla County. The general location of the land irrigated from Ice Harbor is shown in Figure 4.11-1.

Fourteen pumping stations currently use water from Ice Harbor to irrigate approximately 37,000 acres of land. Additional lands are irrigated from wells. In general, the pumping stations draw water through intake screens in the reservoir and pump the water uphill to corresponding distribution systems. The majority of the pumps are of the vertical type and a few are centrifugal pumps. Several of these pumping facilities are joint-use facilities with two or more operators using one plant site.

Many of the irrigation pumpers are large agricultural-based corporations that use pumping plants or collection systems located on the reservoir bank to pump water to lands lying adjacent to the reservoir. Irrigators pumping from the pool use natural flow rights permitted or granted by Ecology, as well as easements and permits issued by the Corps. Ice Harbor-irrigated operations are typically characterized by very large farms; high yields; high levels of irrigation management practices, which include center pivot irrigation systems; and large amounts of hired labor. Cropping on these lands is influenced by the high capital investment costs for pumping plants, above average pumping costs, and soil texture. As a result, these operations typically depend on income from high-value crops like potatoes, vegetables, and fruit, while accepting marginal returns that cover variable cost from other rotational crops like wheat and corn (Corps and NMFS, 1994).

Twelve farm operators manage 33,933 of the approximately 37,000 acres irrigated by Ice Harbor. The remaining 3,067 acres were not specifically identified by operator. Total acreage farmed, total acreage irrigated from Ice Harbor, and primary crops are identified for each farm in Table 4.11-2. About 21 percent of the 37,000 acres is in permanent crops, like fruit tree orchards or vineyards, and represents about 51 percent of the estimated value of the 37,000 acres of irrigated lands. The remaining acreage by crop varies from year to year as crops are rotated. Potatoes, for example, are only grown one year in every three or four for disease control.

The estimated irrigated acreage by crop for the 1996 to 1997 growing season is provided in Table 4.11-3. Cottonwood, which is grown for pulp and paper production, is the largest crop in terms of acreage, accounting for approximately 23.2 percent of crop acreage irrigated from Ice Harbor in 1996/1997. This crop is scheduled to be harvested for the first time in the year 2000. Potatoes, the next largest crop, account for approximately 14.9 percent of the 1996/1997 irrigated acreage. Field corn and fruit tree orchards accounted for approximately 13 and 11 percent of the 1996/1997 irrigated acreage, respectively.

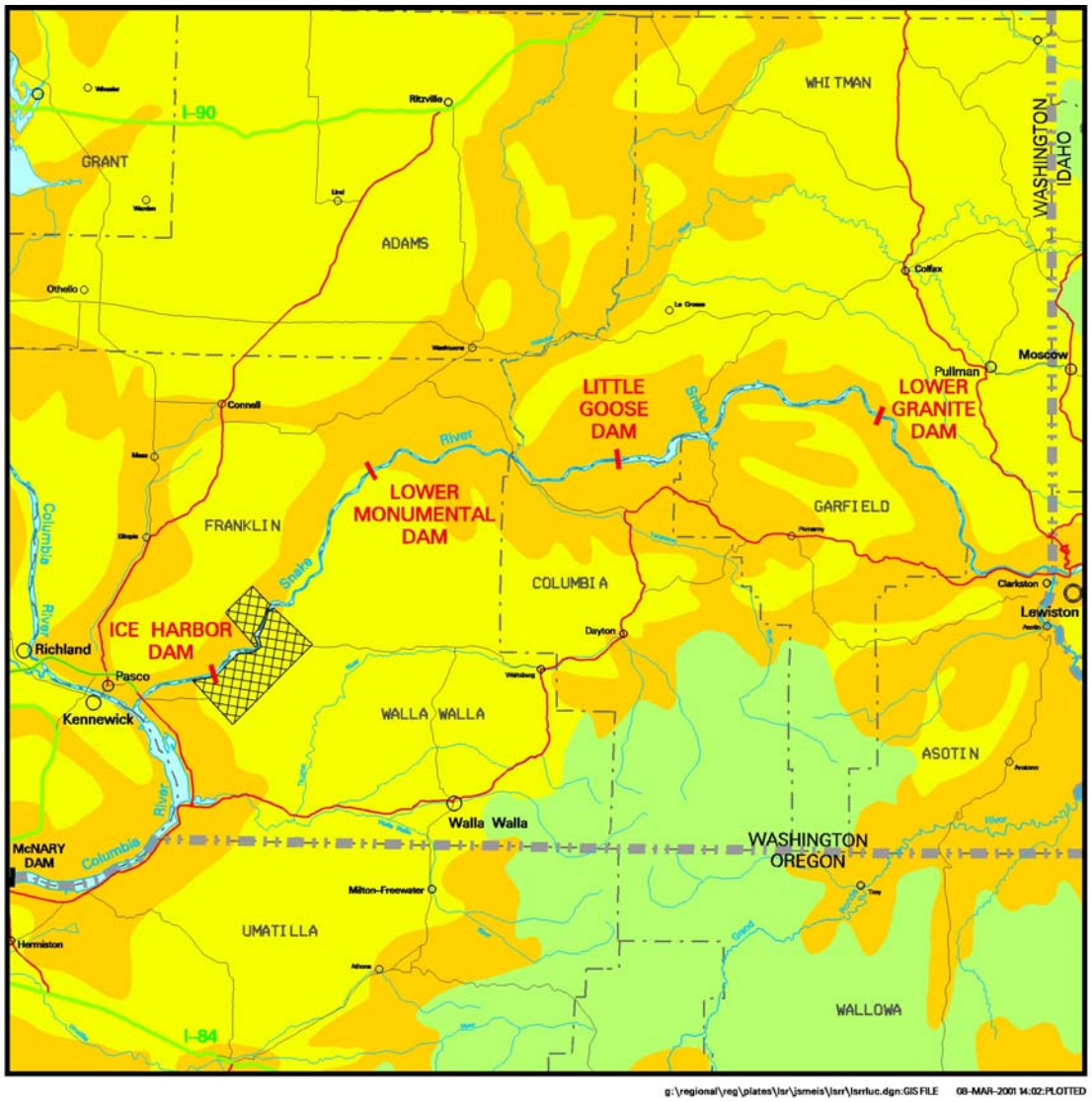

Figure 4.11–1.
REGIONAL LAND USE & COVER

Table 4.11-2. Acreage and Crops Grown on Farms Irrigated from Ice Harbor Reservoir

Pump Stations (Ref. No.)[1/]	Total Acreage	Total Acreage Irrigated from Ice Harbor	Primary Crops
IH-1	1,500	1,500	sweet corn, onions, potatoes
IH-2	4,500	4,500	hybrid cottonwood
IH-3	12,000	9,500	potatoes, wheat, field corn, onions, sweet corn
IH-5	4,100	4,100	hybrid cottonwood
IH-6	5,000	2,200	field corn, wheat, potatoes
IH-7	2,900	2,700	grapes, apples
IH-9	540	540	apples
IH-10	4,000	1,800	apples, cherries
IH-11	6,017	4,008	apples, cherries, sweet corn, potatoes, wheat, peas, field corn
IH-12	900	900	field corn, potatoes, asparagus, wheat
IH-16	600	320	apples, cherries
IH-17	1,200	1,200	potatoes, onions
IH-18	225	165	vineyards, apples
IH-19	500	500	na
Total		**33,933**	

1/ This numbering system matches the numbering used in an earlier water supply analysis developed for the Corps (Anderson Perry, 1991) Pump stations IH-4, IH-8, and IH-13 through IH-15 are not included in this table because water pumped via those stations is not used for agricultural production.

na – not available

Source: DREW Water Supply Workgroup, 1999

Table 4.11-3. Estimated Crop Acreage Irrigated from Ice Harbor Reservoir by Type

Crop	Percent of Irrigated Crop Acreage
Cottonwood/Poplar	23.2
Potatoes	14.9
Field Corn	13.5
Fruit Tree Orchards	11.1
Wheat	9.5
Vineyards	6.2
Sweet Corn	5.4
Onions	3.0
Undefined	13.2
Total (37,000 acres)	**100.0**

Source: DREW Water Supply Workgroup, 1999

Water from the lower Snake River also supplies private wells that are used to irrigate agricultural lands. Wells are discussed in more detail in Section 4.11.2, Municipal, Industrial, and Other Water Uses.

4.11.2 Municipal, Industrial, and Other Water Uses

Water is also withdrawn from the lower Snake River for municipal and industrial (M&I) uses and for wildlife habitat enhancement. Reservoir water also recharges groundwater supplies for agricultural wells and is used as a source of water for cattle.

There are eight M&I pump stations along the lower Snake River, all located on Lower Granite (Table 4.11-4). Water withdrawn via these stations is used for municipal water system backup, golf course irrigation, industrial process water for paper production and concrete aggregate washing, and park irrigation. The two stations owned by Clarkston Public Utility District (PUD) #1 have not been operated over the past few years and no plans exist to operate them in the immediate future. Clarkston's drinking water, supplied by the Asotin County PUD, is presently withdrawn from seven deep wells. The neighboring city of Lewiston's primary source of drinking water is the Clearwater River. It also withdraws water from six wells.

Table 4.11-4. M&I Pump Stations on Lower Granite Reservoir

Station	Use	1996 Water Usage
PUD #1	water system backup	not used in several years
PUD #1	water system backup	not used in several years
Clarkston Golf Course	golf course irrigation	460,000 gallons/day
Potlatch Corporation	mill process water and steam generation	12,287,000,000 gallons
Washington State Parks	park irrigation	12,813,000 gallons
Idaho State Parks	park irrigation	no meter
Whitman County Park	park irrigation	540,000 gallons
Atlas Sand & Rock	concrete aggregate washing	not available
Lewiston Golf Club	golf course irrigation	1.0-1.5 million gallons/day in June-August

Source: DREW Water Supply Workgroup, 1999

Water is also withdrawn from the lower Snake River to irrigate vegetation for HMU wildlife areas. HMUs were established along the lower Snake River to compensate for wildlife habitat lost as a result of inundation by the Snake River dams. There are currently eight HMUs being irrigated by 11 surface water pumping plants and two HMUs being irrigated by well-supplied water (Table 4.11-5). These irrigated HMUs cover approximately 960 acres of land, the majority of which is located on Ice Harbor Reservoir. Irrigation is typically used to promote vegetation growth for wildlife cover and feeding.

Table 4.11-5. Irrigated HMUs Along the Lower Snake River

HMU	Water Supply Source
Big Flat	River Intake, Pump Stations
Lost Island	River Intake, Pump Stations
Hollebeke	River Intake, Pump Stations
Skookum	River Intake, Pump Stations
Fifty-five Mile	River Intake, Pump Stations
Ridpath	Ground Water Well
New York Bar	River Intake, Pump Stations
Swift Bar	River Intake, Pump Stations
John Henley	Ground Water Well
Chief Timothy	River Intake, Pump Stations

Source: Annex J of Appendix D, Natural River Drawdown Engineering

Wells located within one mile of the lower Snake River could be affected by a natural drawdown. State water well reports indicate that approximately 225 wells are located within 1 mile of the lower Snake River. Approximately 53 percent of these wells are used for either domestic or irrigation purposes. The uses and locations of these wells are summarized by county in Table 4.11-6.

Table 4.11-6. Well Reports by Use and County (Number of Wells)

Use	Asotin	Columbia	Franklin	Garfield	Walla Walla	Whitman	Total	% of Total
Domestic	40	2	9	3	12	12	**78**	**35**
Industrial				1	2	3	**6**	**3**
Irrigation	7	1	18	1	9	4	**40**	**18**
Multiple	5	5	4	4	3	4	**25**	**11**
Municipal	7				2	1	**10**	**4**
Other	2		9	2	2	1	**16**	**7**
Test Well	3		4			2	**9**	**4**
Not Reported	3	4	5	2	15	12	**41**	**18**
Total	**67**	**12**	**49**	**13**	**45**	**39**	**225**	
% of Total	**30**	**5**	**22**	**6**	**20**	**17**	**100**	

Source: DREW Water Supply Workgroup, 1999

Cattle watering corridors provide access across government property for cattle to water from the lower Snake River reservoirs. These corridors are fenced off down to the river bank. Sixty-nine corridors have been identified along the Snake River. Twenty-nine of these corridors are located on Lower Monumental. Twenty-one cattle watering corridors are located on Little Goose, with the remaining 19 corridors divided between Ice Harbor (11) and Lower Granite (8).

4.12 Land Ownership and Use

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4.12.1 Regional Land Use

About two-thirds of land in the Columbia River Basin is publicly owned. Public lands in the Columbia River Basin are managed by Federal government agencies, state and local governments, and Indian tribes. Federal lands, including Indian reservations under Federal and tribal jurisdiction, account for approximately 55 percent of the total land area. These lands include national forests, National Park System lands, Bureau of Land Management (BLM)-managed resource lands, national wildlife refuges, and Federal reservations used for military or related purposes. The Umatilla National Forest, the closest national forest to the lower Snake River, is located approximately 12 miles from the river. BLM lands are concentrated in southern Idaho and southeastern Oregon. The Hells Canyon National Recreation Area begins 35 miles upstream of the project area and encompasses a 168-mile-long corridor along the Snake River. Idaho, Oregon, and Washington all have sizable acreages of state-owned lands, which are typically managed for income from timber, range, and mineral resources, but also provide wildlife habitat and recreation. The acreage of state lands near the lower Snake River dams is relatively small but includes a number of wildlife and park units. Indian reservations in the vicinity of the lower Snake River are discussed in Section 4.8, Native American Indians.

Forest is the predominant land cover in the Pacific Northwest, accounting for approximately 49 percent of land cover in the region. This proportion is, however, noticeably less in the Columbia River Basin. The rangeland proportion for the Columbia River Basin is somewhat higher than for the region as a whole because it contains most of the drier interior zones within the region. The highest concentrations of rangeland are in Oregon and Idaho, where range covers most of the Snake River Plain and the southeastern quadrant of Oregon. Over 60 percent of rangelands in the region are Federally-owned, with two-thirds of that administered by BLM. Cropland accounts for about 12 percent of regional land cover. The proportion located in the Columbia River Basin is higher, especially in Washington where cropland accounts for 19 percent of the total state area, most of which is located in eastern Washington. Urban land uses, concentrated in the Portland-Vancouver, Spokane, Boise, and Eugene-Springfield areas,

account for about 2 percent of regional land use. Regional land use and cover is shown in Figure 4.11-1 in Section 4.11, Agricultural, Municipal, and Industrial Water Uses. This map emphasizes rangeland, forest land, and agriculture. Urban land uses are not specifically identified.

The potentially affected lower Snake River region was divided into three subregions—downriver, reservoir, and upriver—as part of the regional economic analysis developed for this FR/EIS (see Technical Appendix I, Economics). The counties that comprise these subregions and together form the lower Snake River region study area are presented in Table 4.14-1 in Section 4.14, Social Resources (see also Figure 4.14-1). These subregions separate the lower Snake River study area into three functional geographic areas based on the type of likely impacts if dam breaching were to occur. This is discussed further in Section 4.14.1, Regional Demographics and Employment.

Land use in the reservoir subregion is predominantly agricultural. Agricultural land uses comprise about 80 percent of land cover in the six-county area (Table 4.12-1). Cropland is the dominant agricultural land use in this subregion (Table 4.12-2). Agricultural land tenure in the study area has undergone significant change in recent decades. All three subregions have experienced a decrease in the number of farms and an increase in average farm size. The downriver subregion has the largest number of farms and acres farmed of the three subregions. Between 1959 and 1992, this subregion lost 1,279 farms or 18.4 percent of the 1959 total (Figure 4.12-1). The reservoir and upriver subregions over this period lost 1,544 and 1,537 farms, respectively, 34.1 and 32.6 percent of their 1959 totals (Figures 4.12-2 and 4.12-3).

Table 4.12-1. Land Use in the Reservoir Subregion

	Land Area	BLM		Forest Service		Wilderness		Non-Federal Timberland		Farms	
County	(Acres)	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Adams	1,235,027	481	0.0	0	0.0	0	0.0	0	0.0	996,742	80.7
Asotin	410,041	10,422	2.5	53,797	13.1	2,634	0.6	26,000	6.3	274,546	67.0
Columbia	558,046	519	0.1	159,500	28.6	80,472	14.4	49,000	8.8	304,928	54.6
Garfield	463,746	433	0.1	95,467	20.6	28,035	6.0	9,000	1.9	325,472	70.2
Walla Walla	831,508	630	0.1	2,433	0.3	0	0.0	18,000	2.2	710,546	85.5
Whitman	1,393,670	1,294	0.1	0	0.0	0	0.0	9,000	0.6	1,404,289	100.8[1/]
Total	**4,892,038**	**13,779**	**0.3**	**311,197**	**6.4**	**111,141**	**2.3**	**111,000**	**2.3**	**4,016,523**	**82.1**

1/ This presumably reflects inconsistencies in the databases compiled by McGinnis et al., 1997. Source: McGinnis et al., 1997

Table 4.12-2. Agricultural Land Use in the Reservoir Subregion

	Adams	Asotin	Columbia	Garfield	Walla Walla	Whitman
Total Farmed Acres	996,742	274,546	304,928	325,472	710,546	1,404,289
Cropland	781,122	85,202	180,083	197,054	604,519	1,132,001
Pasture/Range	na	164,217	102,789	118,395	61,183	237,375
Woodland	3,068	22,696	15,023	6,158	20,101	20,985
Other	na	2,431	7,033	3,865	24,743	13,928
Avg. Farm Size	1,656	1,933	1,596	1,750	954	1,262
Number of Farms	602	142	191	186	745	1,113

na = not available. Source: McGinnis et al., 1997

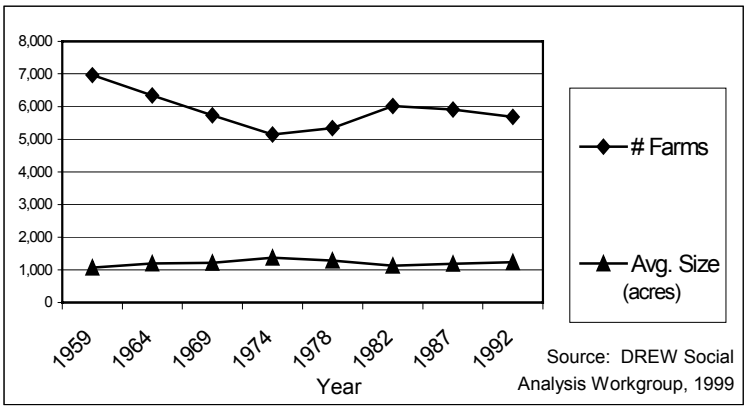

Figure 4.12-1. Number and Average Size of Farms in the Downriver Subregion, 1959 to 1992

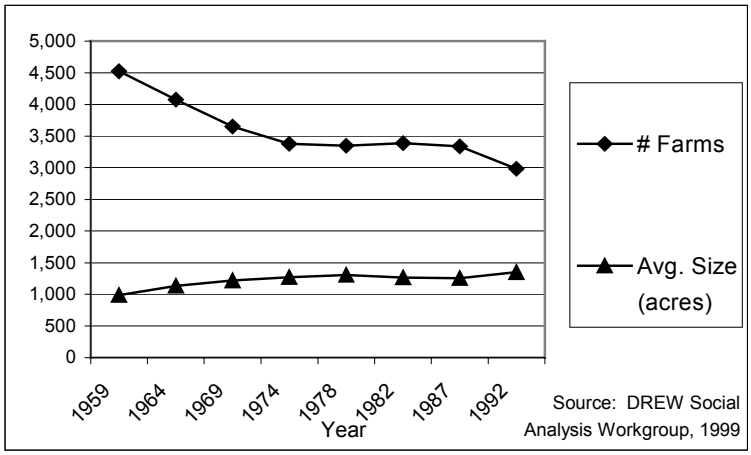

Figure 4.12-2. Number and Average Size of Farms in the Reservoir Subregion, 1959 to 1992

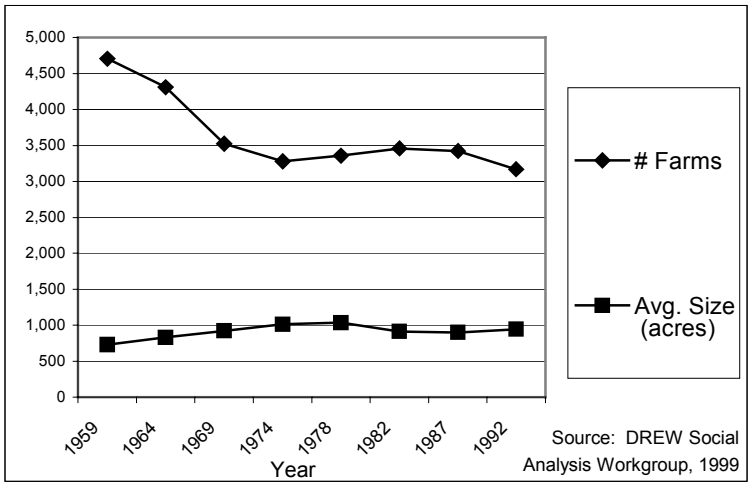

Figure 4.12-3. Number and Average Size of Farms in the Upriver Subregion, 1959 to 1992

This has not, however, been a simple linear decline. Rather, all three subregions experienced both increases and decreases in the number of farms between 1959 and 1992 (Figures 4.12-1 through 4.12-3). The average size of farms also fluctuated over this period. In general, the trend has been toward increasing farm size in all three subregions.

4.12.2 Lower Snake River Corridor

Any direct effects from the proposed action would be felt within the immediate river corridor and primarily on lands adjacent to the river or reservoirs. The lower Snake River corridor is almost entirely in private ownership. The only public lands in the immediate river vicinity are Federal project lands administered by the Corps and isolated parcels owned by the State of Washington. The key land units leased to the state are Chief Timothy, Central Ferry, and Lyons Ferry state parks.

The lower Snake River reservoirs generally fill the width of the canyon, leaving relatively little flat land for cultivation. Grassland range is the predominant land cover along the approximate 140-mile-long river corridor. There are some relatively small and isolated cropland areas on the valley floor and river terraces, particularly toward the western end of the river corridor. There are also approximately 37,000 acres irrigated from, and located adjacent to, Ice Harbor Reservoir. The Lewiston-Clarkston area has a significant concentration of urban development at the eastern end of the corridor, including residential, industrial, and commercial uses. Isolated pockets of developed land are located in small communities, including Almota, Riparia, and Windust. Unlike many reaches of the Columbia-Snake River System, much of the lower Snake River is not paralleled by highways.

4.12.3 Lower Snake River Reservoirs

Ice Harbor Lock and Dam encompass 13,039.5 acres, of which 9,001.8 acres lie below the normal operating pool elevation of 437 feet above NGVD29. Lower Monumental Lock and Dam encompass 14,104 acres, of which 4,960.4 acres lie below the normal operating pool elevation of 540 feet above NGVD29. Little Goose Lock and Dam encompass 15,684.8 acres, of which 10,825.2 acres lie below the normal operating pool elevation of 638 feet above NGVD29. Lower Granite Lock and Dam encompass about 15,684.8 acres, of which approximately 8,448.2 acres lie below the normal operating pool elevation of 738 feet above NGVD29. This acreage is shown by type of acquisition and project in Table 4.12-3.

The Corps currently administers 291 outgrants, i.e., easements (including deed reservations), leases, permits, licenses, etc., on the LSRP (Table 4.12-4). Easements are granted for various purposes including roads, utilities, pipelines, and pumping plants. Terms are commensurate with the use, but normally range from 25 years to perpetuity. 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. The one commercial concession lease to a private party at Ice Harbor, is for a 10-year term with rent payable under a graduated rent system and based upon a percentage of receipts.

Table 4.12-3. Acreage by Type of Acquisition and Project

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Totals
	Current Acreage Based On Corps Acquisition or Excessing Actions				
Fee	6,717.1	10,210.9	10,227.3	11,707.5	
Public Domain	759.6	347.7	272.0	254.8	
Easement	440.8	28.4	0.5	66.0	
Riverbed	5,122.0	3,517.0	5,185.0	5,640.0	
License				0.1	
Permit				0.2	
Total	**13,039.5**	**14,104.0**	**15,684.8**	**17,668.6**	**60,496.9**
	Acreage Based on Normal Operating Pool				
Normal Operating Pool (msl)	437 ft	540 ft	638 ft	738 ft	
Acreage Above	4,037.7	9,143.6	4,859.6	9,220.4	**27,261.3**
Acreage Below					
Riverbed	5,122.0	3,517.0	5,185.0	5,640.0	**19,464.0**
Land	3,879.8	1,443.4	5,640.2	2,808.2	**13,771.6**
SubTotal	9,001.8	4,960.4	10,825.2	8,448.2	**33,235.6**
Total	**13,039.5**	**14,104.0**	**15,684.8**	**17,668.6**	**60,496.9**

Note: The state-owned riverbed consists of 19,464 acres that were not acquired by the Federal government.
Source: Walla Walla District Real Estate Database

Table 4.12-4. Real Estate Outgrants Associated with the Lower Snake River Project

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Total
Easements	50	47	20	101	**218**
Leases	3	3	8	19	**33**
Licenses	1	1	3	2	**7**
Permits	4	13	7	9	**33**
Total	**58**	**64**	**38**	**131**	**291**

Source: Appendix K, Real Estate (Table 5-1)

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4.13 Recreation and Tourism

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4.13.1 Recreation

The lower Snake River and its reservoirs, dams, and adjacent shorelines provide numerous opportunities for recreation. Water-based recreational activities include fishing, water-skiing, boating, windsurfing, and swimming. Many boat launch ramps, beaches, marinas, and other facilities have been developed to support these activities. Land-based activities such as picnicking, camping, hunting, and hiking are also popular and take place at facilities along the reservoirs. Recreational sites on the Lower Snake River Project reservoirs represent the bulk of water-oriented recreational opportunities in southeastern Washington. The following sections discuss existing recreational facilities and activities and existing visitation.

4.13.1.1 Recreation Facilities and Activities

Recreation use and development at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite are authorized under Federal legislation, including the Federal Water Project Recreation Act of 1964 and the Flood Control Act of 1944. Under these laws, the Corps cooperates with the state park departments in Idaho and Washington and a variety of other local entities, such as counties, cities, and port districts, to maintain a system of water-related recreation facilities. These include boat launch ramps, swimming beaches, marinas, campgrounds, picnic areas, and interpretive sites.

There are 33 developed recreation sites adjacent to the lower Snake River reservoirs. These include 29 boat launch ramps with 59 launch lanes, 5 moorage and marina facilities with at least 305 boat moorage spaces, 9 campgrounds with approximately 455 individual campsites, and 49 day-use facilities (Table 4.13-1) (Corps, 1998c). Nearly all of these sites provide recreation opportunities that either depend on water or are enhanced by the proximity of water.

Table 4.13-1. Lower Snake River Recreation Facilities

Recreation Site	Boat Ramps	Boat Launch Lanes	Boat Moorage Spaces	Picnic/Group Shelters	Campsites
Lower Granite Lake (Lower Granite Pool)					
Offield Landing	1	1			
Wawawai County Park				4	9
Wawawai Landing	1	1			
Blyton Landing	1	1			
Nisqually John Landing	1	1			
Chief Timothy State Park	1	4			66
Hells Canyon Resort (Redwolf Marina)	1	2	137		
Greenbelt Ramp	1	2	3		
Southway Ramp	1	2			
Swallows Park	1	4		2	
Hells Gate State Park	1	6	1/	6	93
Chief Looking Glass Park and Marina	1	2			
Clearwater Park North Lewiston Ramp	1	1			
Lake Bryan (Little Goose Pool)					
Little Goose Landing	1	1			
Central Ferry State Park	1	4			62
Garfield County Ramp	1	2			
Willow Landing	1	1			
Illia Landing	1	1			
Illia Dunes Boyer Park and Marina	1	3	100	3	28
Lake West (Lower Monumental Pool)					
Devils Bench	1	2			
Ayers Boat Basin	1	2		2	
Lyons Ferry Marina	1	1			
Lyons Ferry State Park	1	2		4	52
Texas Rapids Riparia	1	1		3	
Lake Sacajawea (Ice Harbor Pool)					
North Shore Ramp	1	2			
Charbonneau Park	1	4	45	7	54
Levey Park	1	2		8	
Fishhook Park	1	2	20	8	61
Windust Park	1	1		2	30
Matthews Recreation Area	1	1			
Total for All Lakes	**29**	**59**	**305**	**49**	**455**

Source: Corps, 1998c
1/ Data unavailable. To be updated with current information.

Recreational sites located at the dams and along the lower Snake River vary greatly in terms of size, type of facilities, level of development, features, management, use, and accessibility. The larger, more intensively developed recreation sites often have a variety of facilities to support different activities. Many provide boat launch ramps, docks, marinas, campgrounds, and day-use areas with developed swimming and picnicking facilities. These sites typically have paved boat launch lanes and parking areas, restrooms with running water, retail and service concessions, landscaping, and irrigated lawns. Several of the larger developed facilities along the river were developed by the Corps and are operated by counties or port districts under lease. The smaller recreation sites along the river are less developed and support one or two key uses, typically water access via boat launch ramps. In addition to the developed facilities, there are many informal sites that simply provide access to the water or to publicly-owned lands.

Lower Granite Lake is the most heavily developed for recreation (Table 4.13-1). Eight of the 14 recreation sites associated with Lower Granite Lake are located relatively close to the Lewiston-Clarkston area. These sites, mostly urban in character and use, contribute significantly to the quality of life in the Lewiston-Clarkston area. The parks adjacent to the reservoir are popular for water-oriented activities such as boating and swimming. However, the most heavily used recreational facilities are the Lewiston Levee Parkway and the extensive riverside trail systems located at Swallows Park and Greenbelt Park. Two marinas, the privately-operated Hells Canyon Resort and the state-operated Hells Gate State Park, are located in the Lewiston-Clarkston area and serve local and transient boats. Private, 60-foot-plus boats were reported using Clarkston shorelines for moorage in 1994 (Corps and NMFS, 1994). In addition, several companies operating out of the Lewiston-Clarkston area offer jet boat tours of Hells Canyon upriver from Lower Granite Lake.

Lake Sacajawea is the second most heavily developed of the reservoirs, with four major parks and two boat launch sites. All of the sites are relatively isolated. While all of the sites on Lake Sacajawea are fairly isolated, the three sites farthest downstream (Levey Park, Ice Harbor Dam, and Charbonneau Park) are located within 10 to 15 miles of Pasco and Kennewick. As the inclusion of Ice Harbor Dam in the list of recreation sites on Lake Sacajawea suggests, the dams themselves receive considerable visitation. This is especially the case with Ice Harbor Dam, which received an estimated 250,000 visitors in 1998 (Table 4.13-3).

Recreation development along Lake Bryan is limited by rugged terrain. Developed sites along Lake Bryan include two that are leased from the Corps by the State of Washington and one that is leased by the Port of Whitman County. Recreation development at Lake West is also limited, largely due to the high cliffs that surround the reservoir. The six developed recreational sites located along Lake West range from a simple fishing access ramp to Lyons Ferry State Park and Lyons Ferry Marina.

Water-oriented activities such as fishing, boating, and water skiing take place at all four reservoirs. Swimming occurs at all four reservoirs and is the most popular activity at Little Goose. Land-based activities such as picnicking, hiking, and camping are popular to varying degrees at different reservoirs. At Lower Granite, trail use is the most popular activity due to the high use of trails at Lewiston-Clarkston riverside parks. Table 4.13-2

displays visitor distribution activity for each dam and reservoir. 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 4.13-2 account for recreationists engaging in more than one activity during a visit. The resulting sum of activities is greater than 100 percent at each reservoir.

Table 4.13-2. Visitor Distribution by Activity at the Lower Snake River Reservoirs (%)

Activity	Lower Granite Lake	Lake Bryan	Lake West	Lake Sacajawea
Boating	26	28	22	20
Camping	3	13	9	14
Fishing	18	25	27	38
Hunting	0	1	3	1
Picnicking	13	32	25	22
Sightseeing	15	26	13	24
Swimming	13	32	12	14
Water-skiing	3	5	4	8
Other	61	46	43	38

Source: Corps, 1998d

4.13.1.2 Visitation

The number of recreational visits varies considerably by reservoir. Use data compiled by the Corps for fiscal year 1998 are presented in Table 4.13-3. Lower Granite is the most heavily used, with 1,144,800 visitors in fiscal year 1998. Lower Monumental is used least, with 157,700 visitors over the same period. 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.

Visitation also varies considerably by season, with use heavily concentrated in the summer. Weather is the most important factor determining the seasonal use and demand for water-related outdoor recreation in the basin. The primary recreational activities, including sight-seeing, fishing, boating, and water-skiing, occur year-round at most of the dams and reservoirs in the Columbia River Basin. However, the peak periods of use for all activities occur during the warm, dry summer months.

Annual visitation typically builds slowly, beginning in April and continuing in May, with visits tending to increase rapidly from the end of May through June and July, peaking in August. Lower Snake River recreation facilities typically receive over 50 percent of average annual visitation from May through August. Peak recreation season roughly corresponds to the period between Memorial Day and Labor Day weekends. Local weather conditions are most amenable for water-dependent and water-related recreation activities, most students are out of school for the summer, and families tend to take their vacations during this period. Visitation generally begins to decline in September.

Many outdoor recreationists visiting the four dams and reservoirs live in relatively close proximity. A survey of outdoor recreationists, excluding anglers, was conducted at the

Table 4.13-3. Visitation at Recreation Areas

Project/Recreation Area	Number of Visits (FY98)
Lower Granite Lake	
Chief Looking Glass	27,900
Chief Timothy State Park	104,100
Clearwater Park	24,000
Clearwater Ramp	20,900
Hells Canyon Reservation	43,700
Hells Gate State Park	90,400
Lewiston Levee	269,900
Lower Granite Dam	33,400
North Shore	37,500
Southway Ramp	108,300
Swallows Park	371,400
Wawawai County Park	24,300
Total	***1,144,800***
Lake Bryan	
Boyer Park	85,300
Central Ferry State Park	54,800
Illia Landing	4,000
Little Goose Dam	52,900
Willow Landing	3,200
Total	***222,700***
Lake West	
Ayer Boat Basin	2,800
Lower Monumental Dam	44,500
Lyons Ferry State Park	73,900
Lyons Ferry Marina	22,300
Texas Rapids	7,900
Total	***157,700***
Lake Sacajawea	
Charbonneau Park	71,800
Fishhook Park	48,800
Ice Harbor Dam	250,500
Levey Park	14,200
Windust Park	21,700
Total	***437,700***
Combined Total	**1,962,900**

Source: Corps, 1998e

four reservoirs between June 24, 1997 and November 29, 1997. This survey found that 52 percent of 367 respondents resided within 50 miles of the reservoir, with approximately 26 percent living within 20 miles (AEI, 1999a). A similar survey conducted of anglers found that over 70 percent of 576 respondents lived within 50 miles of the reservoirs, with approximately 41 percent living within 20 miles (AEI, 1999b).

4.13.2 Tourism

Increasing numbers of tourists are drawn to the lower Snake River, the recreational amenities available along the river, and the four project dams and reservoirs. Tourism contributes to the economies of the communities located along the river. Three of the four lower Snake River dams (Ice Harbor, Little Goose, and Lower Granite) have a visitors center where people can learn about power production, navigation, archaeology, local geology, the history of the river, recreation opportunities, and fish transportation and passage facilities. There are also fish viewing facilities at these three dams. The dams and associated visitors centers are themselves important recreational sites, receiving significant numbers of visitors throughout the year. This is especially the case with the Ice Harbor Dam, which received an estimated 250,000 visitors in 1998 (Table 4.13-3). Tourists also visit the fish hatchery and associated interpretive facilities at Lyons Ferry Hatchery, which is operated by the State of Washington.

Three commercial cruise lines operate four cruise ships on the lower Columbia and Snake rivers. Week-long tours regularly depart Portland, travel upriver to Clarkston, and then return to Portland. The Columbia-Snake River System cruises are generally scheduled from the beginning of April through the first week of June, and again from September through the first half of November. In between the spring and fall river cruise periods, the cruise ships operate in Alaskan waters. Passengers pay an average of about $2,000 each for 8-day, 7-night trips on the lower Columbia and Snake rivers. These trips stop at several communities and other points of interest along the way and about 95 percent of all passengers take an optional side trip from Clarkston up Hells Canyon via jet boat. Approximately 50,000 passengers are accommodated on these cruises each year, with this total distributed fairly evenly between the spring and fall cruise periods.

4.14 Social Resources

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The following discussion is divided into three main sections. Section 4.14.1 provides an overview of regional demographics and employment. Section 4.14.2 provides a general overview of the communities in the region in terms of population and economic diversity. It also outlines the focus community selection process used for this FR/EIS and introduces the typology of communities developed for this FR/EIS by the University of Idaho (UI). Section 4.14.3 addresses low income and minority populations and provides information on race and poverty.

4.14.1 Regional Demographics and Employment

The social resources of communities located in the vicinity of the lower Snake River would be affected by the proposed alternatives. For the purposes of analysis, the potentially affected lower Snake River region was divided into three subregions: upriver, reservoir, and downriver. The counties that comprise these subregions and the combined lower Snake River study area are identified in Table 4.14-1 and Figure 4.14-1. These subregions separate the lower Snake River study area into three functional geographic areas based on the type of likely impacts that would occur under a dam breaching scenario. The downriver subregion would be the terminus of barge transportation if the four lower Snake River dams were breached. The reservoir subregion would see changes in barge transportation and recreation. The upriver subregion would also experience changes in barge transportation and recreation. The three subregions are used to evaluate localized impacts in the lower Snake River study area. Other potential impacts associated with this study that would have more regional effects were analyzed at the state level.

Table 4.14-1. Regional Analysis Study Area and Subregions by State and County[1/]

Downriver Subregion	Reservoir Subregion	Upriver Subregion
Oregon	**Washington**	**Idaho**
Gilliam	Adams	Clearwater
Hood River	Asotin	Custer
Morrow	Columbia	Idaho
Sherman	Garfield	Latah
Umatilla	Walla Walla	Lemhi
Wasco	Whitman	Lewis
Washington		Nez Perce
Benton		Valley
Franklin		**Oregon**
Klickitat		Wallowa

1/ The regional analysis subregions are comprised of the counties, as shown.

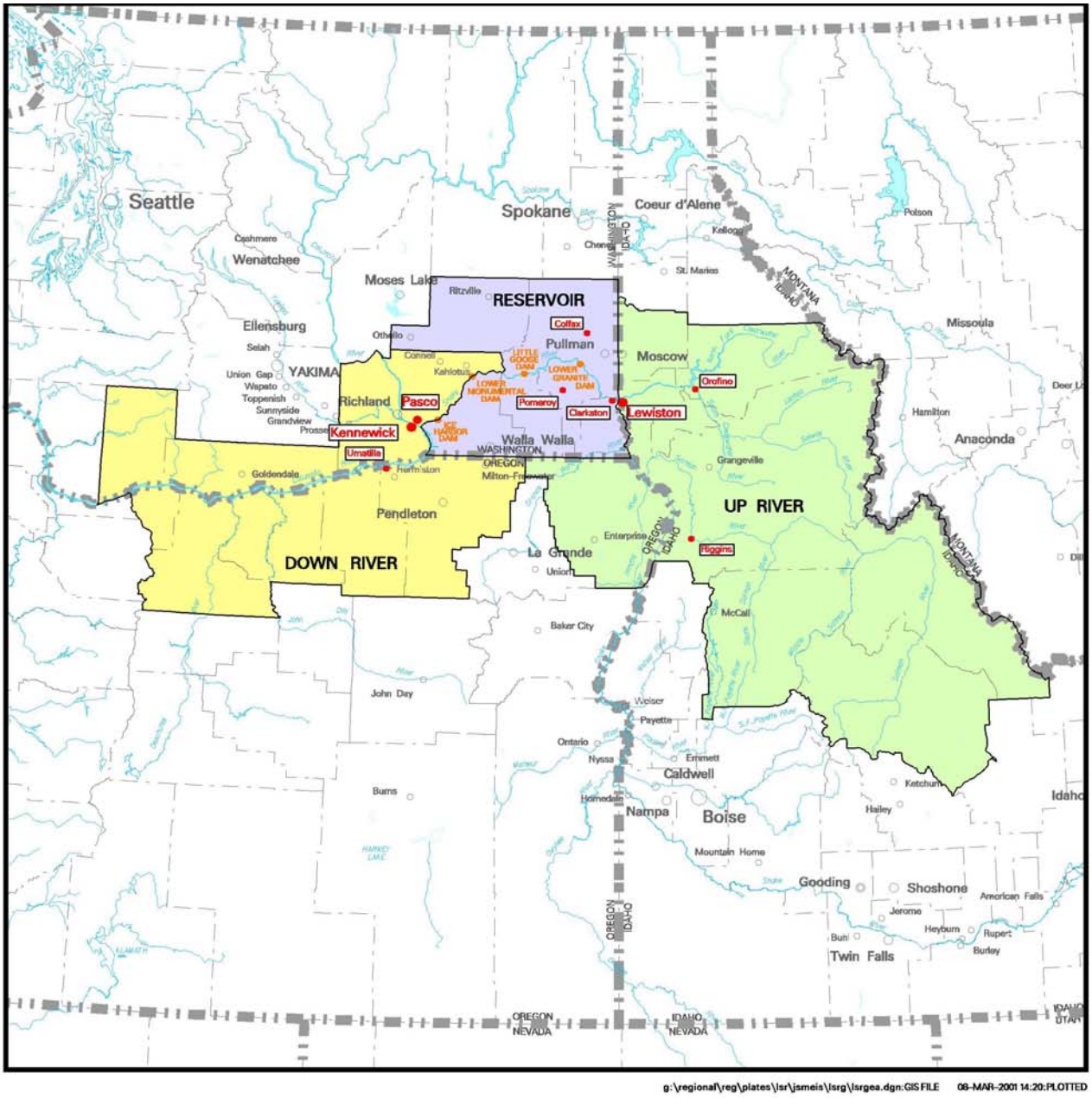
In addition to regional impacts that may occur in the vicinity of the lower Snake River, local economies that benefit from the fishing industry would also be affected by changing anadromous fish harvest levels. Anadromous fish have wide ranging ocean distributions and, as a result, changes in harvest levels could affect coastal economies in Oregon, Washington, British Columbia, and Alaska.

The DREW Anadromous Fish Workgroup estimated that Snake River stocks accounted for 7 percent of hatchery and wild origin smolts produced in the Columbia River Basin in the 1980s. The Inland Columbia River fishery received about 46 percent of the economic benefits associated with Columbia River anadromous fish production in the 1980s. Ocean fisheries in British Columbia, Washington, and Oregon received an estimated 21 percent, 18 percent, and 10 percent of regional economic benefits, respectively. The remaining 5 percent was divided between ocean fisheries in Alaska (4 percent) and California (1 percent) (see Appendix I, Economics, Section 3.5). Recreational fishing accounted for about 46 percent of total regional benefits. Treaty and non-Treaty commercial harvesting accounted for a further 39 percent, with the remaining 15 percent resulting from hatchery sales.

The following sections discuss regional trends in employment, income, population, and age. For ease of presentation, trends for the lower Snake River study area are discussed at the subregional level. Reference is made to individual counties, as appropriate.

4.14.1.1 Employment

The economy of the Pacific Northwest has undergone substantial change over the past three decades. From 1969 to 1998, the number of jobs in Washington, Oregon, and Idaho increased at a faster rate than the national average (123 percent compared to 76 percent nationally). Employment increases ranged from 122 percent for Washington to 204 percent for Oregon. In 1998, Washington, Oregon, and Idaho accounted for 55 percent, 33 percent, and 12 percent of total employment in the three state area, respectively.



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ECONOMIC SUBREGIONS

- Down River
- Reservoir
- Up River
- FOCUS COMMUNITIES
- LOWER SNAKE RIVER DAMS

BOUNDARIES

- State
- County

KM 70 35 0 MILES 35 70

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

490,000 ACRES

1 : 53,222,400

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.14–1.
REGIONAL ANALYSIS

Employment in Washington, Oregon, and Idaho increased in all sectors over this period. There were, however, changes in the relative importance of various sectors. Farm employment declined from 6 to 3 percent of total employment. Manufacturing employment declined from 19 to 12 percent, while employment in the government sector declined from 20 to 14 percent. The services and retail trade sectors saw the largest absolute and relative increases in employment over this period, gaining 1,294,358 and 650,789 jobs (270 and 158 percent), respectively. Employment in the services sector increased from 17 to 29 percent of total employment, while retail trade employment increased from 15 to 17 percent. The services, retail trade, and government sectors were the largest employers in 1998 (Table 4.14-2). These changes broadly reflected changes in the United States economy where employment in the farm and manufacturing sectors declined in both absolute and relative terms and the largest increases were in the services and retail trade sectors. The services and retail trade sectors were the largest employers in the United State in 1998, accounting for 31 percent and 17 percent of total employment, respectively.

Table 4.14-2. Employment in Washington, Oregon, and Idaho, 1969 and 1998

	1969		1998		1969 - 1998	
	Jobs	Percent of Total Jobs	Jobs	Percent of Total Jobs	Absolute Change	Percent Change
Total full- and part-time employment[1/2/]	2,774,271	100	6,187,107	100	3,412,836	123
By Type						
Wage and salary employment	2,335,879	84	5,025,695	81	2,689,816	115
Proprietors' employment	438,392	16	1,161,412	19	723,020	165
Farm proprietors' employment	92,887	3	102,457	2	9,570	10
Nonfarm proprietors' employment	345,505	12	1,058,955	17	713,450	206
By Industry						
Farm employment	164,873	6	188,410	3	23,537	14
Nonfarm employment	2,609,398	94	5,998,697	97	3,389,299	130
Agriculture, Forestry, and Fishing	26,234	1	97,769	2	71,535	273
Mining	7,881	0	8,492	0	611	8
Construction	132,349	5	367,777	6	235,428	178
Manufacturing	515,523	19	749,255	12	233,732	45
Transportation	146,572	5	277,226	4	130,654	89
Wholesale Trade	129,596	5	303,398	5	173,802	134
Retail Trade	413,046	15	1,063,835	17	650,789	158
FIRE	199,108	7	441,947	7	242,839	122
Services	478,585	17	1,772,943	29	1,294,358	270
Government	560,504	20	894,498	14	333,994	60

1/ Employment data are by place of work, not place of residence, and could, therefore, include people who work in the area but do not live there. Employment is measured as the average annual number of jobs, full-time plus part-time, with each job that a person holds counted at full weight.

2/ Washington, Oregon, and Idaho accounted for 55 percent, 33 percent, and 12 percent of total employment in 1998.

Source: U.S. Department of Commerce, 2000a

Full- and part-time employment in the lower Snake River study area increased by 84 percent between 1969 and 1998. This relative increase was smaller than the statewide increase (123 percent) but larger than the national increase (76 percent). Increases ranged from 74 percent in the upriver subregion to 194 percent in the reservoir subregion. In 1998, the upriver,

reservoir, and downriver subregions accounted for about 24 percent, 22 percent, and 55 percent of total employment in the lower Snake River study area, respectively.

Employment increased in all sectors in the lower Snake River study area between 1969 and 1998, with the exception of mining. There were, however, changes in the relative importance of various sectors. These trends broadly reflected those at the regional and national levels with relative declines in the farm (7 percent), manufacturing (5 percent), and government sectors (2 percent), and increases in the services (6 percent) and retail trade (2 percent) sectors. Historically, the lower Snake River study area had a larger concentration of employment in the farm sector then the region as a whole (16 percent compared to 6 percent in 1969), with smaller concentrations of employment in the other sectors, especially manufacturing, wholesale trade, and finance, insurance, and real estate (FIRE). The largest employers in 1969 were the government (20 percent), services (18 percent), and farm (16 percent) sectors. In 1998 the largest employers were services (24 percent), government (18 percent), and retail trade (17 percent) (Table 4.14-3). These sectors were the largest employers for all three subregions, which have generally similar concentrations of employment by sector (Table 4.14-4).

Table 4.14-3. Employment in the Lower Snake River Study Area, 1969 and 1998

	1969		1998		1969 - 1998	
	Jobs	Percent of Total Jobs	Jobs	Percent of Total Jobs	Absolute Change	Percent Change
Total full- and part-time employment[1/]	181,125	100	332,557	100	151,432	84
By Type						
Wage and salary employment	141,949	78	260,640	78	118,691	84
Proprietors' employment	39,176	22	71,917	22	32,741	84
Farm proprietors' employment	16,361	9	15,527	5	(834)	(5)
Nonfarm proprietors' employment	22,815	13	56,390	17	33,575	147
By Industry						
Farm employment	28,356	16	29,894	9	1,538	5
Nonfarm employment	152,769	84	302,663	91	149,894	98
Agriculture, Forestry, and Fishing	1,892	1	7,161	2	5,269	278
Mining	375	0	136	0	(239)	(64)
Construction	8,713	5	15,602	5	6,889	79
Manufacturing	24,958	14	30,678	9	5,720	23
Transportation	7,428	4	17,762	5	10,334	139
Wholesale Trade	4,513	2	9,701	3	5,188	115
Retail Trade	26,534	15	56,297	17	29,763	112
FIRE	8,046	4	15,427	5	7,381	92
Services	32,501	18	80,065	24	47,564	146
Government	36,893	20	60,289	18	23,396	63

1/ Employment data are by place of work, not place of residence, and could, therefore, include people who work in the area but do not live there. Employment is measured as the average annual number of jobs, full-time plus part-time, with each job that a person holds counted at full weight.
2/ The upriver, reservoir, and downriver subregions accounted for 24 percent, 22 percent, and 55 percent of total employment in 1998.
Source: U.S. Department of Commerce, 2000a

Table 4.14-4. Employment in the Lower Snake River Study Area by Subregion, 1998

	Upriver		Reservoir		Downriver	
	Jobs	Percent of Total Jobs	Jobs	Percent of Total Jobs	Jobs	Percent of Total Jobs
Total full- and part-time employment[1/]	78,290	100	71,691	100	182,576	100
By Type						
Wage and salary employment	57,559	74	56,501	79	146,580	80
Proprietors' employment	20,731	26	15,190	21	35,996	20
Farm proprietors' employment	3,733	5	4,273	6	7,521	4
Nonfarm proprietors' employment	16,998	22	10,917	15	28,475	16
By Industry						
Farm employment	4,625	6	7,585	11	17,684	10
Nonfarm employment	73,665	94	64,106	89	164,892	90
Agriculture, Forestry, and Fishing	863	1	2,055	3	4,243	2
Mining	47	0	0	0	89	0
Construction	4,330	6	2,059	3	9,213	5
Manufacturing	8,221	11	5,978	8	16,479	9
Transportation	3,078	4	1,294	2	13,390	7
Wholesale Trade	1,958	3	3,279	5	4,464	2
Retail Trade	14,235	18	10,779	15	31,283	17
FIRE	4,284	5	3,371	5	7,772	4
Services	17,051	22	15,841	22	47,173	26
Government	16,134	21	16,967	24	27,188	15

1/ Employment data are by place of work, not place of residence, and could, therefore, include people who work in the area but do not live there. Employment is measured as the average annual number of jobs, full-time plus part-time, with each job that a person holds counted at full weight.
2/ The upriver, reservoir, and downriver subregions accounted for 24 percent, 22 percent, and 55 percent of total employment in 1998.
Source: U.S. Department of Commerce, 2000a

The preceding discussion addresses direct employment by sector. Another way to view regional employment is to consider employment in sectors with large sales to final demand (sales to export outside the area, sales to create investment, and sales by government), the "basic" industries that drive an economy. The following discussion addresses basic industries by subregion and includes direct, as well as indirect and induced employment. Indirect employment includes jobs associated with industries that supply inputs to the sector in question. Induced employment includes jobs associated with spending in the economy from the salaries paid to workers in the direct and indirect sectors.

Government (local, state, and federal) was the largest single source of direct, indirect, and induced employment in the upriver subregion in 1994, employing 31.4 percent of the labor force. Timber based industries (paper mills, sawmills, logging, and wood products) were the second largest source of direct, indirect, and induced employment in the upriver subregion accounting for 21 percent of total employment in 1994.

Government was also the largest single source of direct, indirect, and induced employment in the reservoir subregion in 1994, employing 36.3 percent of the labor force. Grain producers were the second largest single source, employing 8.8 percent of the labor force. Food processing was also a relatively large source of direct, indirect, and induced employment, accounting for 7 percent of total employment in 1994.

The professional services sector was the largest single source of direct, indirect, and induced employment in the downriver subregion, accounting for 22.2 percent of the labor force in 1994. Government was the second largest single source, employing 18.5 percent of the labor force. Food processing accounted for 9 percent, while grain producers employed 4.9 percent of the labor force (DREW Regional Analysis Workgroup, 1999).

4.14.1.2 Income

Sources of Personal Income

Total personal income includes earnings (wage and salary disbursements, other labor income, and proprietors' income); dividends, interest, and rent; and transfer payments. From 1969 to 1998, non-labor income (dividends, interest, and rent and transfer payments) as a share of total income in Washington, Oregon, and Idaho increased from 22 percent to 32 percent of total personal income. The manufacturing, farm, and retail trade sectors declined as a share of total personal income over this period, while the share accounted for by the services and finance, insurance, and real estate (F.I.R.E.) sectors increased (Table 4.14-5).

Non-labor income also increased as a share of total personal income in the lower Snake River study area, increasing from 21 to 37 percent between 1969 and 1998. The farm sector declined from 14 percent to 3 percent of total personal income over this period. The manufacturing (6 percent), retail trade (3 percent), and construction (2 percent) sectors also declined as a share of personal income over this period, while the share accounted for by the services, transportation, and government sectors increased. The lumber and wood products sector also saw a relative decline over this period, decreasing from 5.4 percent to 1.5 percent of total personal income.

Table 4.14-5. Sources of Personal Income, 1969 and 1998

	Washington, Oregon, and Idaho			Lower Snake River Study Area		
	1969	1998	Change 1969 to 1998	1969	1998	Change 1969 to 1998
Farming	4	1	(3)	14	3	(11)
Agricultural Services	1	1	0	1	1	0
Mining	0	0	0	0	0	0
Construction	5	5	(1)	6	4	(2)
Manufacturing	19	12	(7)	14	8	(6)
Transportation	6	5	(1)	4	7	2
Wholesale trade	5	4	(1)	2	2	0
Retail trade	9	6	(3)	9	6	(3)
F.I.R.E	4	5	1	2	2	0
Services	11	19	8	12	15	3
Government	15	12	(3)	16	17	1
Dividends, interest and rent	14	20	6	13	21	8
Transfer Payments	8	12	4	8	16	8

Notes: F.I.R.E. = Finance, real estate, and insurance.
Totals do not sum to 100 percent because they do not adjust for the social insurance and residence adjustments used to calculate Total personal Income.
1/ Pacific Northwest in this case consists of Washington, Oregon, and Idaho.
Source: U.S. Department of Commerce, 2000b

Per Capita Income

The states of Washington, Oregon, and Idaho had respective per capita incomes of $23,974, $21,915, and $19,199 in 1995. U.S. per capita income in 1995 was $23,359. Per capita income in the 25-county study area was $17,570 in 1995, with little variation across the three subregions (Table 4.14-6). Viewed in 1995 dollars, per capita income increased in the study area and all three subregions during the 1970s and ranged in 1980 from $15,732 in the upriver subregion to $21,287 in the downriver region. Since 1980, however, this figure has declined in both the downriver and reservoir subregions, while the upriver subregion has experienced modest increases (Table 4.14-6). In 1995 per capita income in the 25 study area counties ranged from $14,576 in Morrow County, Oregon in the downriver subregion to $22,058 in Benton County, Washington also in the downriver subregion.

Table 4.14-6. Per Capita Income by Subregion, 1970 to 1995 (1995 dollars)

	1970	1980	1990	1995
Downriver	15,490	21,287	19,167	17,332
Reservoir	15,906	19,566	18,916	17,760
Upriver	13,173	15,732	17,590	17,661
Study Area	**14,772**	**18,805**	**18,529**	**17,570**

Source: DREW Social Analysis Workgroup, 1999 (Table 4)

4.14.1.3 Population

The states of Washington, Oregon, and Idaho had a combined population of 10.6 million in 2000 (Table 4.14-7). Washington state was the most densely populated with an average of 73.1 persons per square mile in 1990. Oregon and Idaho were less densely populated with state averages of 29.6 and 12.2 persons per square mile, respectively (U.S. Census Bureau, 2000a).

The total population of the lower Snake River study area was approximately 617,367 in 2000 (Table 4.14-7). The majority of this area is sparsely populated and many of the lower Snake River study area counties had 1990 population densities below 10 persons per square mile. Population densities ranged from 0.8 person per square mile in Custer County, Idaho to 66.1 persons per square mile in Benton County Washington. The second most densely populated county was Nez Perce County, Idaho with 39.8 persons per square mile (U.S. Census Bureau, 2000a).

Population is distributed unevenly among the 25 counties and three subregions that comprise the study area. The downriver subregion accounted for more than half of the lower Snake River study area's population in 2000. Benton County, Washington (142,475) and Umatilla County, Oregon (70,584) in the downriver subregion accounted for 23 percent and 11 percent of the 2000 study area population, respectively. Walla Walla County, Washington (55,180) in the reservoir subregion accounted for about 9 percent of the 2000 total.

Table 4.14-7. Population, 1970 to 2000

	Population (1,000s)				Percent Change		
	1970	1980	1990	2000	1970–80	1980-90	1990-2000
United States	203,302	226,542	248,710	281,422	11.4	9.8	11.6
Washington	3,413	4,132	4,867	5,894	21.1	17.8	17.4
Oregon	2,092	2,633	2,842	3,421	25.9	7.9	16.9
Idaho	713	944	1,007	1,294	32.4	6.6	22.2
State Total	6,218	7,710	8,716	10,609	24.0	13.1	17.8
Downriver Total	199	276	284	350	39.2	2.8	19.0
Reservoir Total	113	124	125	139	9.6	0.4	10.5
Upriver Total	101	115	114	128	13.5	-0.6	10.5
Subregion Total	413	516	523	617	24.8	1.4	15.3

Source: U.S. Census Bureau, 1970, 1980, 1990, 2000b

Population in Washington, Oregon, and Idaho increased at rates ranging from two to three times the national average during the 1970s (Table 4.14-7). The lower Snake River study area also grew rapidly over this period, increasing by 102,448 people or 24.8 percent. Most study area counties reported population increases during this decade, but for the most part these increases were smaller than their respective state averages. The downriver subregion grew most rapidly (39.2 percent) and also experienced the highest absolute population increase due in part to expanding irrigated agriculture and increased activity at the Hanford Reservation. The Hanford Reservation is located in Benton County, Washington in the downriver subregion. This county accounted for about 41 percent of the total study area population increase during this decade.

Population in the Pacific Northwest and the nation as a whole continued to grow in the 1980s but at slower rates than in the preceding decade (Table 4.14-7). The study area experienced a relatively modest growth rate of 1.4 percent, with 11 of the 25 study area counties experiencing net-outmigration. Population in the downriver and reservoir subregions grew by 2.8 and 0.4 percent, respectively, while population in the upriver subregion decreased by 0.6 percent. The population of Benton County, which increased by 62 percent over the preceding decade, increased by just 2.8 percent between 1980 and 1990.

Population in Washington, Oregon, and Idaho grew at a faster rate than the national average in the 1990s, with increases ranging from 16.9 percent in Oregon to 22.2 percent in Idaho, compared to a national average of 11.6 percent (Table 4.14-7). Much of this increase was due to migration, which accounted for about 63 percent of total population growth for the three state areas between 1990 and 1999 (U.S. Census Bureau, 1999). All but one of the study area counties reported population growth over this period, with Benton County accounting for approximately 32 percent of the net study area increase of 94,413. Population increases in the subregions ranged from 10.5 percent in the upriver and reservoir subregions to 19 percent in the downriver subregion. Morrow County, Oregon and Franklin County, Washington in the downriver subregion experienced the largest percentage increases in the lower Snake River study area, with population increases of 30.7 percent and 24.1 percent, respectively. As the aggregate subregion figures suggest, many of the study area counties saw relative population increases that were below their respective state averages. None of the counties in Idaho, for example, increased at the state average of 22.2

percent. The closest was Valley County with a relative increase of 20.2 percent (U.S. Census Bureau, 1990; 2000b).

Age

Average median age increased in all three subregions and all 25 study area counties between 1980 and 1990 (Table 4.14-8). Average median age in 1990 ranged from 33.2 years old in the reservoir subregion to 35.7 years old in the upriver subregion. Average median age was around 30.5 years old in all three subregions in 1980. The median age is the middle age in each county. Half the population in the county is younger than this age, the other half is older. The average median ages presented by subregion in Table 4.14-8 are weighted averages of the median ages of the counties that make up each subregion. The upriver subregion counties saw the greatest increase in median age between 1980 and 1990, with increases ranging from 2 to 8.2 years. Median age in four of the nine upriver subregion counties increased by more than 5 years over this period.

Another measure of age is the dependency ratio. This ratio compares the population under 18 and over 64 years old with the population of working age. The average dependency ratio for each subregion is shown in Table 4.14-8. These ratios range from 72.3 in the upriver subregion to 74.5 in the downriver subregion. A dependency ratio of 70, for example, means that for every ten people of working age there are seven people under 18 or above 65 years of age.

Table 4.14-8. Age by Subregion, 1980 to 1990

	1980	1990	Dependency Ratio, 1990
Downriver Average	30.7	34.8	74.5
Reservoir Average	30.5	33.2	74.3
Upriver Average	30.4	35.7	72.3

Source: DREW Social Analysis Workgroup, 1999 (Table 8)

4.14.2 Communities

This section provides an overview of the 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 4.14.2.1 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 social impact assessment 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 4.14.2.2 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 4.14.2.3 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 social impact assessment prepared for this FR/EIS (Harris et al., 1999b). These documents are all available on the Corps website. In

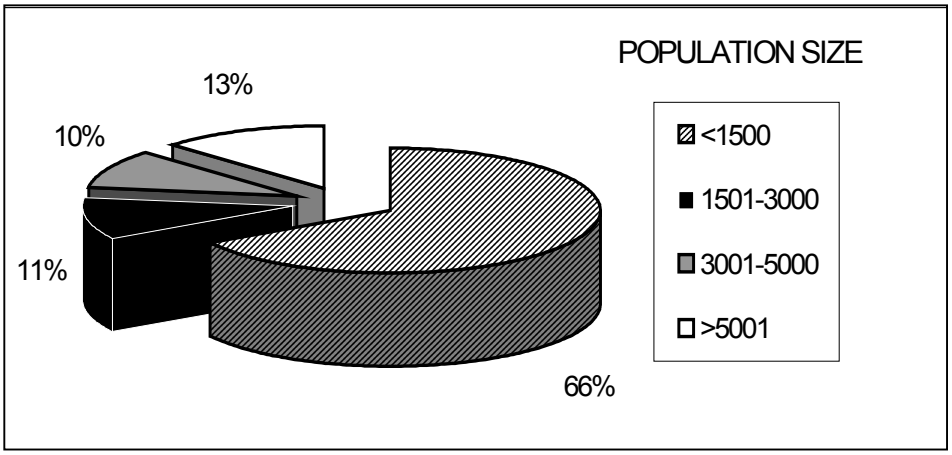
addition, the results of the DREW Social Analysis are discussed further in Section 7 of Appendix I, Economics.

4.14.2.1 Lower Snake River Study Area

The 101 communities located in the lower Snake River study area range from small rural towns with fewer than 200 residents to cities with populations that range from 8,000 to almost 50,000. The majority of the area's communities are small. Only 13 percent of the 101 communities in the lower Snake River study area have more than 5,000 residents (Figure 4.14-2) and just five communities have more than 20,000 residents. More than half (66 percent) of these communities have fewer than 1,500 residents (Figure 4.14-2).

The major population centers in the area are the Tri-Cities (Richland, Kennewick, and Pasco), Walla Walla, the Quad-Cities (Pullman, Moscow, Lewiston, and Clarkston), and Hermiston/Pendleton. These larger cities serve as regional trade centers, educational centers, and provide a diversity of employment opportunities that range from manufacturing and professional services to tourism.

Most communities in the lower Snake River study area have gained population since 1990. Communities located in rural areas that offer high quality scenery and recreational opportunities have tended to have particularly rapid growth rates.



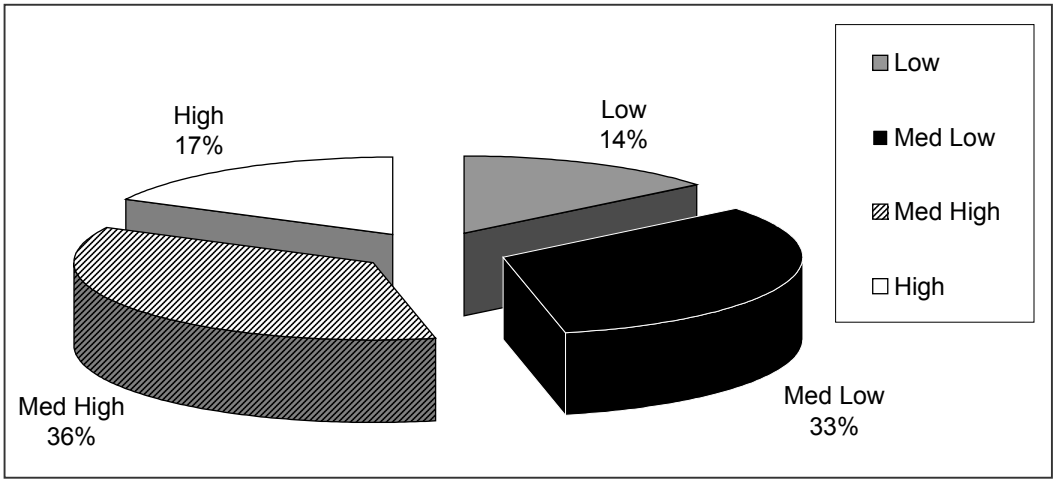
Source: DREW Social Analysis Workgroup, 1999 (Figure 10)

Figure 4.14-2. River Study Area Communities by Size

Economic Characteristics

As noted in the preceding section and illustrated in Figure 4.14-2, the majority of the communities in the lower Snake River study area are small. Small communities are usually less economically diverse than their larger counterparts, with fewer industries and fewer firms per industry. Economic diversity is generally recognized as an important component of community resiliency, which may be defined as a community's ability to successfully deal with multiple social and economic change (USDA Forest Service and BLM, 1997). Economic diversity may be measured based on the number of economic sectors present and the concentration of direct employment in any one sector. The Interior Columbia Basin Ecosystem Management Project (ICBEMP) classified all of the communities in the Interior Columbia Basin into one of four economic diversity categories: low, medium low, medium

high, or high (Harris et al., 1999a). Based on this analysis, 47 percent of the communities in the lower Snake River study area fall in the low or medium low economic diversity categories (Figure 4.13-3). The majority of the communities falling in these categories are small agricultural towns.

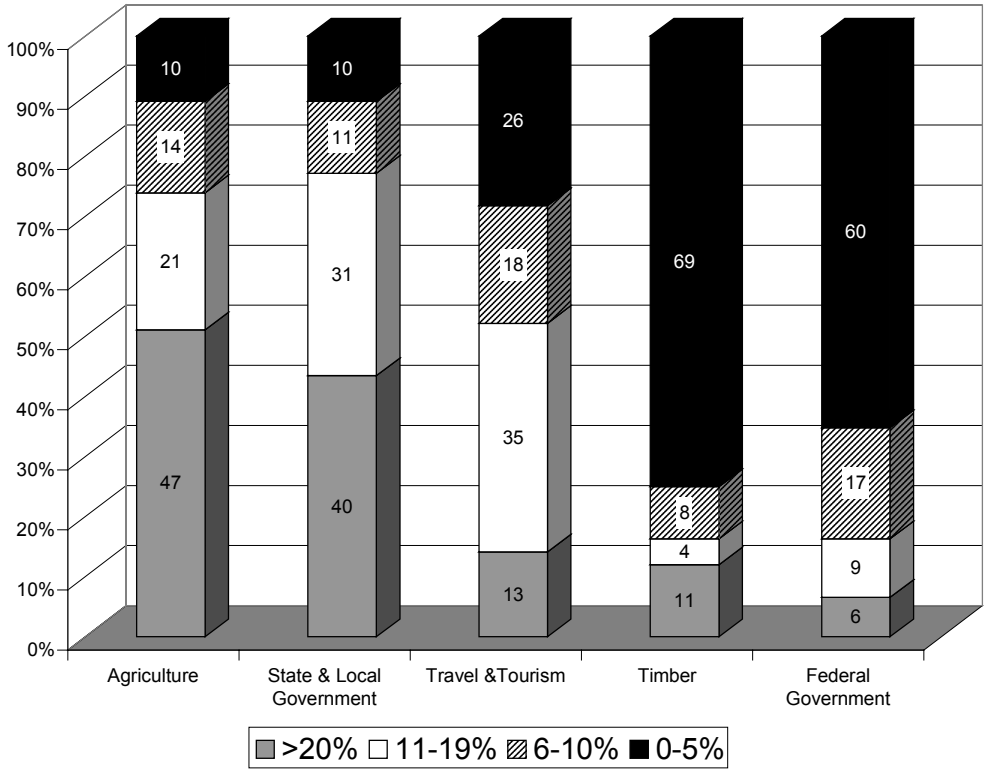


Source: DREW Social Analysis Workgroup, 1999

Figure 4.14-3. Distribution of Lower Snake River Study Area Communities by Economic Diversity

The distribution of communities by the percentage of employment in selected industrial sectors (agriculture, state and local government, travel and tourism, timber, and Federal government) is shown in Figure 4.14-4. Almost half (47 percent) of lower Snake River study area communities have 20 percent or more of their employment in the agricultural sector, which includes farm proprietors and employees, as well as farm services. An additional 21 percent of lower Snake River study area communities have between 11 and 19 percent of their labor force employed by the agricultural sector (Figure 4.14-4). The state and local government sector, which includes school employees, is also an important employer at the community level. This sector employs 20 percent or more of the labor force in 40 percent of the communities in the lower Snake River study area and between 11 and 19 percent of the labor force in another 31 percent of lower Snake River study area communities. Travel and tourism, timber, and the Federal government sector also employ 20 percent or more of the labor force in selected communities.

While employment in the agricultural sector has declined in the Pacific Northwest and the lower Snake River study area over the past three decades, the data presented in Figure 4.14-4 indicate that agriculture is still a major employer in many communities. Similarly, while employment has declined in the forest products sector, this sector is still a major employer in a number of lower Snake River study area communities.



Note: Data obtained from the ICBEMP Study (USDA Forest Service and BLM, 1997) were only available for 92 of the 101 communities located in the lower Snake River study area.
Source: DREW Social Analysis Workgroup, 1999 (Figure 12)

Figure 4.14-4. Distribution of Lower Snake River Study Area Communities by Percentage of Direct Employment in Selected Industrial Sectors

Selected Focus Communities

The DREW social analysis assessed the social impacts of the proposed alternatives at a regional scale and also through nine focus communities. These communities, which are identified on Figure 4.14-1, were selected to illustrate a broad range of potential impacts, positive or negative, under one or more of the alternatives. As a group, these communities are diverse in size, economic activity, and potential socioeconomic impacts. The DREW social analysis did not address tribal communities, which were examined in a separate study contracted via CRITFC (see Section 4.8, Native American Indians).

The community-based social impact assessment prepared for this FR/EIS examined 18 focus communities, including the 9 communities examined in the DREW social analysis. The community-based assessment process involved examining secondary data and conducting interactive forums in each of the communities. These forums, conducted by a team of social scientists from UI, were designed to assess the perceptions of community residents of the past, present, and future situations in their communities and the likely impacts of various salmon restoration options. Communities were selected for this analysis based on a series of predetermined criteria including economic diversity and state of residence. The selected communities were also distributed across a second tier of

classification variables that addressed transportation, population levels, and natural resource dependency.

Four-hour public forums, held in each of the selected communities allowed the UI team to record local perspectives on past community responses to economic and social change and assess potential social impacts that would result from the project. Each forum was open to all members of the affected community. In addition, active community members were targeted and asked to attend to ensure that a range of potential interests and perspectives were represented. The community forum process is described in more detail in Harris et al. (1999a).

Community Types

The UI team developed a community typology based on their initial theoretical sampling process and the results of the community forums. This typology identified meaningful clusters of communities based on descriptive themes relevant to the proposed salmon recovery pathways and grouped them based on land use patterns, economic composition, and connections to the lower Snake River. This typology provided a means of generalizing the results from the 18 community forums across a broader range of communities located within the study area.

Descriptions of these six community types identified by the UI team are presented in Table 4.14-9. Base case conditions are presented for the 18 focus communities in Table 4.14-10. The communities are grouped by community type.

4.14.2.2 Coastal Region

Changes in anadromous fish harvest levels could affect coastal economies in Oregon, Washington, British Columbia, and Alaska. Two local areas were selected to illustrate the potential effects of the proposed alternatives on coastal communities. These areas were the Astoria area in Clapsop County, Oregon and the Taholah and Westport area in Grays Harbor County, Washington.

Since the early 1980s, the economies of both Clapsop and Grays Harbor counties have become less dependent on manufacturing industries, such as lumber and wood products, and more dependent on service industries and non-earned income, such as transfer payments and investments. Figures 4.14-5 and 4.14-6 summarize the sources of personal income in Clapsop and Grays Harbor Counties, respectively. These summaries focus on natural resource-based industries. Income generated by the identified sectors includes direct, as well as indirect and induced income. This means that income generated in other dependent sectors, such as retail and service businesses, is included in the identified sectors. These summaries indicate that natural resource based industry continues to play an important role in the economies of Clapsop and Grays Harbor Counties accounting for 29 percent and 24 percent of total personal income, respectively. Commercial fishing contributed 8 percent ($52.9 million) of total personal income in Clapsop County in 1993 and 4 percent ($48.2 million) in Grays Harbor County in 1995 (Figures 4.14-5 and 4.14-6) (The Research Group, 2000).

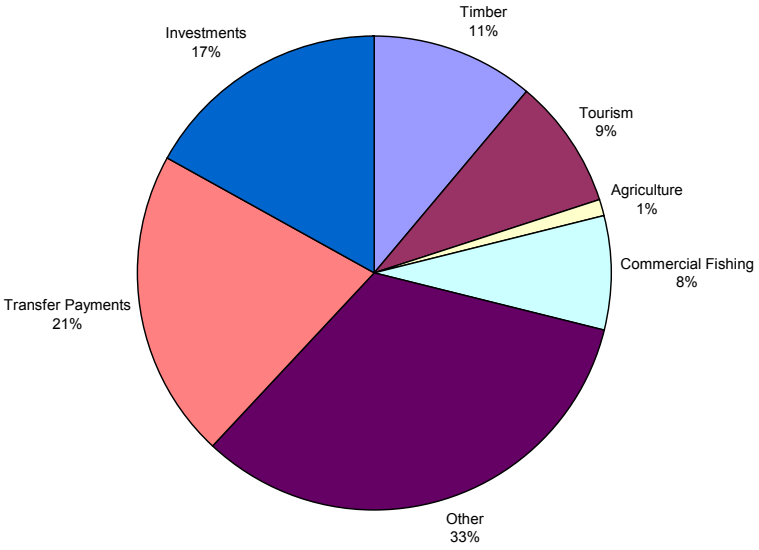
Table 4.14-9. Community Type Descriptions

Community Type	Description
Trade Center	Trade center communities are typically characterized by diverse urban land use patterns with the dominant focus on intensely developed land types such as industrial, commercial, retail, and residential uses, as well as parks and open spaces. These communities are characterized by a diverse economy that serves as a regional trade center. These communities directly use the Snake River for port facilities, transportation of commodities, fisheries, and tourism. Residents also use the river for personal recreation pursuits.
Highly Productive Dryland Agriculture	This type of community is characterized by less intensive, rural development with a predominance of agriculture-oriented industrial, commercial, and service establishments. A limited range of industrial sectors, often dominated by agriculture or state and local government, typically characterize the economy of this type of community. These communities are surrounded by highly productive, agricultural lands and directly use the Snake River for port facilities and transportation of agricultural commodities. Residents also use the river for personal recreation pursuits.
Productive Dryland Agriculture	This type of community is similar to the Highly Productive Dryland Agriculture community type, with the exception of the surrounding agricultural lands, which tend to be productive and/or marginal rather than highly productive.
Multiple Natural Resource Use	These communities, characterized by natural and rural landscapes, are dominated by a mixture of resource-based uses such as tourism, forestry, fisheries, mining, farming, ranching, and conservation. These uses are evident throughout these communities in their industrial, commercial, retail, and service developments. A diverse range of industrial sectors, often including one or more resource-based industry (i.e., forestry, natural resource based tourism, and ranching), state and local government, and/or Federal government, tends to characterize the economy of this type of community. These communities directly use the Snake River for port facilities and transportation of commodities, and indirectly use it for associated fisheries and tourism. Residents may also use the river for personal recreation pursuits.
Snake River Irrigated Agriculture	These communities are characterized by irrigated, rural landscapes. A limited range of industrial sectors, often dominated by agricultural activities or state and local government, typically characterize the economy of this type of community. These communities are influenced by highly developed, irrigated agriculture, such as orchards, vineyards, and row crops. They directly utilize the Snake River for port facilities, and transportation of agricultural commodities. Residents also use the river for personal recreation pursuits.
Columbia River Agriculture	This type of community is associated with the Columbia River and dominated by irrigated and/or dryland agriculture. Normally, these communities are characterized by less intense, rural development. A limited range of industrial sectors, often dominated by agriculture or state and local government, characterize the economy of this type of community. These communities do not directly utilize the Snake River for irrigation, transportation of commodities, or tourism. Residents may use the Snake River for personal recreation pursuits.

Table 4.14-10. Base Case Conditions for Selected Lower Snake River Study Area Focus Communities by Community Type

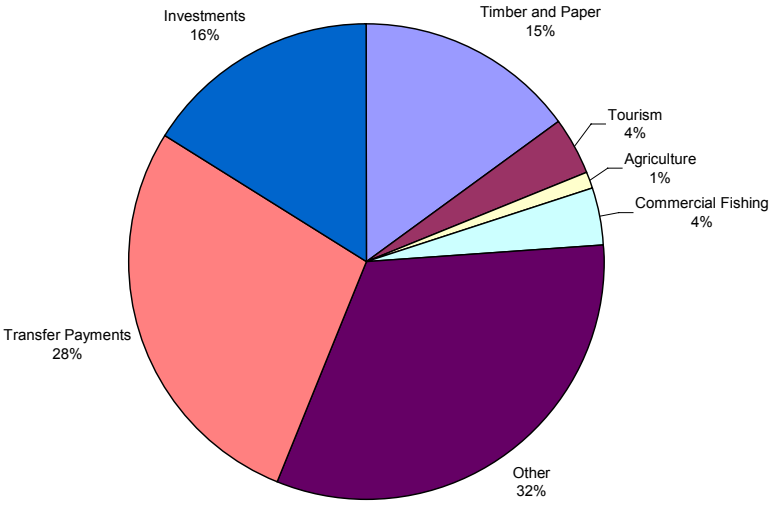
Typical Community Case	Population 1996-97	Subregion	Relation to Snake River	Economic Diversity	Dominant Industries
TRADE CENTER COMMUNITY TYPE					
Lewiston, ID	30,271	Reservoir	Port of Lewiston; Barging/Cruiselines/Transportation; Recreation	High	Travel & Tourism Forestry State/Local Government
Clarkston, WA	6,870	Reservoir	Port of Clarkston; Barging/Transportation; Recreation	High	Travel & Tourism State/Local Government
Kennewick, WA	49,090	Downriver	No direct economic relationship; Recreation	High	Travel & Tourism Diverse
Pasco, WA	25,300	Downriver	No direct economic relationship; Recreation	High	State/Local Government Travel & Tourism Agriculture
HIGHLY PRODUCTIVE DRYLAND AGRICULTURE COMMUNITY TYPE					
Colfax, WA	2,830	Reservoir	Barging of grain; Recreation	Medium	State/Local Government Agriculture
Genesee, ID	730	Upriver	Barging of grain; Recreation	Low	Agriculture State/Local Government
Pomeroy, WA	1,445	Reservoir	Barging of grain; Recreation	High	Agriculture Federal & State/Local Government
PRODUCTIVE DRYLAND AGRICULTURE COMMUNITY TYPE					
Kahlotus, WA	215	Downriver	Barging of grain; Employment; Recreation	Medium	Agriculture Federal & State/Local Government
Washtucna, WA	278	Reservoir	Barging of grain; Recreation	Low	Agriculture State/Local Government
MULTIPLE NATURAL RESOURCE USE COMMUNITY TYPE					
Enterprise, OR	2,035	Upriver	No direct economic relationship; Impacts on upriver fisheries	High	State/Local Government Agriculture Travel & Tourism
Orofino, ID	3,112	Upriver	No direct economic relationship; Impacts on upriver fisheries	High	State/Local Government Forestry Travel & Tourism
Riggins, ID	495	Upriver	No direct economic relationship; Impacts on upriver fisheries	Medium	Travel & Tourism Federal & State/Local Government Agriculture
Weippe, ID	566	Upriver	No direct economic relationship; Impacts on upriver fisheries	Low	Forestry State/Local Government Agriculture
SNAKE RIVER IRRIGATED AGRICULTURE COMMUNITY TYPE					
Prescott, WA	335	Reservoir	School district dependent for tax base on orchards irrigated from Snake River; Recreation	Medium	State/Local Government Agriculture
COLUMBIA RIVER AGRICULTURE COMMUNITY TYPE					
Adams, OR	265	Downriver	No direct economic relationship	Low	Agriculture
Burbank, WA	1,695	Reservoir	No direct economic relationship	Low	Federal & State/Local Government Agriculture
Stanfield, OR	1,770	Downriver	No direct economic relationship	Low	State/Local Government Agriculture Travel & Tourism
Umatilla, OR	3,375	Downriver	No direct economic relationship	Medium	Agriculture State/Local Government Travel & Tourism

Source: Harris et al., 1999a



Source: The Research Group, 2000

Figure 4.14-5. Sources of Total Personal Income in Clapsop County, Oregon, 1993



Source: The Research Group, 2000

Figure 4.14-6. Sources of Total Personal Income in Grays Harbor County, Washington, 1995

4.14.2.3 Southern Idaho

In response to concerns raised about potential impacts to communities located upriver of the lower Snake River study area, the UI team conducted nine community forums in communities located in southern Idaho. The focus community selection process and the forums were largely the same as those employed in the lower Snake River study area. The nine communities were grouped based on the initial theoretical sampling process and the results of the community forums. Three community types were identified: the trade center community type (Boise and Twin Falls), the multiple natural resource use community type (Ashton, Cascade, and Salmon), and the middle Snake River irrigated agricultural community type (Firth, Hagerman, Homedale, and Rupert). Base case conditions are presented for the nine focus communities in Table 4.14-11. The communities are grouped by community type.

Table 4.14-11. Base Case Conditions for Selected Southern Idaho Focus Communities by Community Type

Typical Community Case	Population 1996-97	Subregion	Relation to Snake River[1/]	Economic Diversity	Dominant Industries
TRADE CENTER COMMUNITY TYPE					
Boise, ID	166,647	Upper Basin	Transportation, Flow Augmentation	High	Government; Retail; Tourism
Twin Falls, ID	31,989	Upper Basin	Transportation, Flow Augmentation	High	Government; Retail; Tourism
MULTIPLE NATURAL RESOURCE USE COMMUNITY TYPE					
Ashton, ID	1,085	Upper Basin	Transportation, Flow Augmentation	High	Agriculture; Timber; Services
Cascade, ID	1,059	Upper Basin	Flow Augmentation	Medium	Government; Tourism, Timber
Salmon, ID	3,270	Upper Basin	Transportation, Flow Augmentation, Upriver Fisheries	High	Agriculture; Government; Tourism
MIDDLE SNAKE RIVER IRRIGATED AGRICULTURE COMMUNITY TYPE					
Firth, ID	453	Upper Basin	Transportation, Flow Augmentation	Low	Food processing; Agriculture
Hagerman, ID	812	Upper Basin	Transportation, Flow Augmentation	Medium	Agriculture; Government
Homedale, ID	2,285	Upper Basin	Transportation, Flow Augmentation	High	Agriculture/ranching; Mining; Government
Rupert, ID	5,936	Upper Basin	Transportation, Flow Augmentation	Medium	Food processing; Agriculture; Fed/state government

1/ References to flow augmentation pertain to existing flow augmentation and should not be interpreted as an indication that addition flow augmentation would be required under Alternatives 1 through 3.
Source: Harris et al., 1999b

4.14.3 Low Income and Minority Populations

4.14.3.1 Poverty

The percentage of the population below the poverty rate increased in all three subregions between 1989 and 1997 (Table 4.14-12).

The estimated percent of the population below the poverty rate in the reservoir and upriver subregions in 1997 was above the average for Washington and Idaho, as well as the nation

as a whole (Table 4.14-12). Estimates ranged from 10.9 percent in Garfield County to 15.6 percent in Asotin County in the reservoir subregion. In the upriver subregion, estimates ranged from 12.1 percent in Custer County to 17.6 percent in Idaho County.

The average for the downriver subregion was above the averages in Washington and Oregon, but below the national average (Table 4.14-12). Estimates for 1997 ranged from 7 percent in Morrow County, Oregon to 17.7 percent in Franklin County, Washington.

Table 4.14-12. Poverty Rates, 1979, 1989, and 1997

	1979 (%)	1989 (%)	1997 (%)
Downriver Average	9.6	14.6	12.5
Reservoir Average	14.3	19.2	14.7
Upriver Average	13.0	14.9	14.0
Washington	9.8	10.9	10.2
Oregon	10.7	12.4	11.6
Idaho	12.6	13.3	13.0
United States	12.4	13.1	13.3

Source: DREW Social Analysis Workgroup, 1999 (Table 7); U.S. Census Bureau, 2000a

4.14.3.2 Race and Ethnicity

The results of the 2000 census indicate that lower Snake River study area contained a larger proportion of Caucasians (85 percent) and American Indians (1.7 percent) than the United States (75.1 percent and 0.9 percent, respectively), a higher proportion of "some other race" and two or more races (10.7 percent compared to 7.9 percent nationally), and a smaller proportion of Blacks or African Americans (0.9 percent compared to 12.3 percent nationally) (Tables 4.14-13 and 4.14-14). The lower Snake River study area also had a smaller proportion of people of Hispanic or Latino origin (13.8 percent compared to 16.7 percent nationally).

Table 4.14-13. Race and Ethnicity in the United States and Pacific Northwest States, 2000

	United States	Pacific Northwest States			
		Idaho	Oregon	Washington	Total
Total Population (1,000s)	**281,421.9**	**1,294.0**	**3,421.4**	**5,894.1**	**10,609.5**
One Race	97.6	98.0	96.9	96.4	**96.8**
White	75.1	91.0	86.6	81.8	**84.5**
Black or African American	12.3	0.4	1.6	3.2	**2.4**
American Indian and Alaska Native	0.9	1.4	1.3	1.6	**1.5**
Asian	3.6	0.9	3.0	5.5	**4.1**
Native Hawaiian and Other Pacific Islander	0.1	0.1	0.2	0.4	**0.3**
Some other race	5.5	4.2	4.2	3.9	**4.0**
Two or more races	2.4	2.0	3.1	3.6	**3.2**
Hispanic or Latino (of any race)	16.7	7.9	8	7.5	**7.7**

Note: Race and ethnicity categories were expanded in the 2000 census and for the first time allowed respondents to indicate if their racial background included more then one race. People identifying as Hispanic or Latino are also included in one of the race categories.
Source: U.S. Census Bureau, 2000b

Table 4.14-14. Race and Ethnicity by Subregion, 2000

	Lower Snake River Subregions			
	Upriver	Reservoir	Downriver	Total
Total Population	**127,558**	**139,360**	**350,449**	**617,367**
One Race	98.3	97.6	97.3	**97.6**
White	93.9	85.7	81.6	**85.0**
Black or African American	0.3	1.2	1.0	**0.9**
American Indian and Alaska Native	2.5	0.8	1.7	**1.7**
Asian	0.9	2.2	1.5	**1.5**
Native Hawaiian and Other Pacific Islander	0.1	0.2	0.2	**0.1**
Some other race	0.7	7.4	11.3	**8.3**
Two or more races	1.7	2.4	2.7	**2.4**
Hispanic or Latino (of any race)	2.0	13.1	18.3	**13.8**

Note: Race and ethnicity categories were expanded in the 2000 census and for the first time allowed respondents to indicate if their racial background included more then one race. People identifying as Hispanic or Latino are also included in one of the race categories.
Source: U.S. Census Bureau, 2000b

The population of the lower Snake River study area has become more diverse over time, with the proportion of the population identifying as Caucasian decreasing from 94 percent in 1980 to 90.3 percent in 1990, and 85 percent in 2000 (Table 4.14-14 and 4.14-15). This decrease largely coincides with an increase in the number of people identifying as "Other Race". The proportion of people identifying Hispanic (now Hispanic or Latino) origins has also increased over the past two decades from 4.4 percent in 1980 to 13.8 percent in 2000. The number of people identifying Hispanic or Hispanic or Latino origins increased by 274 percent between 1980 and 2000 in absolute terms.

Table 4.14-15. Race and Ethnicity in the 25 Study Counties 1980 to 1990

	1980		1990		1980-1990	
	Total	% of Total	Total	% of Total	Total	% Change by Group
Total Population	**515,507**	**100.0**	**522,999**	**100.0**	**7,492**	**1.5**
Caucasian	484,779	94.0	472,528	90.3	(12,251)	(2.5)
African American	4,074	0.8	4,493	0.9	419	10.3
Indian	6,932	1.3	8,698	1.7	1,766	25.5
Asian	4,767	0.9	8,434	1.6	3,667	76.9
Other Race	14,953	2.9	28,889	5.5	13,936	93.2
Hispanic Origin	22,783	4.4	43,337	8.3	20,554	90.2

Note: Census data are subject to self-reporting and processing errors. This is particularly the case with Native Americans and Hispanic seasonal workers. The Census Bureau considers "Hispanic Origin" to be an ethnic category rather than a racial category. People of Hispanic origin may be of any race and are counted in the race figures as well. People categorized in the "Other Race" category include those who write in other racial categories, such as multiracial or multiethnic, on the census form.
Source: DREW Social Analysis Workgroup, 1999 (Table 9)

The population of the upriver subregion was the least diverse of the three subregions in 2000, with about 94 percent of the population identifying themselves as white and only 2 percent of the population identifying as Hispanic or Latino (Table 4.14-14). American

Indians did, however, comprise a slightly higher proportion of the population in Nez Perce (5.3 percent), Lewis (3.8 percent), and Idaho (2.9 percent) Counties than they did in the lower Snake River study as a whole (1.7 percent). These counties coincide with the location of the Nez Perce Indian Reservation.

About 86 percent of the reservoir subregion identified as white in the 2000 census, with 13.1 percent of the population identifying as Hispanic or Latino. The population identifying as Hispanic or Latino is largely concentrated in Adams and Walla Walla Counties where 47.1 percent and 15.7 percent of the populations identify as Hispanic or Latino, respectively. In Adams County nearly one-third of the population identified themselves as "some other race" (see the categories in Table 4.14-15). The Hispanic or Latino population comprises a much smaller share of total population in the other reservoir counties.

The more heavily populated downriver subregion was the most diverse of the three subregions in 2000, with about 82 percent of the population identifying themselves as white and about 18 percent identifying as Hispanic or Latino. About 47 percent of the population in Franklin County, Washington identified as Hispanic or Latino in the 2000 census. People identifying as Hispanic or Latino also comprised a larger than average share of the populations of Hood River (25 percent) and Morrow (24.4 percent) counties in Oregon. American Indians comprised slightly higher proportions of the population in Umatilla (3.4 percent), and Wasco (3.8 percent) counties, Oregon and Klickitat County, Washington (3.5 percent). The counties coincide with the locations of the Umatilla Indian Reservation, the Warm Springs Indian Reservation, and the Yakama Indian Reservation, respectively. American Indian tribes are described in Section 4.8 of this document.

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4.15 Aesthetics

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4.15.1 Landscape Character	4.15-1
4.15.2 Project Aesthetic Conditions	4.15-1
4.15.3 Views and Viewers	4.15-2

The aesthetics study area encompasses the 140-mile river canyon along the lower Snake River. This section presents a description of the study area, aesthetic conditions, views, and viewers.

4.15.1 Landscape Character

The lower Snake River passes through the Blue Mountains and Columbia basalt plain of Oregon and Washington. The landscape in the western, downstream end of the subregion is characterized by low hills covered with steppe vegetation. Because of the slight twisting nature of the river valley, views within the valley rarely extend beyond 2 to 3 miles. Reservoir pool width along the 140-mile corridor varies between one eighth and one mile.

Land uses near and adjacent to reservoirs include agriculture, port facilities, recreation, and residential. Development near the reservoirs is fairly intensive at the eastern and western ends (Lewiston-Clarkston and the Tri-Cities, respectively). Parks, marinas, and housing developments adjacent to the river create a suburban/urban character in places. By contrast, the remote interior portions of the river corridor are less developed and relatively difficult to access (BPA et al., 1995).

4.15.2 Project Aesthetic Conditions

Aesthetically pleasing views are a critical component of most outdoor recreation activities. Visual quality within the study area is directly affected by varying the river and reservoir levels. Currently, the aesthetic appearance of the reservoirs in the system is directly related to pool elevation. In general, a lake will appear more aesthetically appealing when it is at or near full pool than when it is drawn down. The run-of-river reservoirs on the lower Snake River only experience 3 to 5 feet daily fluctuations and visual quality does not change much throughout the year.

Water quality parameters that have an aesthetic impact include water temperature, odor, color, turbidity, oil and grease slicks, foam, litter and other debris, algae, aquatic weeds, and dead fish. The general appearance of a water body is an important factor in its

acceptance for recreation use and these parameters are closely related to recreation demand. One of the most important water quality variables is temperature. Excessively warm or cold water temperature has an adverse effect on the enjoyment of swimming and may be unhealthy. Perhaps more importantly, high or low water temperatures often create biological conditions unsuitable for recreation or game fish habitat. Warm water temperatures in combination with nutrients can stimulate growths of aquatic weeds and algae but these effects are not known to limit recreation along the lower Snake River.

The color and clarity of water along the lower Snake River is not ideal, but it is not a known problem or limiting factor for recreation.

4.15.3 Views and Viewers

Typical scenery along the lower Snake River includes rocky shorelines with intermittent sand beaches and irrigated parks. Above rough high rock cliffs, agricultural land predominates on often rolling hills. With two exceptions, the lower Snake River facilities are not visible for any great length of time from major roads or highways. Wawawai River Road (a country road) and State Route 193 follow the north side of Lower Granite Reservoir. U.S. 12 follows the south side of Lower Granite Reservoir for approximately 7 miles from Clarkston to Silcott. Near Pasco, U.S. 12 crosses the river and offers views of the lower Snake River near its confluence with the Columbia River. The river is crossed at six locations, including at all four dams, by state or county highways.

People viewing the study area generally fall into two categories: 1) local residents and those who work along the river in agriculture, transportation, and fisheries; and 2) recreationists using the reservoirs or the river. Most local residents live in the Lewiston-Clarkston area. Tri-Cities residents and travelers often view the dams and reservoirs from U.S. 12 and other nearby roads. Details on recreation and tourism, including annual visitation rates for lower Snake River recreation sites and the projects themselves, are provided in Section 4.12, Recreation and Tourism.

Most viewers of the study area are recreationists using the reservoirs or rivers: local residents, primarily of Lewiston-Clarkston and the Tri-Cities, and travelers on U.S. 12 at either end of the lower Snake reach (BPA et al., 1995).

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

5.1 Introduction
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5.3 Air Quality
5.4 Water Resources
5.5 Aquatic Resources
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5. Environmental Effects of Alternatives

5.1 Introduction

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	5.1.2	Cumulative Effects	5.1-2
	5.1.3	Short- and Long-term Effects	5.1-2

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

5.2 Geology and Soils 5.2-1
5.2.1 Alternative 1—Existing Conditions 5.2-1
5.2.2 Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 3—Major System Improvements 5.2-2
5.2.3 Alternative 4—Dam Breaching 5.2-2
5.2.4 Cumulative Effects 5.2-2
5.2.5 Uncertainties in Potential Geology and Soils Effects 5.2-3

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

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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

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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.

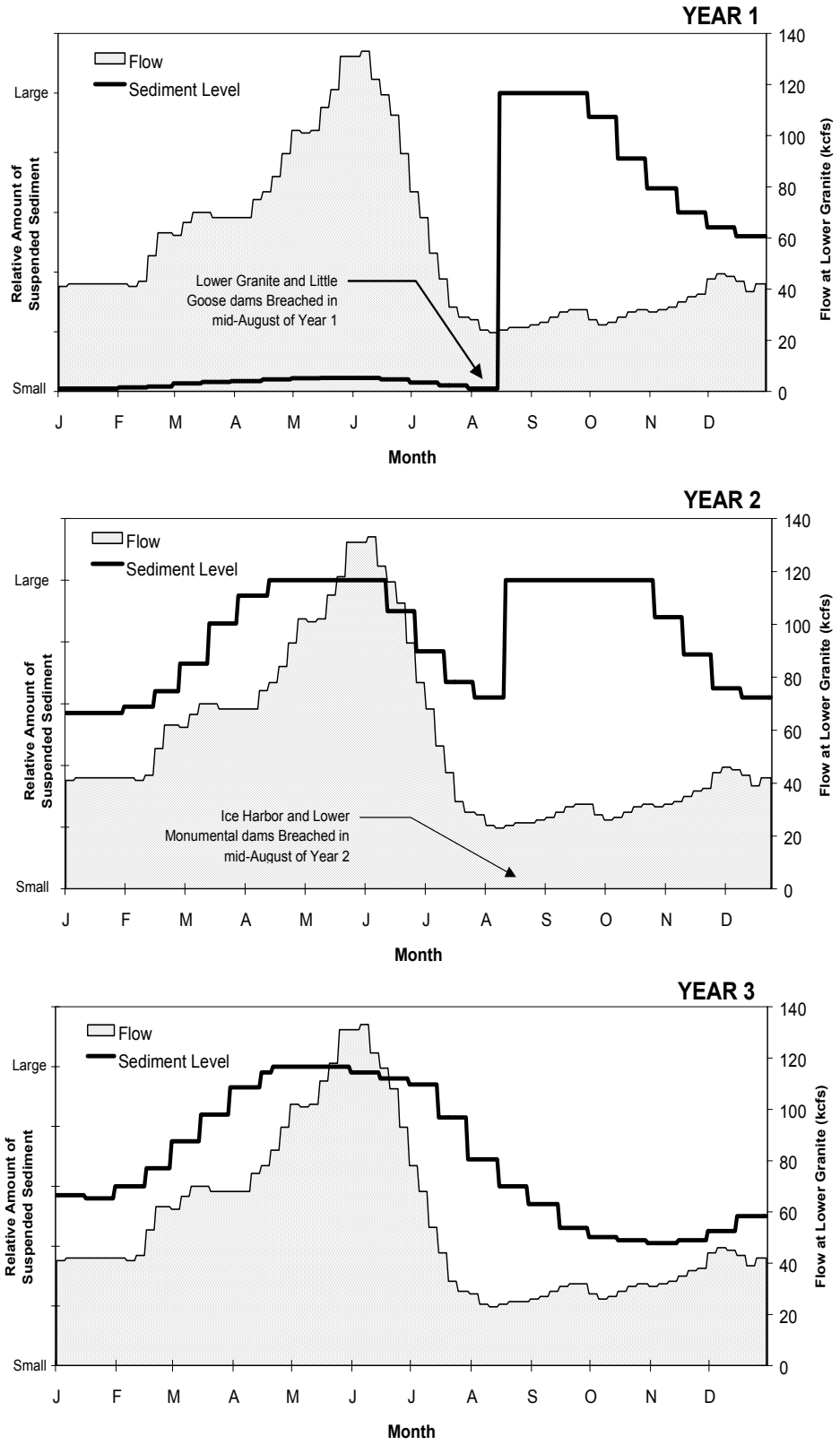
Effects of elevated sediment on anadromous fish are discussed in Section 5.5.1.4. Figure 5.4-1 shows approximately when extreme levels of suspended sediment would be present in the downstream reaches of the lower Snake River if the dams were breached.

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.

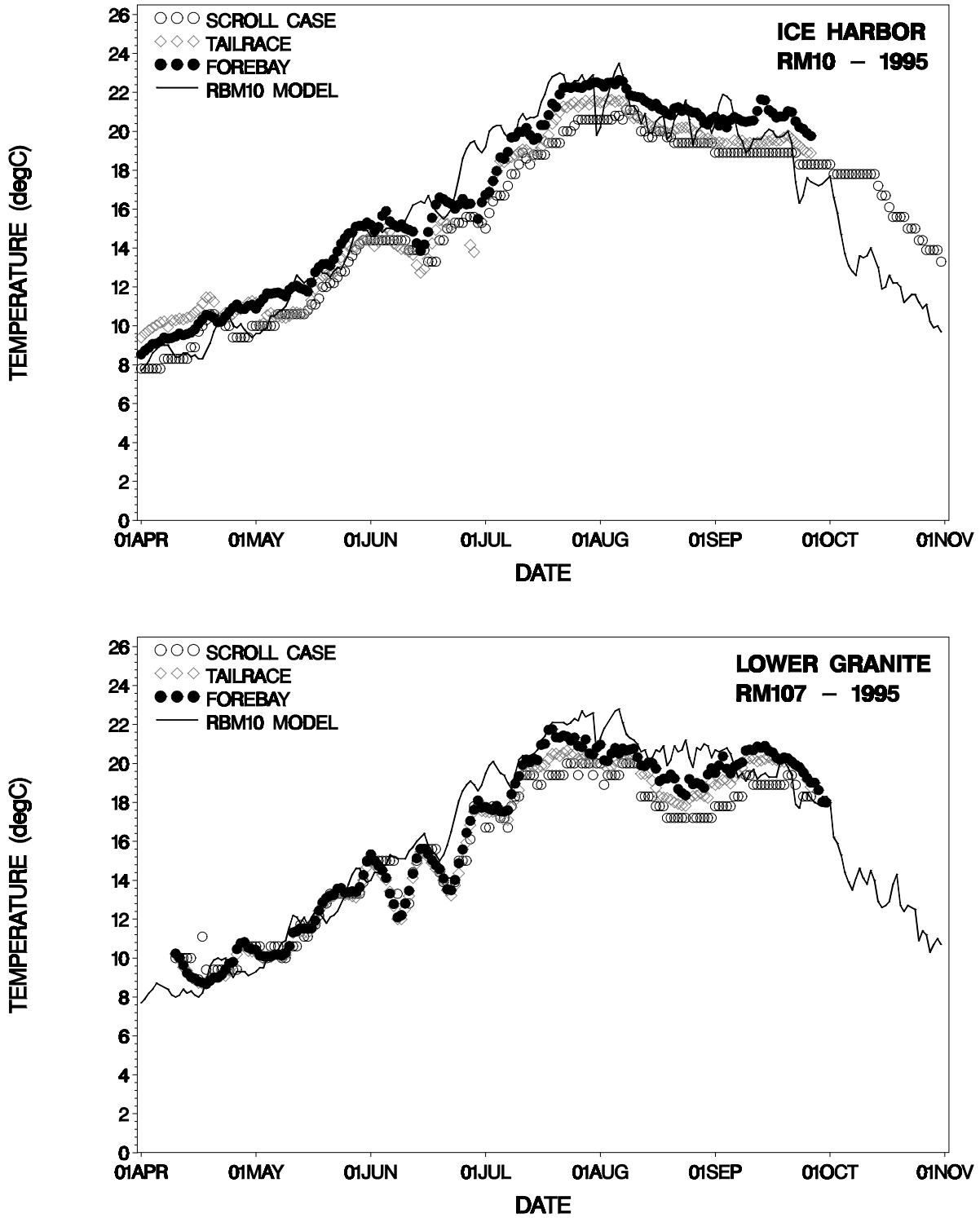
The EPA developed a water temperature model of the Columbia System to support a total maximum daily load (TMDL) for temperature as required under Section 303(d) of the Clean Water Act (Yearsley, 1999). The EPA cooperated with the Corps and provided their temperature modeling expertise and resources to 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



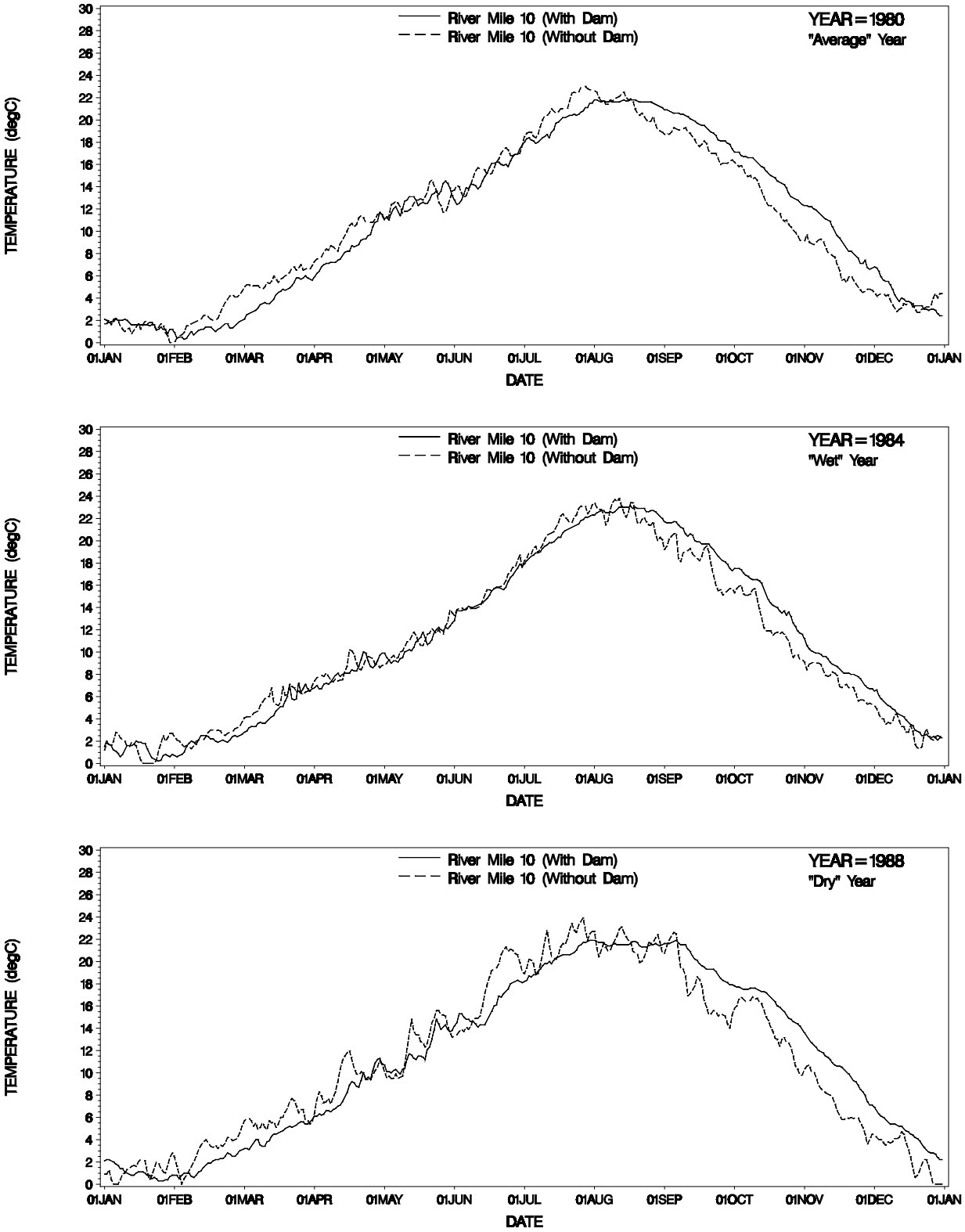
Source: Appendix C, Water Quality

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



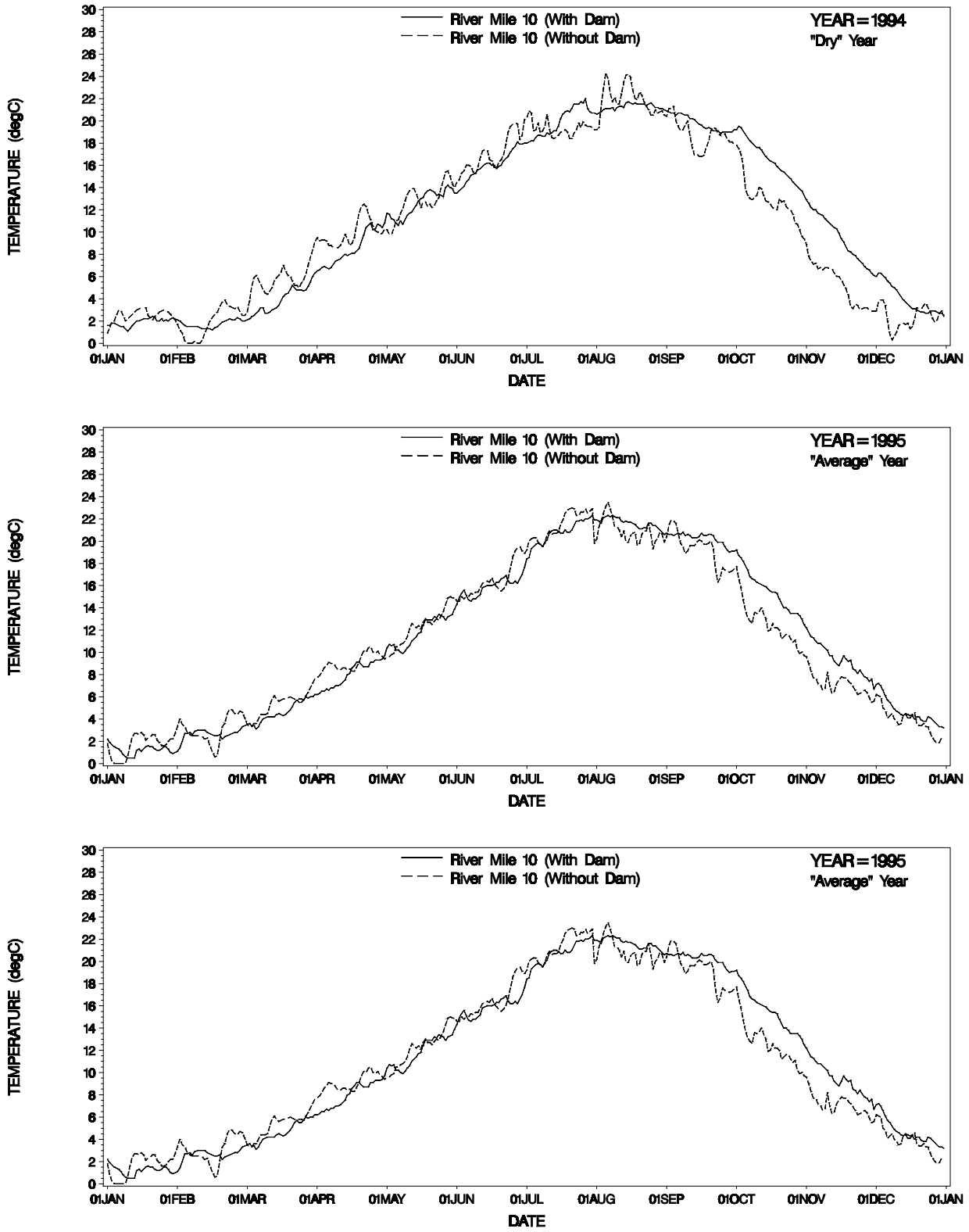
Source: Appendix C, Water Quality

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.

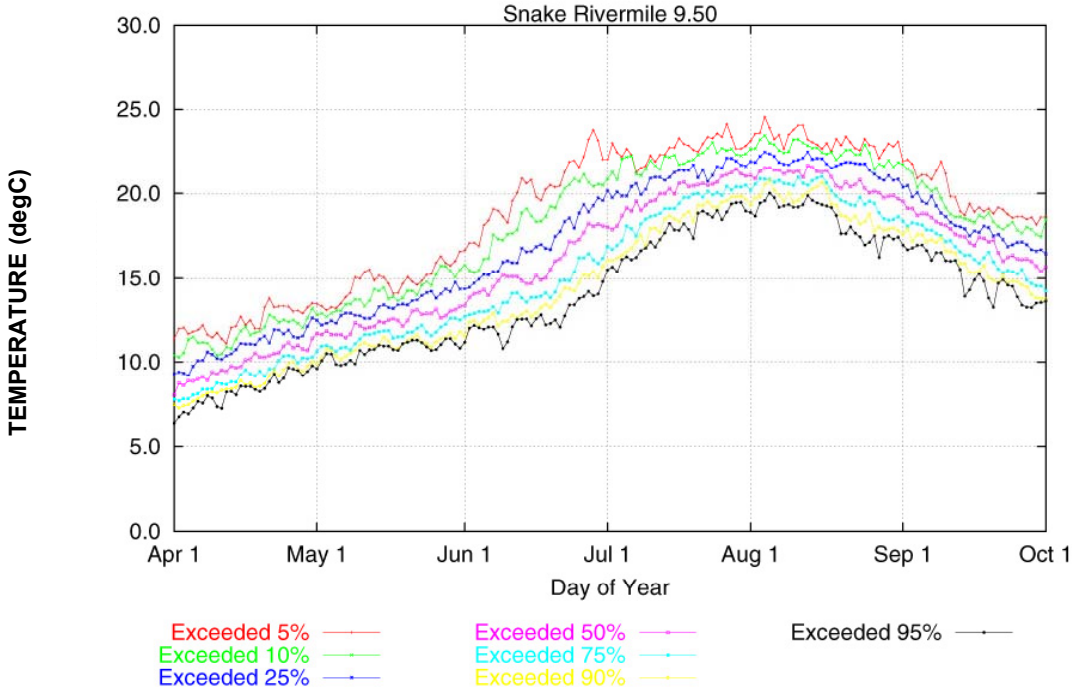
A third modeling study completed by the Pacific Northwest Laboratory (Perkins and Richmond, 1999) used MASS1, a one-dimensional hydrodynamic and water quality model to predict water temperatures on the lower Snake River for the period 1960 through 1995 under near-natural conditions. This long period 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.

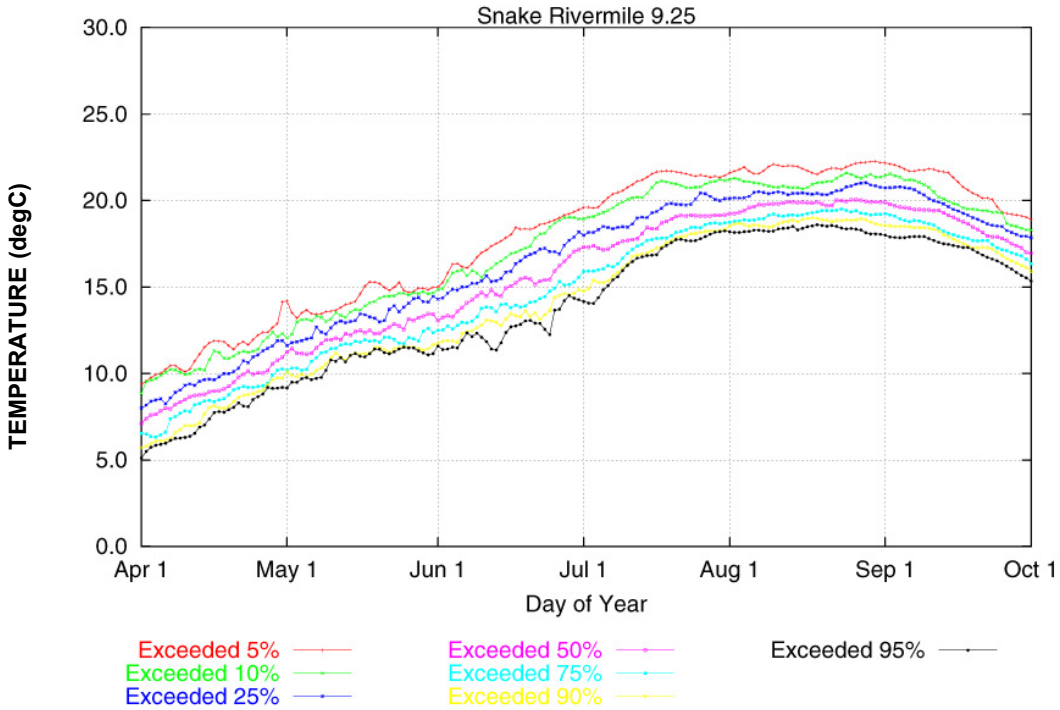
Table 5.4-2. Temperature Modeling Simulations That Were Available for This Analysis

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 Aquatic Resources 5.5-1
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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.

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.

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.

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.

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.

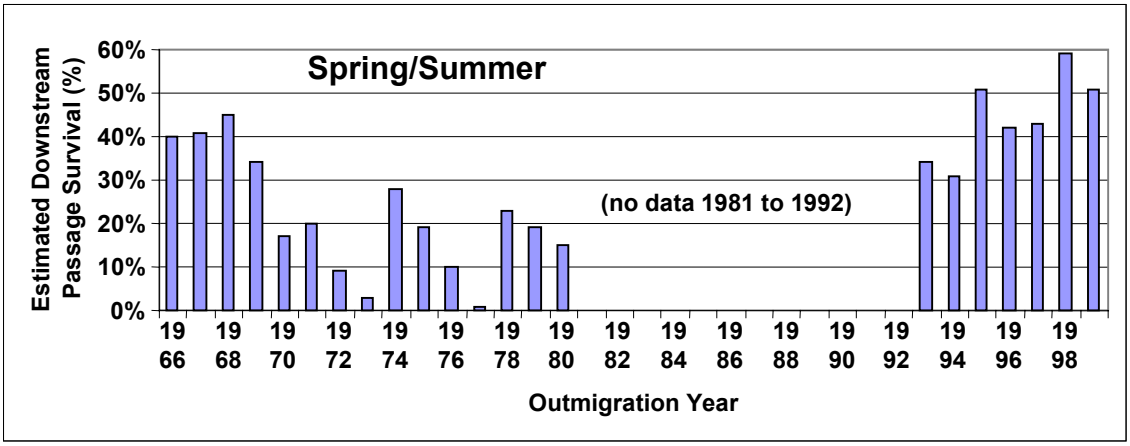
Flow and Water Velocity

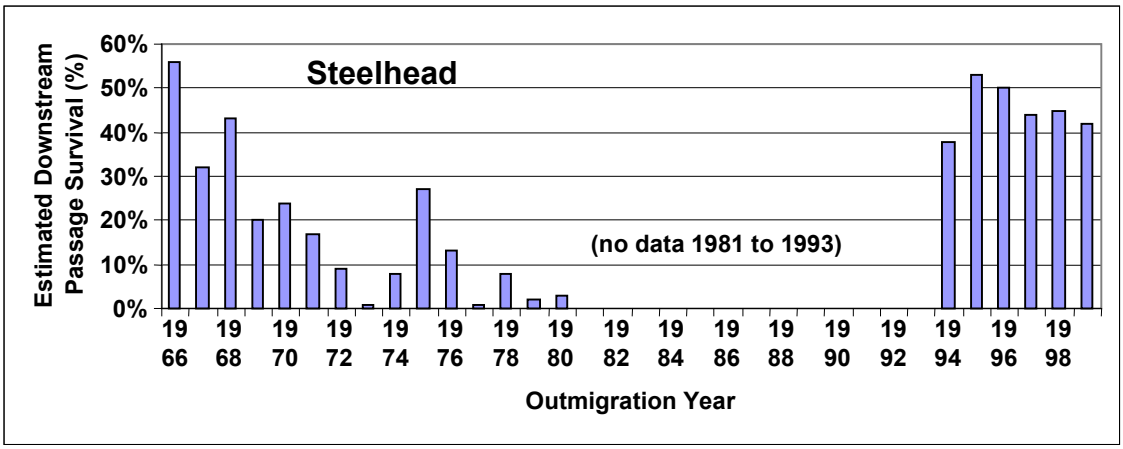
The development of dams and reservoirs has changed the lower Snake River from a free-flowing stretch to a 140-mile river reach of slack water with run-of-river reservoirs that are wider and deeper than the original river. Upstream storage reservoirs have reduced flow peaks during the spring season. The 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).





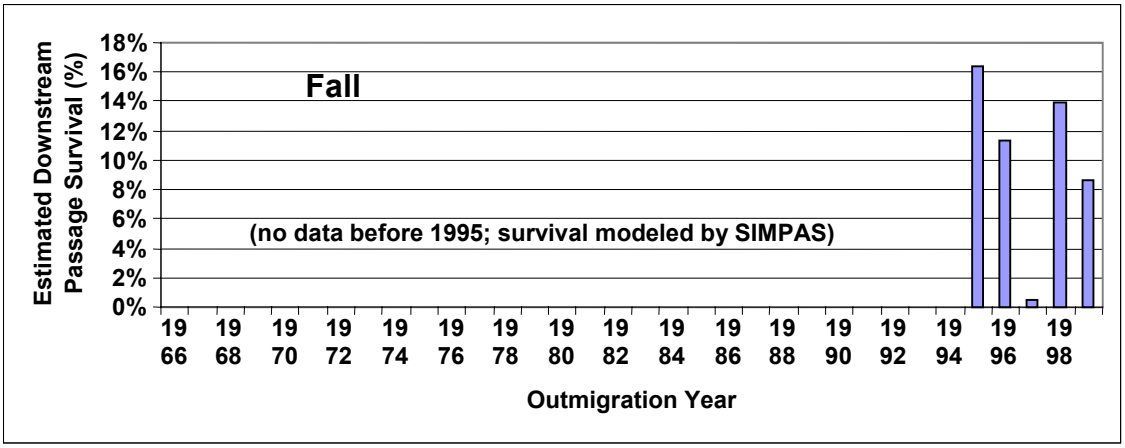


Figure 5.5-1. Estimated Survival (Includes Extrapolation Outside Area Measured) of Juvenile Spring/Summer and Fall Chinook, and Steelhead from the Upper Dam on the Snake River to the Tailrace of Bonneville Dam (no transport fish) (NMFS, 2000, 2000a,b)[1/]

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 Wildife 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.

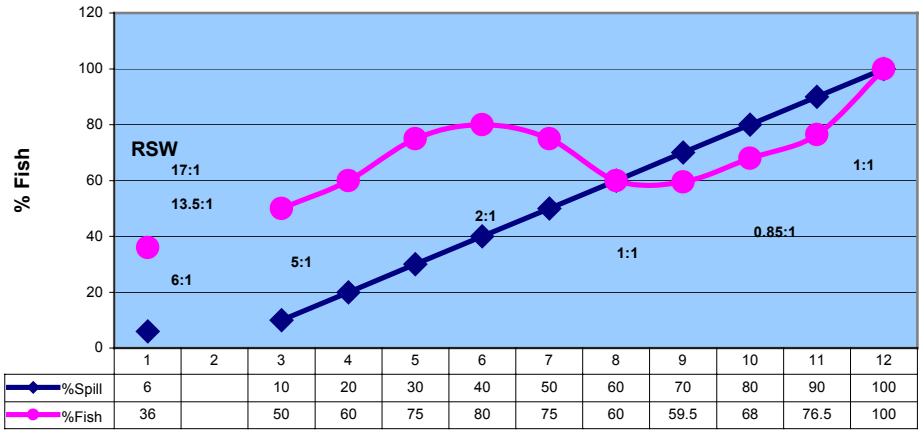
A potential benefit of SBCs could be reduced time spent in the forebay by migrating juveniles, which often appear to mill around in this area or move back upstream before passing downstream. However, among alternative passage routes (e.g., turbine, spillway, SBC), the residence time of fish in the forebay 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.



	1	2	3	4	5	6	7	8	9	10	11	12
%Spill	6		10	20	30	40	50	60	70	80	90	100
%Fish	36		50	60	75	80	75	60	59.5	68	76.5	100

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.

Hydrosystem

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).

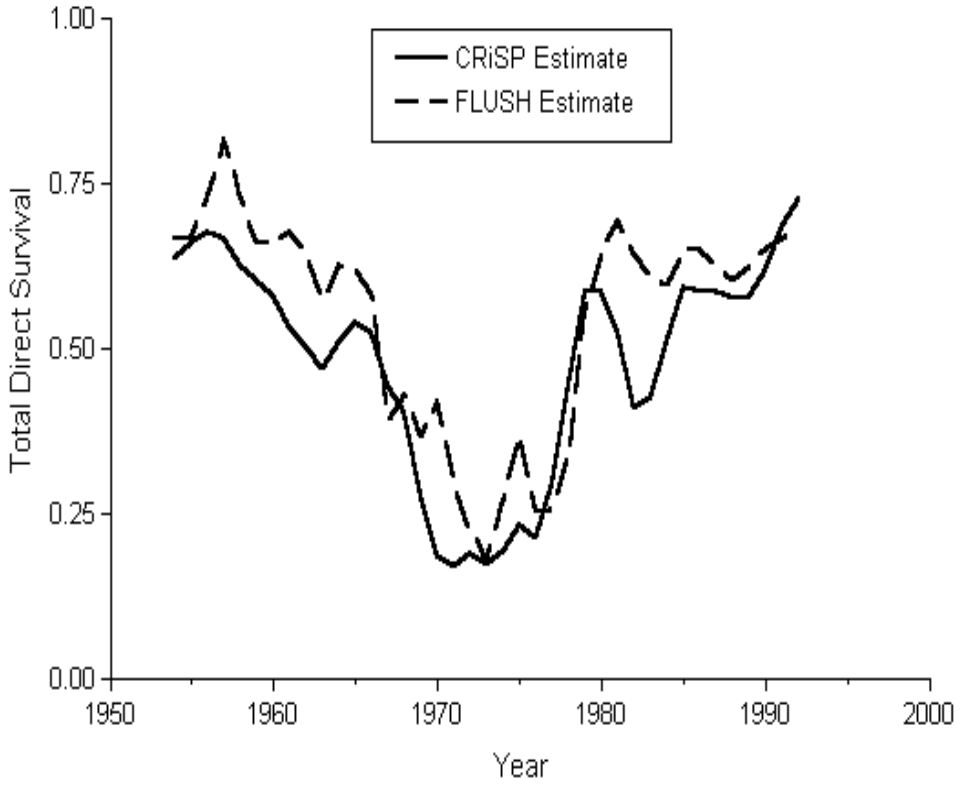
Although the passage models differ in their approach to determining reservoir mortality, they generally agree on the dam survival contribution to total direct survival for juvenile fish migrating from the Lower Granite reservoir to below Bonneville Dam. The historical passage survival estimates by the 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):

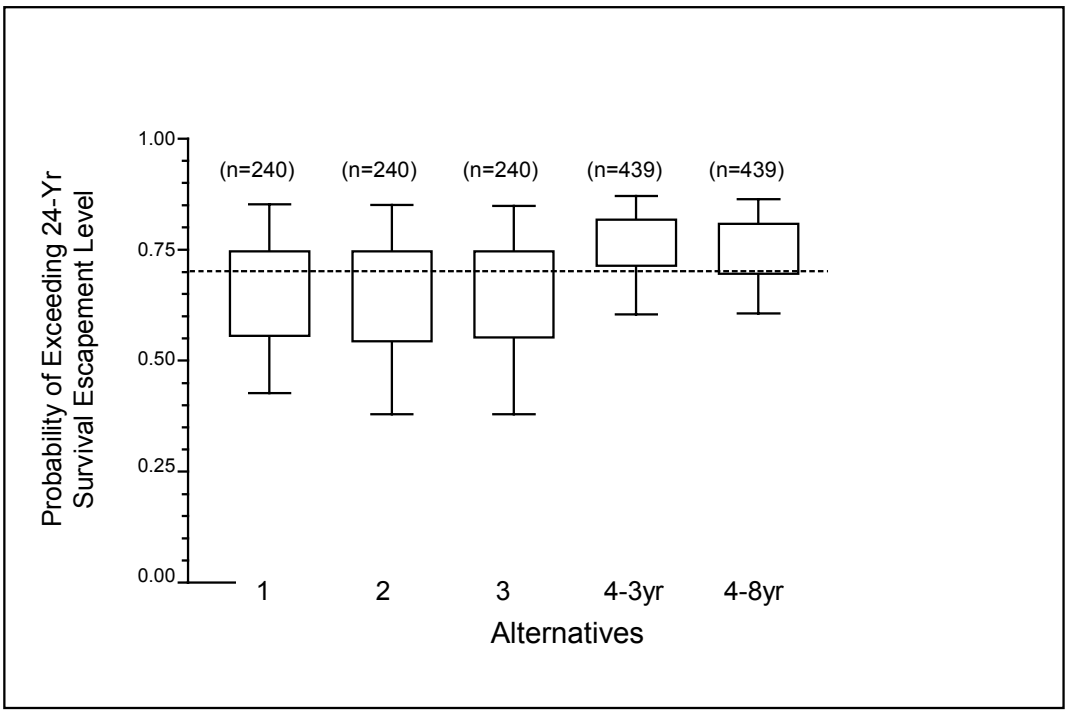
Thus, breaching [Alternative 4] *is more risk-averse in two ways:*

- *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

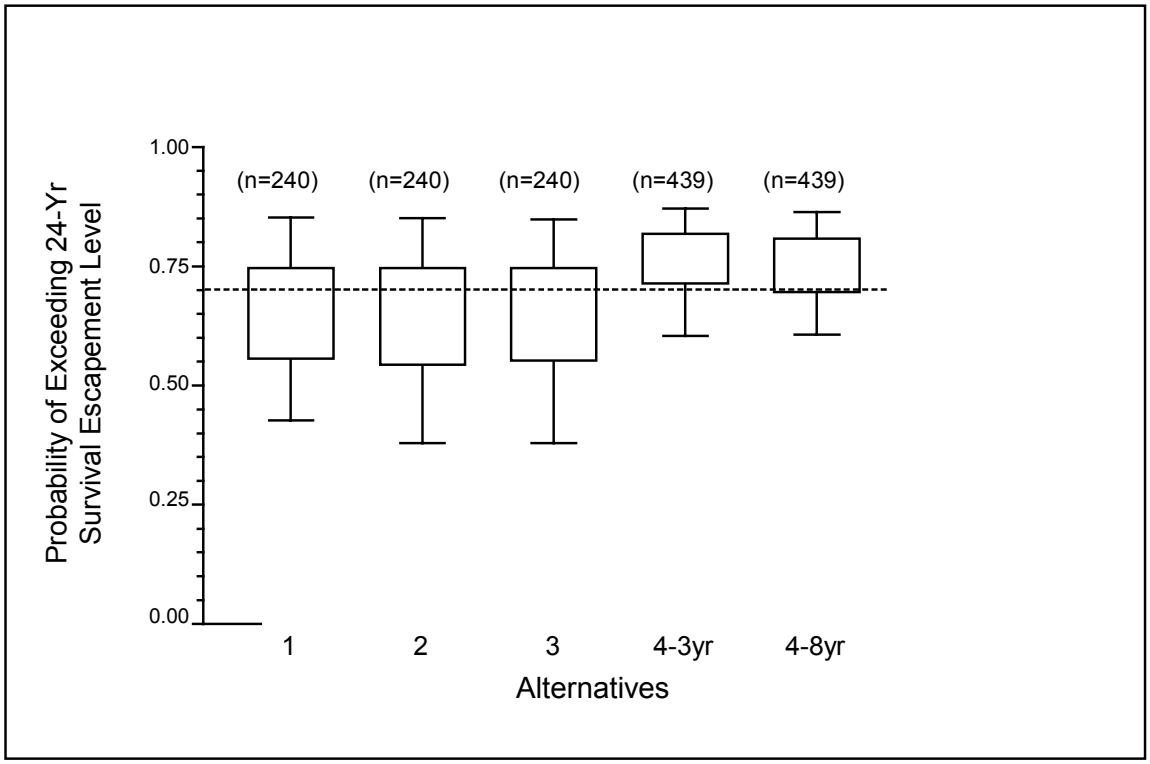
Analysis of which assumptions most affect model results can be informative in helping to determine how much weight should be placed on the overall outcome of this analysis. PATH found that the choice of CRiSP versus FLUSH and sources assumed for extra mortality had the greatest influence on results (Marmorek 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

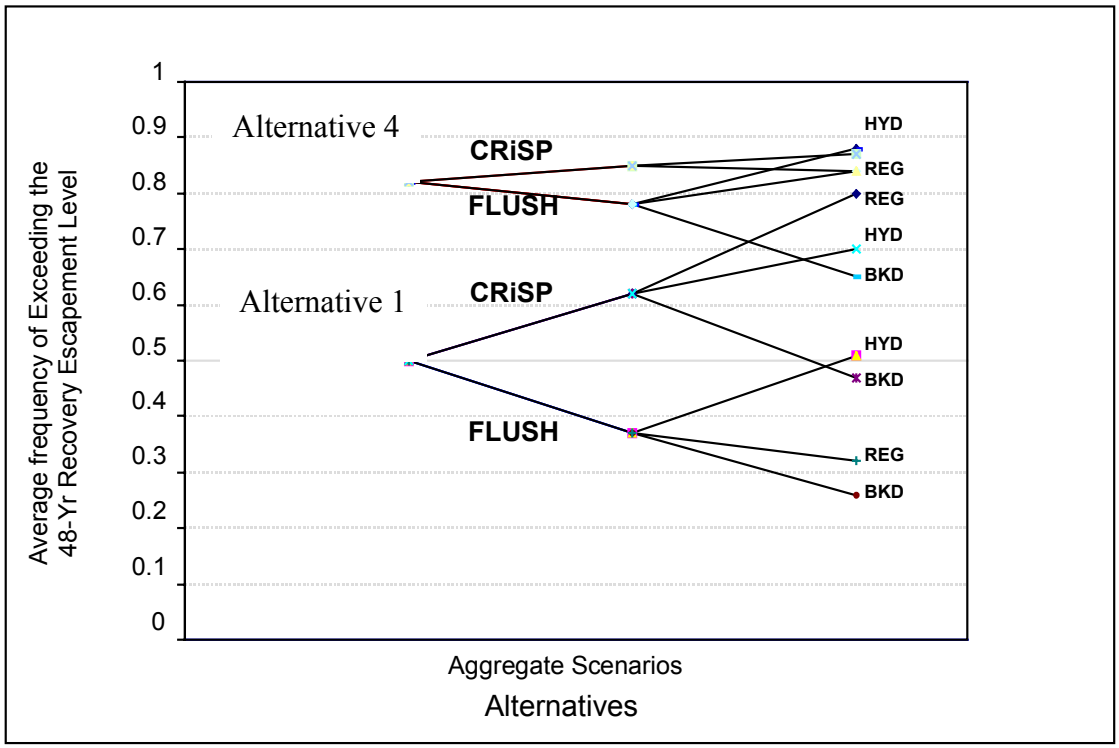
Similar to spring/summer chinook salmon, the main parameter addressed by PATH analysis is the smolt-to-adult life stage. However, the level of detail for fall chinook salmon modeling was much less because there is much less information available on Snake River fall chinook salmon passage survival. The 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.

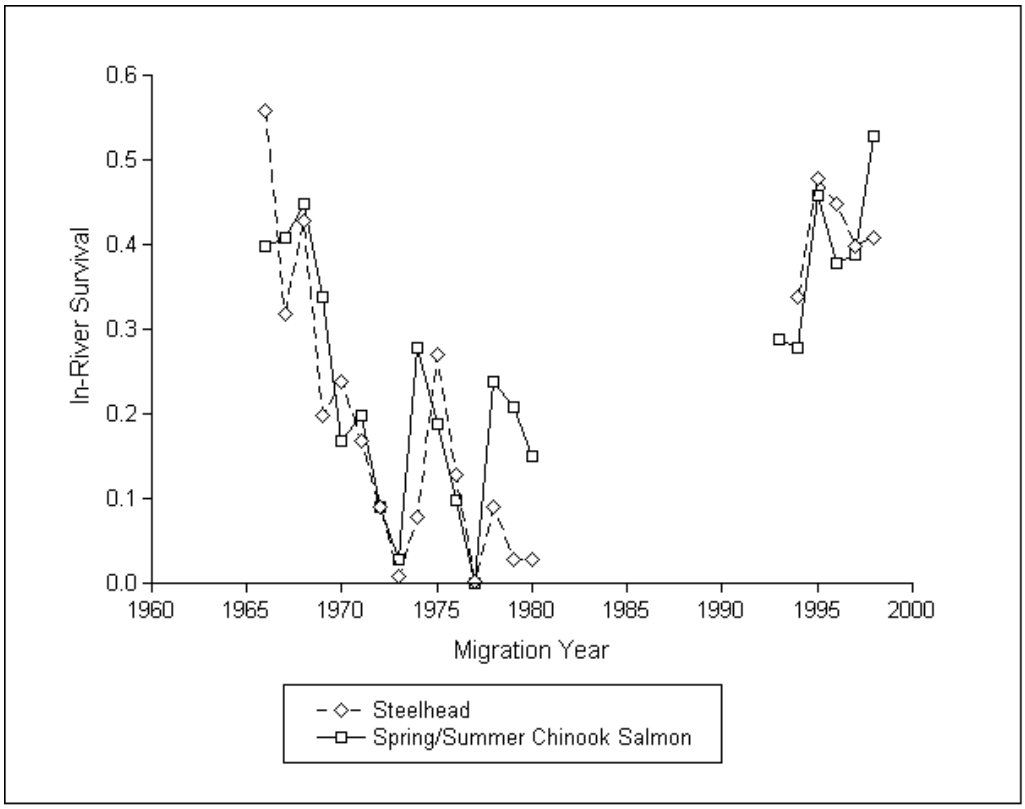
When the region began high voluntary spill under waiver for spring chinook salmon passage, it also affected steelhead. It is well documented that steelhead are more vulnerable to TDG >110 percent, and in the 1990s, after an entire lifecycle, over 4 to 5 years of spill resulted in Columbia and Snake River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

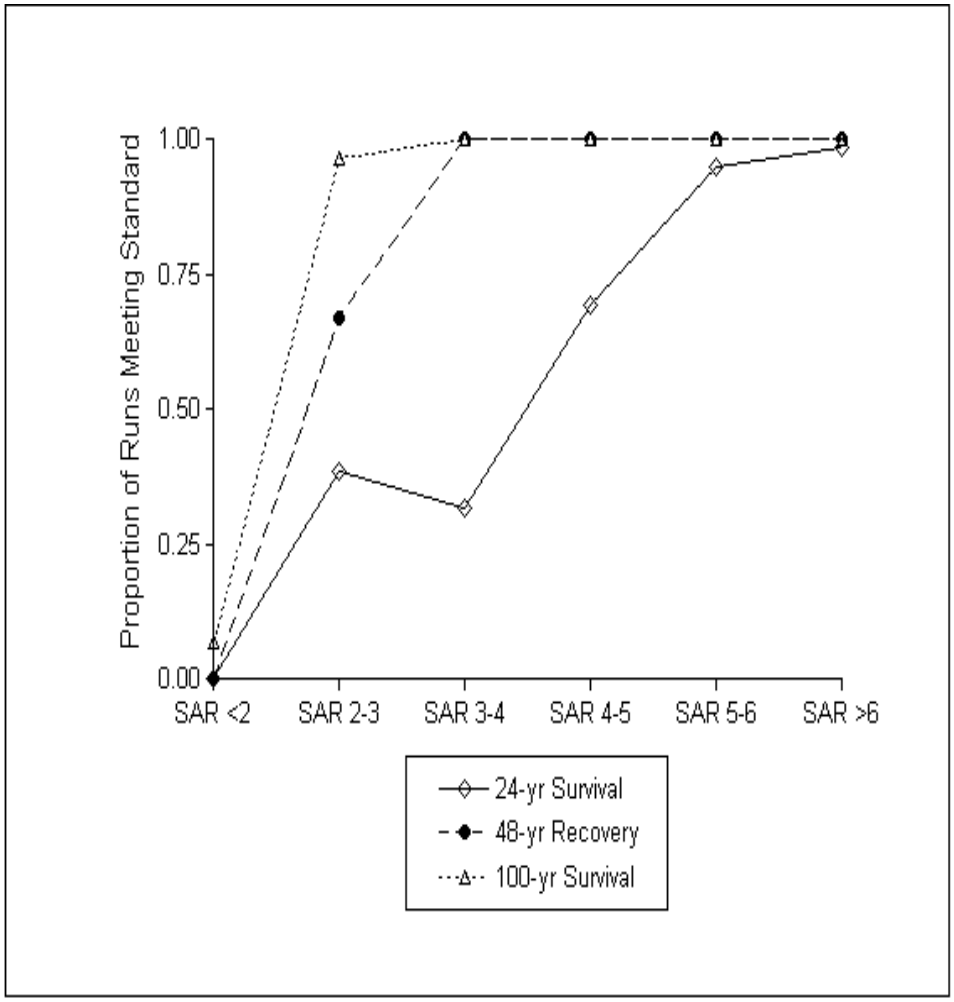
Analysis of the historical SARs for spring/summer chinook salmon was used to develop survival and recovery levels of escapement for steelhead. It was assumed that historical steelhead SARs would correspond to the same spring/summer chinook salmon escapement criteria. Based on the PATH analysis, several 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

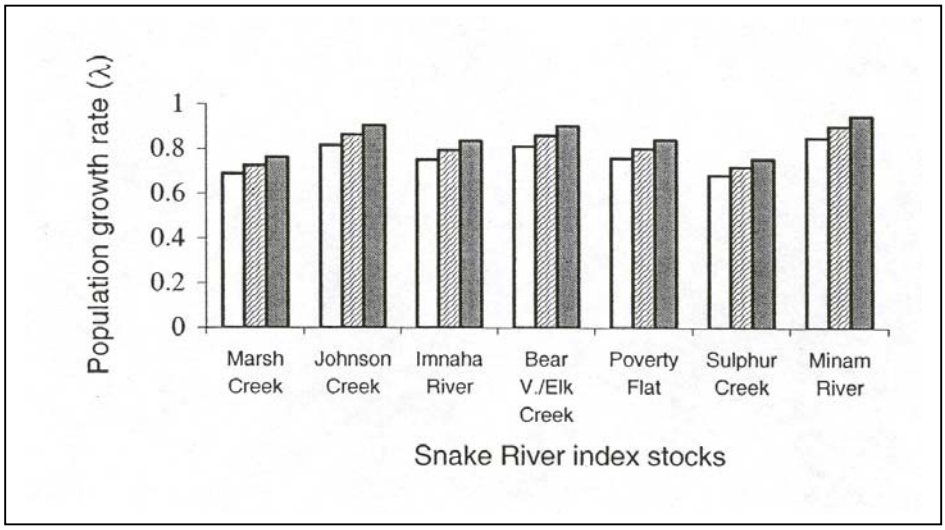


Figure 5.5-9. Numerical Experiments Exploring 100 Percent Survival During In-river Migration

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).

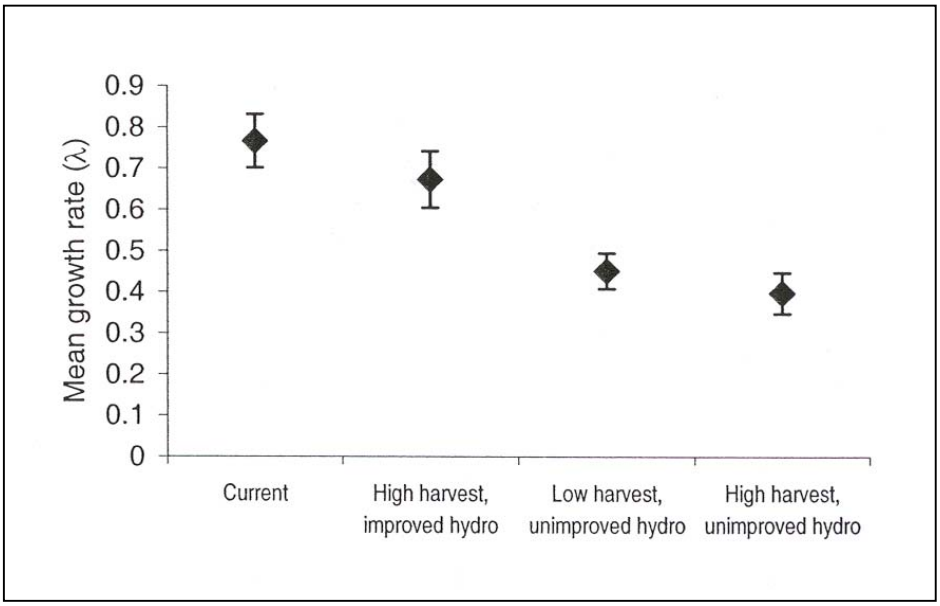


Figure 5.5-10. Effectiveness of Past Management Actions Targeting In-river Survival of Snake River Spring/Summer Chinook Salmon

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).

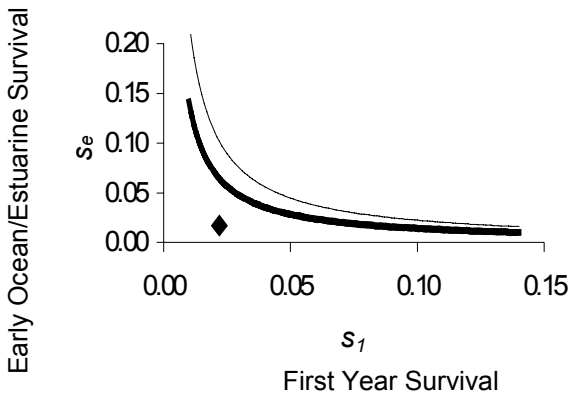


Figure 5.5-11. Isoclines Calibrating Improvements in First Year (s_1) and Early Ocean/Estuarine (s_e) Survival for Poverty Flat Index Stock of Snake River Spring/Summer Chinook Salmon

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

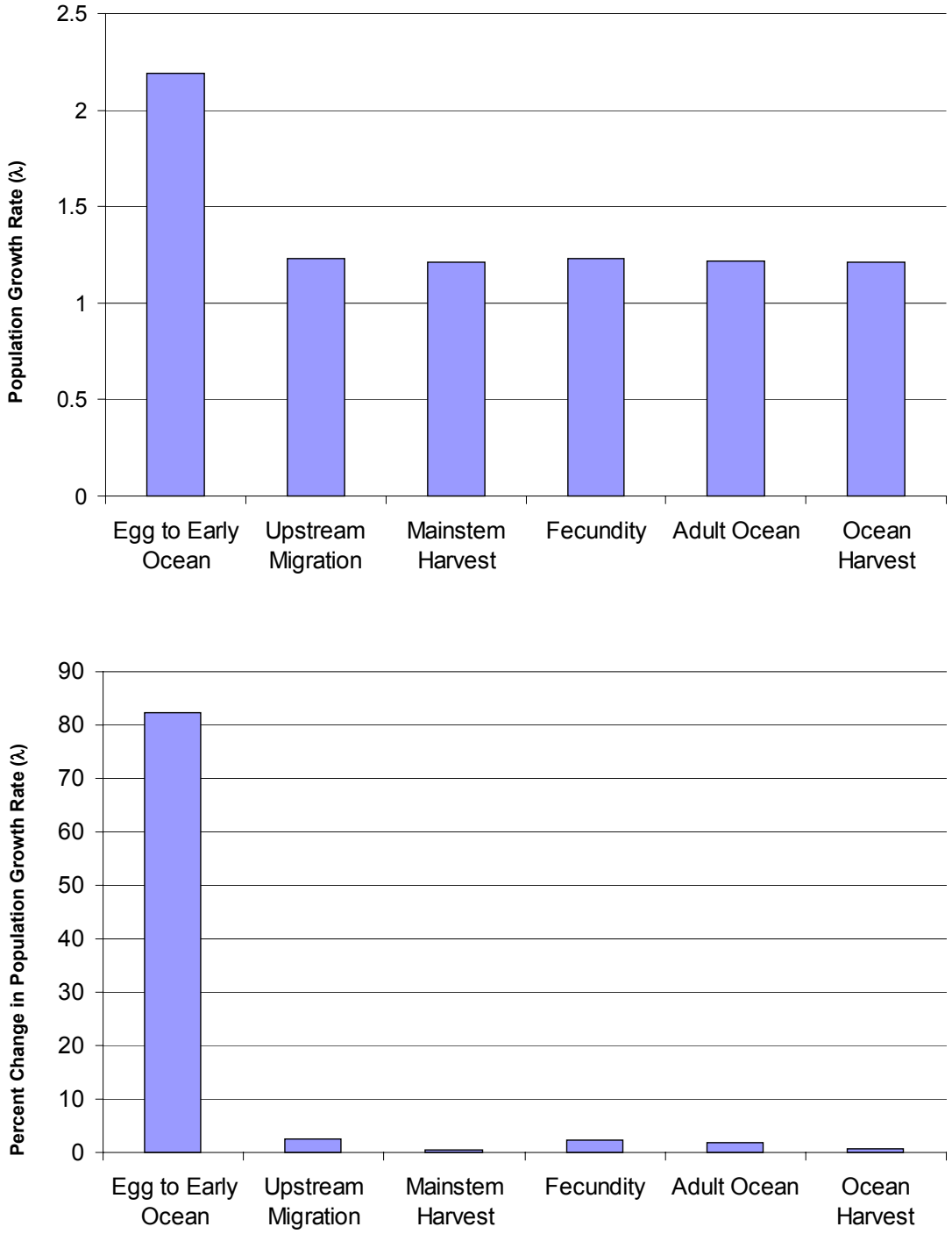


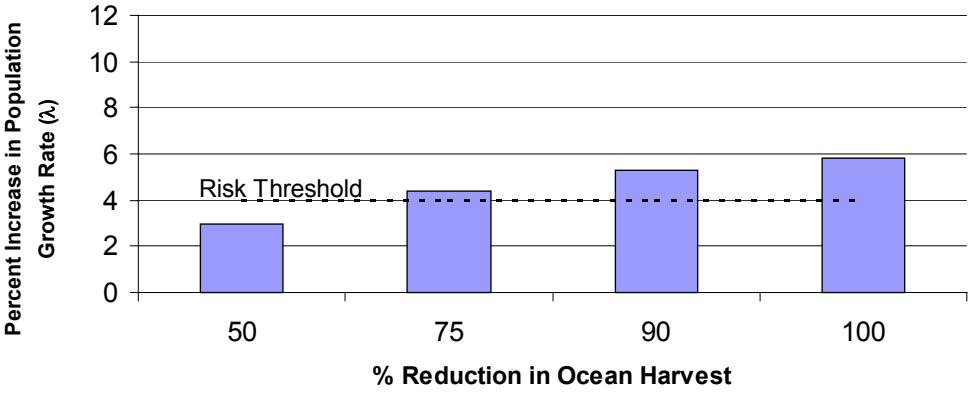
Figure 5.5-12. Population Growth Rate (λ) for Fall Chinook Salmon and Percent Change in Population Growth Rate with 10 percent Reduction in Mortality During Different Life Stages

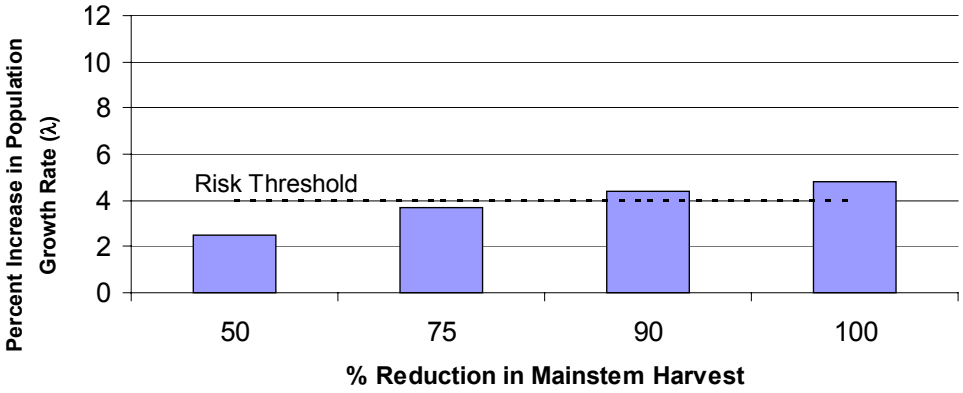
both by 50 percent each (Figure 5.5-13). Thus, harvest reduction is a biologically reasonable management option for recovery of Snake River fall chinook salmon.

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.





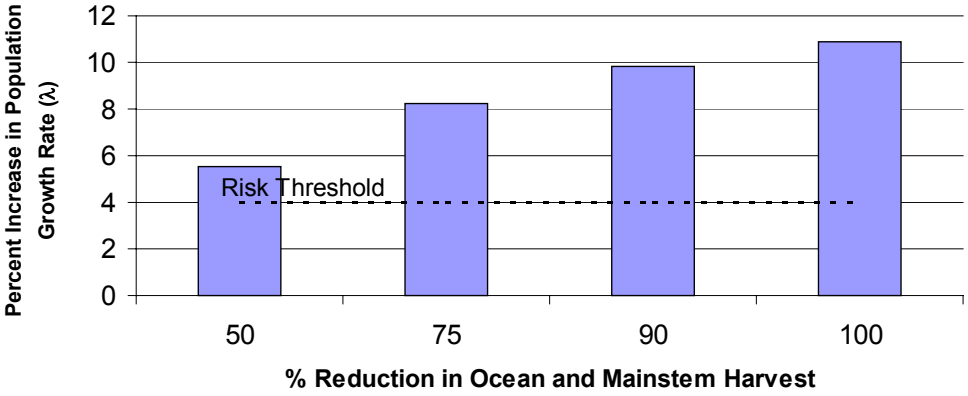


Figure 5.5-13. Percent Increase in Fall Chinook Salmon Population Growth Rate (λ) Relative to an Extinction Risk Threshold over a Range of Ocean and Mainstem Harvest Reductions

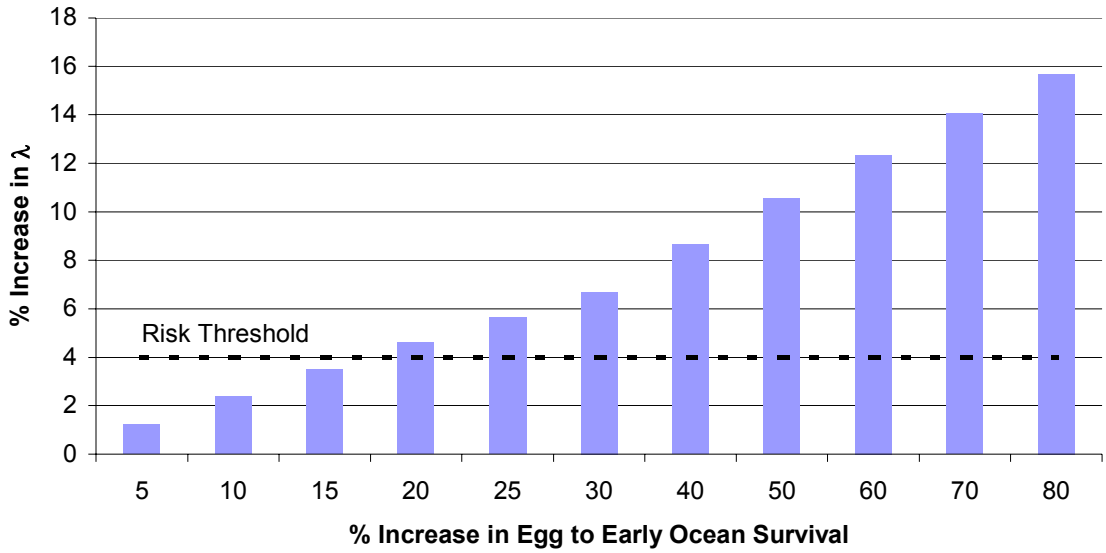


Figure 5.5-14. Percent Increase in Fall Chinook Salmon Population Growth Rate (λ) Relative to an Extinction Risk Threshold Over a Range of Relative Increases in Egg to Early Ocean (First Year) Survivals

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.

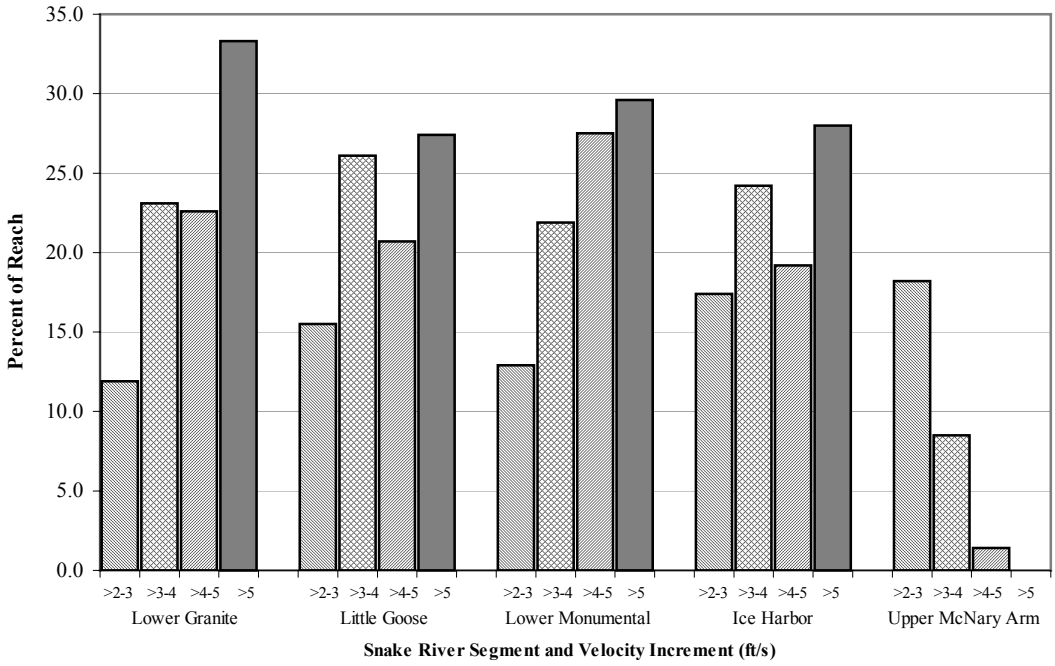


Figure 5.5-15. Proportional Distribution of Predicted River Velocities in a Near-natural Lower Snake River Determined by a Two-Dimensional Model

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

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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

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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).

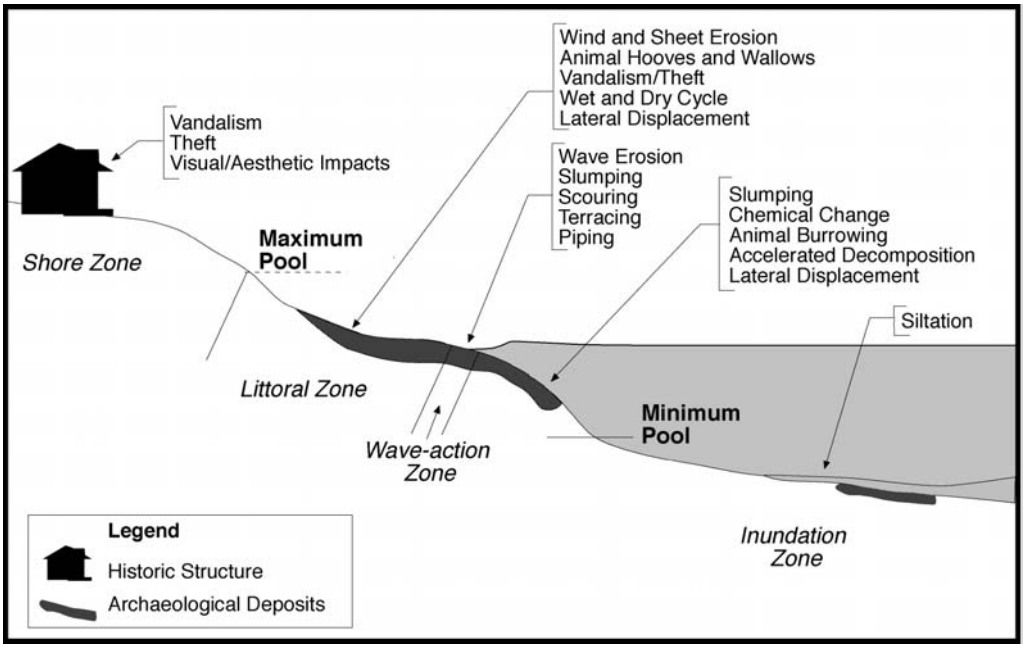

Figure 5.7-1. Reservoir Impact Zones and Potential Impacts on Historic and Cultural Properties

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

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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

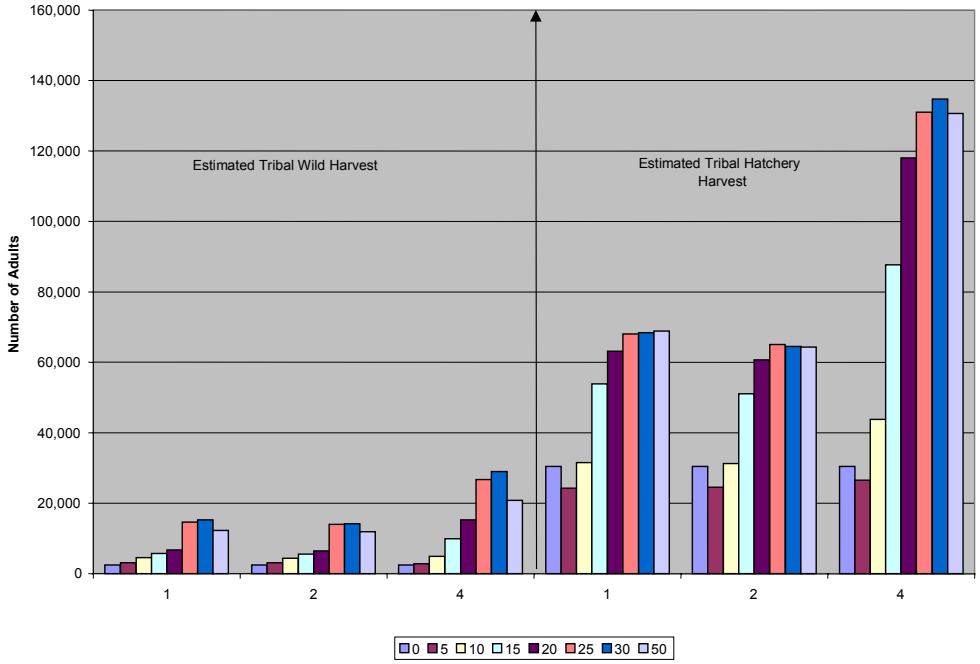
1/ The Tribal Circumstances report does not address Alternative 3—Major System Improvements but the impacts of this alternative on tribal harvest are likely to be similar to those projected for Alternative 2— Maximum Transport of Juvenile Salmon.

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

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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

State	Bushels	Alternatives 1-3 Total Cost ($)	Alternatives 1-3 Cost Per Bushel ($)	Alternative 4 Total Cost ($)	Alternative 4 Cost Per Bushel ($)	Cost Difference Total Cost ($)	Cost Difference Cost Per Bushel ($)	% 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

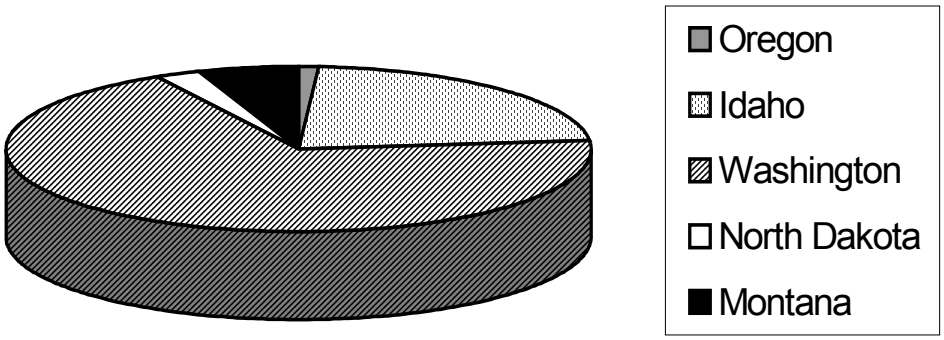
State of Origin	% of Lower Snake River Barged Grain	% of Increased Transportation Costs
Idaho	22.2	28.6
Montana	5.5	6.3
North Dakota	2.6	1.2
Oregon	1.0	0.3
Washington	68.6	63.6

Source: DREW Transportation Workgroup, 1999 (Table 7-11).

Table 5.9-6. Non-Grain Commodity Transportation Cost Comparison for 2007

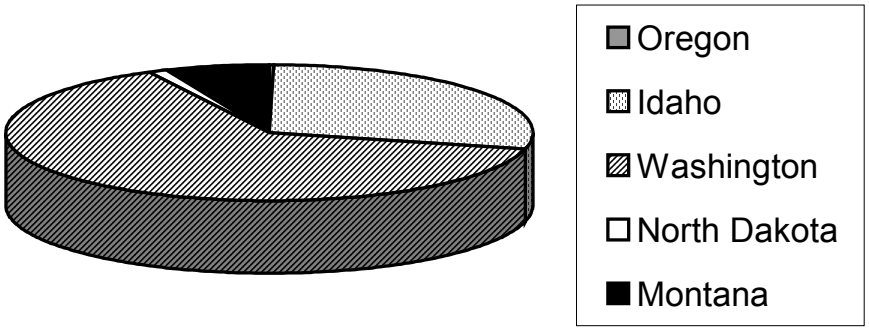
	Tons	Alternatives 1-3 Total Cost ($)	Alternatives 1-3 Cost Per Ton ($)	Alternative 4 Total Cost ($)	Alternative 4 Cost Per Ton ($)	Cost Difference Total Cost ($)	Cost Difference Cost Per Ton ($)	% Increase
Wood Chips and Logs	694,000	47,879,179	68.99	49,320,040	71.07	1,440,861	2.08	3.01
Wood Products	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

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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.

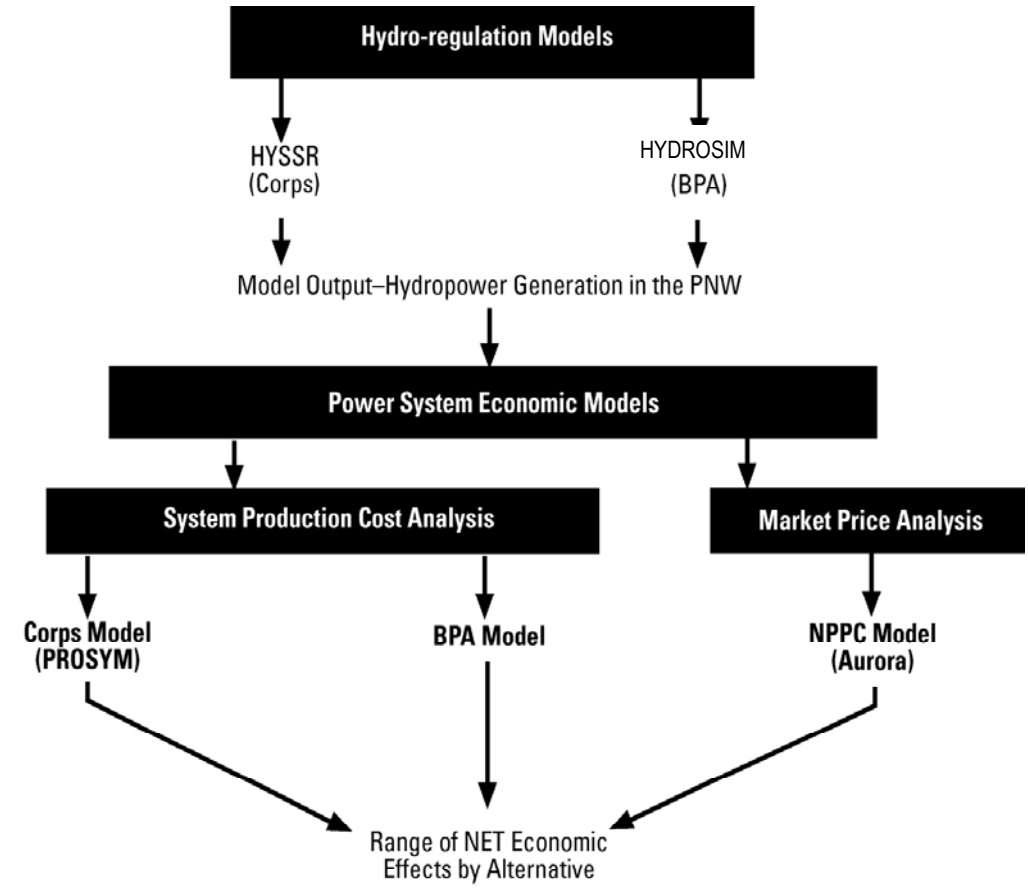
5.10.1 Methodology

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.

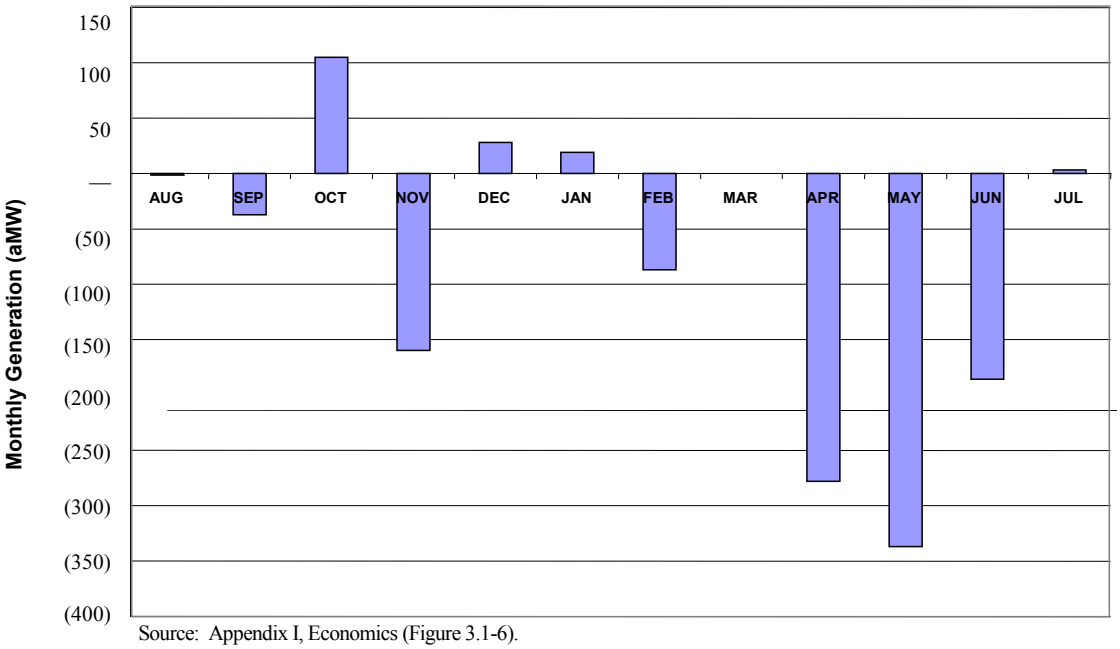


Figure 5.10-2. Difference in Snake River Generation (2000 Biological Opinion – 1995 Biological Opinion)

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

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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)

	6.875 % Discount Rate		4.75 % Discount Rate		0.0 % Discount Rate	
Alternative 4—Dam Breaching	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**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

5.12 Land Ownership and Use 5.12-1
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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

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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:

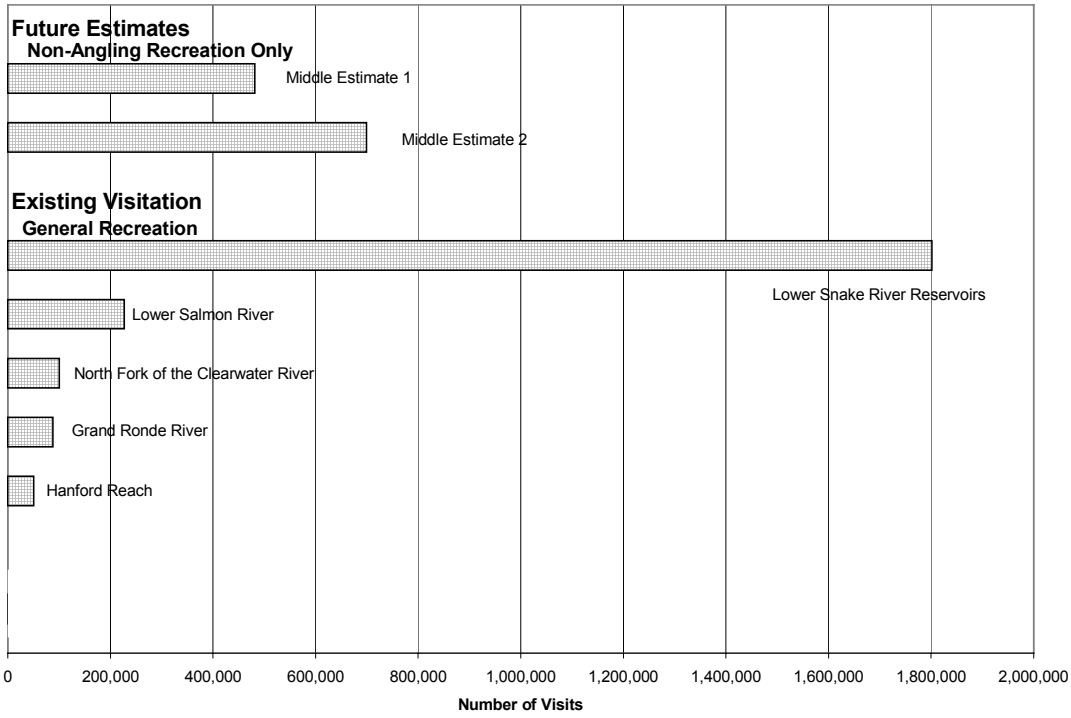
- Hanford Reach of the Columbia River, Washington
- North Fork of the Clearwater River, Idaho
- Lower Salmon River, Idaho
- Lower Deschutes River, Oregon
- Hells Canyon stretch of the Snake River, Idaho, Oregon, and Washington
- Main Salmon River, Idaho
- Middle Fork of the Salmon River, Idaho
- Grand 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

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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

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).

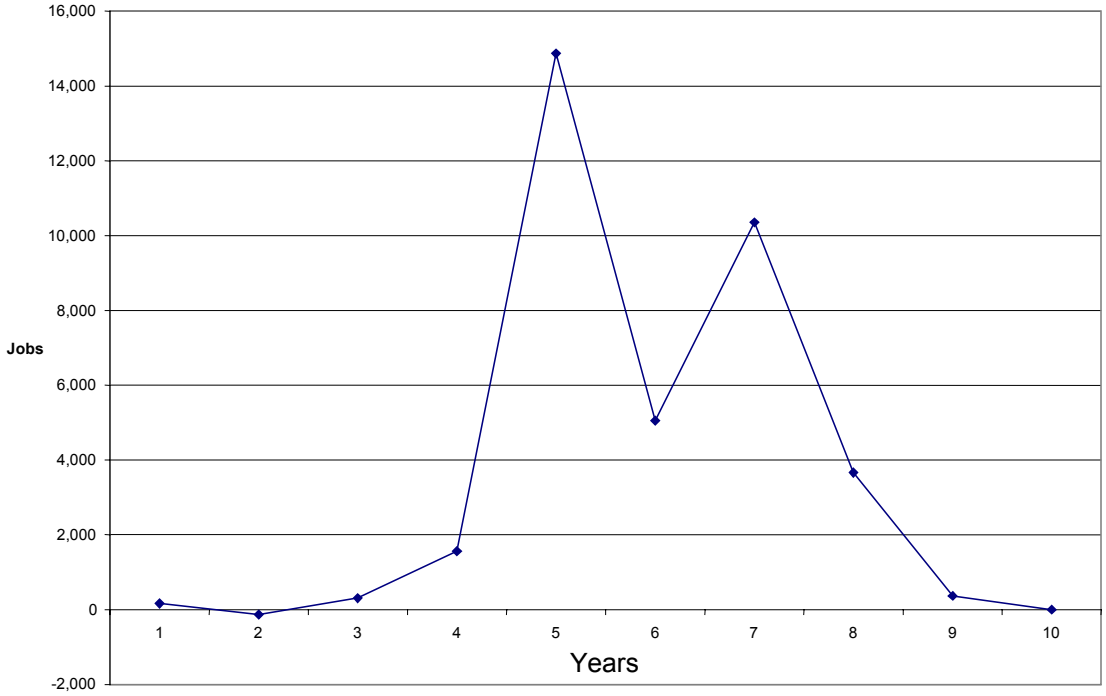
Average point estimates are presented for long-term annual changes in employment in Table 5.14-3. These point estimates suggest that in the long term, employment in the lower Snake River study area would experience a net decrease of 1,372 jobs, which represents less than 1 percent of jobs in the 25-county 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)

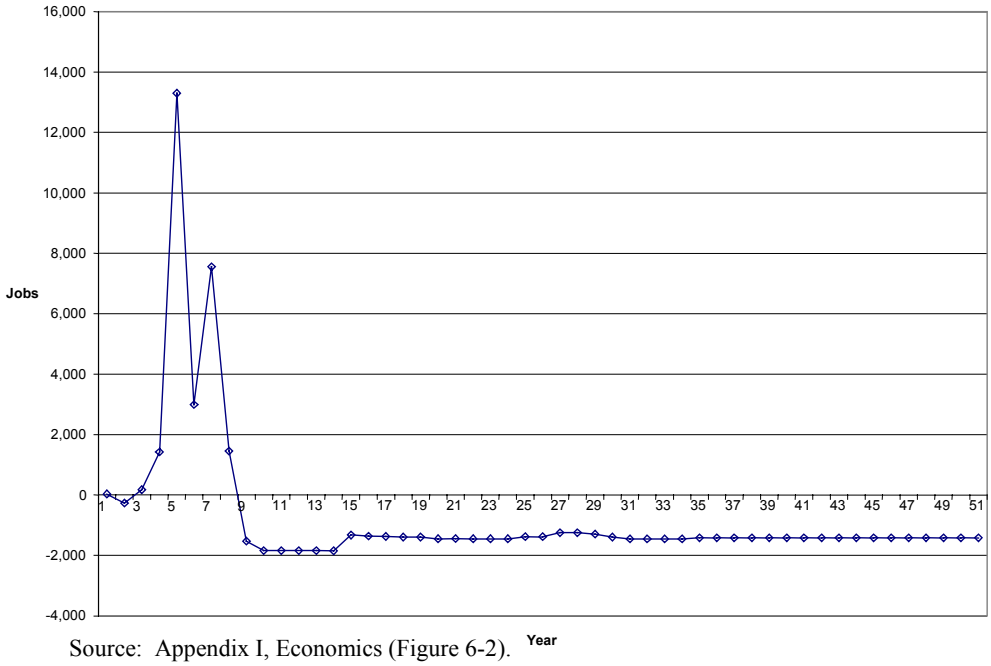
Several impact categories occur either throughout the Pacific Northwest or in an area of a state outside the lower Snake River study area. In addition, impacts associated with changes in commercial and ocean recreational fishing occur in the Pacific Northwest states, Alaska, and British Columbia, Canada. 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

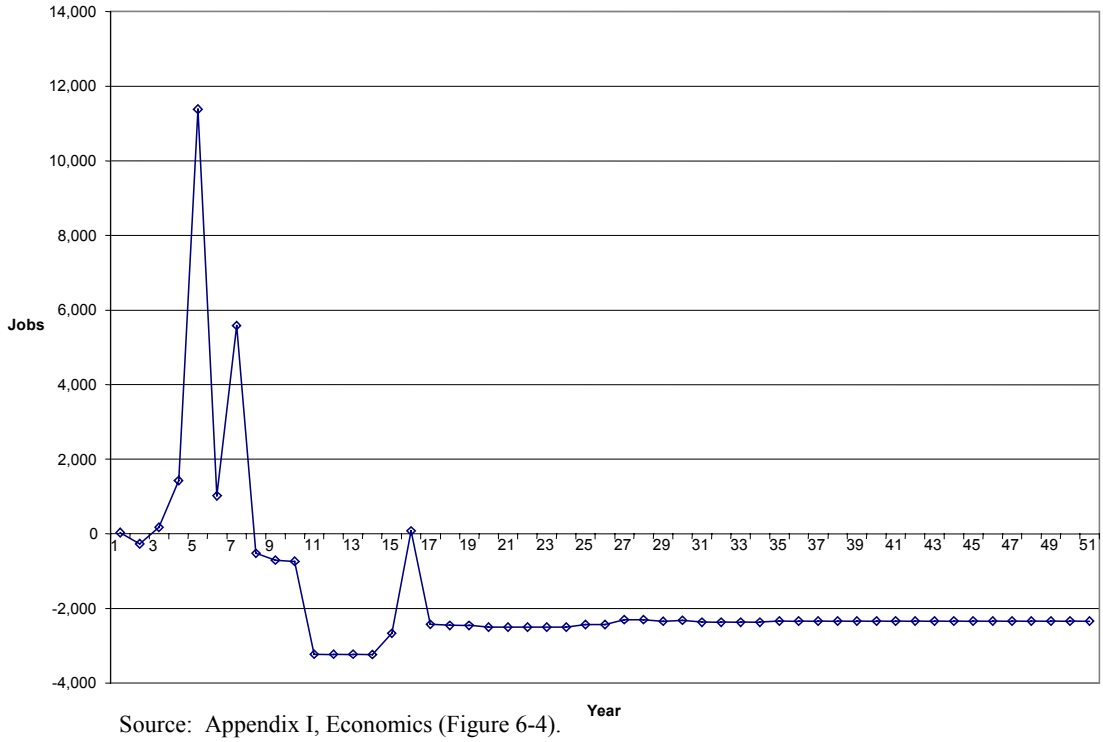
Table 5.14-4. Annual State-level Employment Impacts for Alternative 4—Dam Breaching Excluding those Impacts Modeled for the Subregions (Jobs)[1/2/]

	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

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 <									
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

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

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
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

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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.

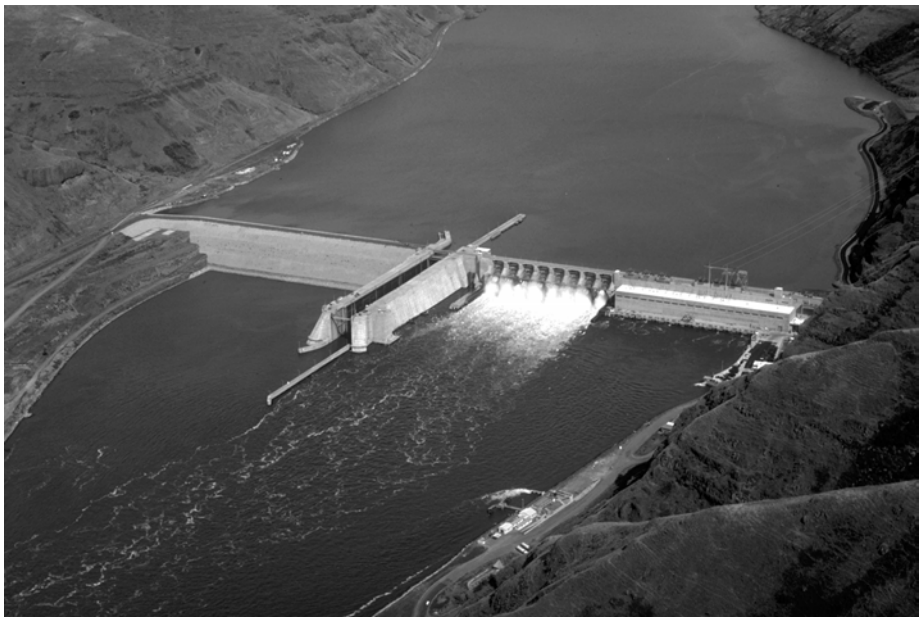

Figure 5.15-1. Current Photograph of the Lower Granite Dam Representative of the First Three Alternatives

Figure 5.15-2. Site Condition During Construction of Lower Granite Dam That May Be Similar to the Breached Condition

5.16 Economic Overview

5.16	Economic Overview	5.16-1
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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

5.17	Cumulative Effects	5.17-1
5.17.1	Snake River Flow Augmentation Analysis	5.17-4
5.17.2	Interior Columbia Basin Ecosystem Management Project	5.17-6
5.17.3	Hells Canyon Relicensing Project	5.17-7
5.17.4	Nez Perce Tribal Hatchery Program	5.17-7
5.17.5	Conservation of Columbia Basin Fish—Federal Final Basinwide Salmon Recovery Strategy	5.17-8
5.17.6	Starbuck Power Project	5.17-9
5.17.7	Wallula Power Plant	5.17-9
5.17.8	Oregon Plan for Salmon and Steelhead	5.17-10
5.17.9	Uncertainties in Cumulative Effects	5.17-10

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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Chapter 6

Plan Selection and Implementation

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6.1 Recommended Plan (Preferred Alternative)

Based on a thorough examination of the best available biological, economic, social, and other environmental information, a plan has been identified which is based on the actions described in Alternative 3—Major Systems Improvements. During review of the 2000 Biological Opinions, comments on the Draft FR/EIS, and additional information, the adaptive migration component of Alternative 3 became the focus of the recommended plan (preferred alternative). The alternative analysis and evaluation of impacts in Section 5 includes all components or actions contained in the recommended plan (preferred alternative). Throughout this section, the recommended plan (preferred alternative) is referred to as Alternative 3—Major System Improvements (Adaptive Migration).

Alternative 3—Major System Improvements (Adaptive Migration) combines a series of structural and operational measures intended to improve fish passage through the four lower Snake River dams. This alternative provides the maximum operational flexibility for juvenile fish passage, optimizes in river passage when river conditions are best for fish and optimizes the juvenile transportation program when this operation is best for fish. It also allows for optimized combined passage when necessary for spread-the-risk operation or to conduct needed research. These improvements are not only intended to reduce direct mortality associated with dam passage, but also to reduce stress on juvenile fish, reduce total dissolved gas levels, and improve operational reliability.

The evaluations, analyses, comparisons, and consideration of impacts and effects discussed in the FR/EIS, associated appendices, and supporting research materials and

reports are the basis for selecting the recommended plan (preferred alternative). The key factors supporting the selection of this alternative were:

- High current juvenile and adult salmon and steelhead survival rates through the Lower Snake River Project
- Proposed improvements provide the maximum flexibility of all alternatives in terms of optimizing both in river migration conditions and transport conditions
- Lesser magnitude of uncertainty in current biological information
- Minimal economic impacts to users
- Compatibility with NMFS and USFWS 2000 Biological Opinions
- Minimal effects to other environmental resources.

Other factors considered in this selection include, but were not limited to, those effects associated with social and community resources, Native American Indians, technical feasibility, effectiveness of structural modifications, regional acceptability, public comments, and length of implementation. Summaries of these factors are discussed below. Sensitivity and trade-off analyses were also conducted and considered for each alternative.

It should be noted that Alternative 1—Existing Conditions was eliminated from further consideration because it failed to meet the biological requirements in the NMFS 2000 Biological Opinion. Alternative 2—Maximum Transport of Juvenile Salmon was ranked lowest of all the remaining alternatives because it maximized the collection and transport of juvenile salmon and steelhead in which a major uncertainty exists related to the delayed mortality of transported fish.

Although Alternative 4—Dam Breaching had a number of positive benefits, it was ranked lower than the Alternative 3—Major System Improvements (Adaptive Migration) for the following reasons: determination that breaching is not necessary at this time to recover listed salmon and steelhead stocks (breaching has not been determined necessary at this time by the NMFS 2000 Biological Opinion); maximum negative economic impacts to current system users (i.e., loss of power, navigation, and irrigation); high sediment movement in the short term; uncertainty of possible harmful effects associated with the potential resuspension of contaminants in sediments; highest degree of uncertainty in the implementation and longest period before positive benefits to listed stocks; and most negative impact to minority populations.

Unless a specific citation is provided, information and tables presented in this section were produced by the Study Team based on the corresponding studies and analyses described in this FR/EIS and associated documents.

6.1.1 Description of the Recommended Plan (Preferred Alternative)

The structural and operational measures identified for the recommended plan (preferred alternative) are considered to be technically feasible or implementable, implying that the Corps has the capability to design, construct, and operate these measures. Some of the proposed systems, such as the removable spillway weirs (RSWs), surface bypass collectors (SBCs), and behavioral guidance structures (BGSs), present challenging technical issues - more challenging than the other non-breach alternatives (Alternatives 1

or 2). This is because these improvements are new technologies that have not been fully tested and require significant retrofitting on existing facilities. The basic SBC and BGS prototype development and testing has been completed at Lower Granite. Research has shown the prototype passes a relatively high percentage of fish with a small percentage of river flow. The SBC may also reduce forebay residence time and could reduce stress and mortality relative to other bypass options such as turbine intake screens and conventional spill. This research has provided the information to support the implementability of this technology (see Section 5.5.1.3). The use of these facilities to collect juvenile fish for transport will require high volume dewatering systems. The Corps has experience developing these types of dewatering systems; however, testing for this application is not completed. In addition, an RSW prototype is being installed this year at Lower Granite for testing in 2002.

6.1.1.1 Structural Measures

The structural improvements associated with the recommended plan (preferred alternative) can be placed into two categories. The first category is near-term improvements, consisting of modifications to existing systems using current technology. These require little or no additional study or research. Near-term improvements can be implemented relatively quickly [within the first 5 years after the Record of Decision (ROD)] and this FR/EIS provides National Environmental Policy Act (NEPA) compliance for implementation. The second category is long-term improvements. These improvements require additional evaluation, prototype development, and testing. Therefore, these improvements take more time to put into place. The actual determination on if, where, how, and when these long-term improvements are implemented would be contingent on the prototype testing and evaluation results. Implementation would also be dependent on a continued need for improvements in the hydropower system. Information related to the implementation of these improvements is shown later in this chapter.

Near-term Improvements

- Complete installation of spillway flow deflector at Lower Monumental and Little Goose
- Upgrade auxiliary fish ladder water supply systems at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite
- Modify extended submerged bar screens at Little Goose and Lower Granite
- Use additional barges for transport with upgraded mooring facilities at Lower Granite.

Long-term Improvements

- Install new juvenile facility at Lower Granite
- Install new cylindrical dewatering screens at all dams
- Replace submerged traveling screens (STSs) with ESBSs at Ice Harbor and Lower Monumental
- Install new wet separators at Lower Monumental and Little Goose
- Install turbine improvements (as powerhouses are rehabilitated)

- Install RSWs with or without BGS at all four dams
- Install two-unit powerhouse surface bypass with or without dewatering system at Lower Monumental and Lower Granite
- Build full-length powerhouse occlusion structure at Little Goose.

6.1.1.2 Operational Measures

Existing Operations

Existing operations are identified and described in Section 2 of the FR/EIS. The four lower Snake River dams are run-of-river facilities. They are used for production of power, as a navigation corridor for the inland waterways, for recreation opportunities, as a source of water for irrigation interests, and to support fish and wildlife needs. Each dam operates and maintains both juvenile and adult fish passage facilities. The Lower Snake River Project lands support project operations or recreation facilities, and some are managed as wildlife habitat either for purposes of compensation or good land stewardship. The ongoing monitoring and evaluation programs that exist will continue to be supported based on priorities identified through regional coordination.

The Corps prepares an annual Water Management Plan that covers relevant factors affecting the operation of Federal Columbia River Power System (FCRPS) (including the Lower Snake River Project), such as Federal reservoir and dam operations to augment flows for fish, power generation, turbine outage and spill scheduling, water temperature management control, total dissolved gas (TDG) management, and special operation for research and other purposes. The plan is updated annually by April 15 of each year by the Technical Management Team (TMT). The Corps' in-season decisions on shaping timing and amount) of water releases (flow augmentation, spill, etc.) during the migration and fish passage season and on the juvenile fish transportation program are made after considering recommendations of the TMT. The TMT includes Federal, state, and tribal representatives who meet throughout the year to monitor and evaluate the shaping of available water based on real-time flow and biological information during the fish passage season. The TMT makes recommendations on water management and system operations to the Action Agencies, which include the Corps, BOR, and BPA.

The Corps continues to operate dams and fish passage facilities in accordance with criteria stated in the Corps' Fish Passage Plan (FPP) to provide safe, efficient passage for anadromous fish species listed under Endangered Species Act (ESA), as well as other migratory fish species. The FPP addresses year-round project operations and describes the procedures and criteria to be used when there are emergency deviations from the FPP. The Fish Passage Operation and Management (FPOM) Coordination Team coordinates the implementation of the FPP. This includes potential changes to fishway operating criteria, main unit operating priority, coordination of special operations that must be implemented during the fish passage season, and how to best operate the facilities when some component fails or must be taken out of service during the fish passage season. The Corps provides opportunity for annual review of the FPP by NMFS, other Federal and state agencies, and tribes. The FPP will be revised as appropriate to incorporate operation criteria for fish facility improvements associated with the recommended plan (preferred alternative).

However, if the Corps faces river or facility conditions that require changes in operation, it may implement an action that differs from the planned implementation. The Corps may, on occasion, in coordination with NMFS and USFWS (concerning consistency with biological opinions), adopt operations specifically tailored to address flood control, approved research needs, emergencies, or to meet requirements or operations to maintain other project uses.

Potential Future Operation Changes

There are two principal areas where potential future operation changes for the lower Snake River need to be further investigated. These areas include:

- Develop and implement biological rules for flow augmentation
- Develop and implement biological rules for smolt transportation including optimal spill for salmon.

The Corps plans to coordinate with Federal agencies to establish these specific rules for both smolt transportation and flow augmentation. These rules may change as scientific uncertainty is reduced and coordination continues. These rules will allow the Corps to make adjustments to operational requirements to more effectively minimize stress. The appropriate ESA consultation steps will be taken to ensure compatibility of the final rules with the Biological Opinions.

There are operational considerations for juvenile fish transportation and flow augmentation that need to be established to accompany the structural improvements in the recommended plan (preferred alternative). The evaluation included in this FR/EIS identified periods within and across the juvenile outmigration seasons for each salmonid stock where transportation appears to be more effective (i.e., during years when NMFS flow targets cannot be met). The evaluation also identifies periods within and across the juvenile outmigration seasons for each salmonid stock where cold-water releases from Dworshak Reservoir produce negative responses (i.e., negative effects to growth requirements of rearing wild juvenile Snake River fall chinook salmon). Biologically inappropriate timing of artificial releases of cold water from Dworshak in the North Fork of the Clearwater River can also negatively affect bull trout. Bull trout can be artificially attracted to remain in cooler stream conditions in the North Fork past the time that warmer water in the South Fork would have caused them to migrate upstream.

The benefits of flow augmentation vary depending on the climatic and hydrologic conditions. The ESA-listed salmonid stocks have evolved and adapted their lifestyle survival to riverine ecological conditions formed by geomorphologic processes. As a result, more specific biological rules for flow augmentation beyond simple flow target triggers need to be established in an attempt to maximize juvenile fish survival in the lower Snake River hydrosystem and through the lower Columbia River hydropower system. More specifically, the augmentation flow release timing and duration from Dworshak Reservoir affecting water temperature in the lower Snake River need to be more ecologically aligned with providing for optimum growth during rearing and achieving the highest migration fitness for Snake River fall chinook salmon. Biological rules need to be developed in order to optimize tradeoff effects between the ecological needs of overlapping salmonid stocks and age classes, as well as the physical relationships of adding cold water to Lower Granite Lake during different flow years.

Consistent across these two proposals for development of biological rules for operation of the lower Snake River hydrosystem is the empirically determined optimal effectiveness of spill for fish passage. If RSWs and other fish passage prototypes prove to contribute substantially to smolt survival following several years of research and monitoring, and are implemented, then spill guidelines, spill caps, and shaping may warrant modification. The same will be true following the development of empirically determined biological rule curves for smolt collection and transportation and flow augmentation. The same may also be true if RSWs and other measures prove to reduce dissolved gas to 110 percent and under for voluntary and/or involuntary spill regimes, as long as such structural or operational measures do not negatively affect salmon and steelhead survival. All such operational rule development will continue to be coordinated within the Regional Forum in a manner consistent with the RPA contained in the NMFS 2000 Biological Opinion.

The benefits of juvenile salmonid transportation vary depending on the climatic and hydrologic conditions (such as experienced during water year 2001 drought conditions). As a result, more specific biological rules for smolt collection and transport beyond simple flow target triggers need to be established in an attempt to maximize juvenile fish survival through the hydropower system.

6.1.2 Consistency with Biological Opinions

In a Record of Consultation and Statement of Decision (ROCASOD [Corps, 2001]), dated May 15, 2001, the Corps concurred with NMFS and USFWS determinations that the integrated operation of the FCRPS, in a manner consistent with the NMFS and USFWS 2000 Biological Opinions, including RPA action items, combined with other ongoing and anticipated measures, would likely ensure survival and recovery of listed salmon and steelhead. This includes the operation of the Lower Snake River Project. The NMFS 2000 Biological Opinion concluded that dam breaching on the lower Snake River is not necessary at this time, but reserved this action as a contingency management alternative if the listed stocks continue to decline in the near future (2005 to 2008). The Biological Opinion states:

> "Although breaching is not essential to implementation of the initial actions called for in the RPA which constitute a non-breach approach, the RPA requires that the Action Agencies prepare for the possibility that breaching or other hydropower actions could become necessary." (NMFS 2000 Biological Opinion, Page 9-131.)

The Corps will implement the RPA action items and incidental take statements applicable to the Corps in the NMFS and USFWS 2000 Biological Opinions. These actions include a mixture of system operations, configuration measures, habitat restoration, and continued research and monitoring activities. However, in concurring with the Biological Opinions' conclusions, the Corps has the discretion to implement actions other than those identified in the Biological Opinions with the intent that the alternative measures result in achieving the Biological Opinion performance standards and/or as modified through the Action Agencies' 1- and 5-year implementation plans.

In implementing the Biological Opinions' lower Snake River actions, the Corps will also contribute to the attainment of the goals identified in the *Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery Strategy* [Basinwide Recovery Strategy

(Federal Caucus, 2000)], dated December 2000. This strategy was developed by several Federal agencies (including the Corps) as part of the Federal Caucus and is a comprehensive, long-term plan to recover 12 anadromous fish stocks and other listed species (i.e., bull trout and sturgeon) in the Columbia-Snake River Basins.

Of all the alternatives investigated in the FR/EIS, the recommended plan (preferred alternative) most closely matches the NMFS 2000 Biological Opinion for the Lower Snake River Project. A comparison of the recommended plan (preferred alternative) and the NMFS 2000 Biological Opinion RPA measures is shown in Table 6-1.

Table 6-1. Comparison of Recommended Plan (Preferred Alternative) and NMFS 2000 Biological Opinion

Features	Recommended Plan (Adaptive Migration)	NMFS 2000 Biological Opinion
Structural Modifications		
Flow Deflector Optimization	●	●
Auxiliary Water Supply	●	●
New Juvenile Facility at Lower Granite	●	●
Turbine Rehabilitation	●	●
Additional Barges and Mooring	●	
ESBS		
Ice Harbor	●	
Lower Monumental	●	●
Mods - Little Goose and Lower Granite	●	●
Cylindrical Dewater Screens	●	●
Separator Improvements	●	●
Miscellaneous Improvements	●	●
Removable Spillway Weir	●	●
Behavioral Guidance Structure	●	
Surface Bypass Collection		
Lower Granite with Dewatering	●	
Lower Monumental with Dewatering	●	
Little Goose (Occlusion Only)	●	
Future Structural Changes	●	●
Operational Elements		
Flow Augmentation	●	●
Voluntary Spill (Fish Passage)	●	●
Transport (Spread-the-Risk)	●	●
Future Operational Modifications		
Flow Augmentation Rules (LSR)	●	
Transportation Rules (LSR)	●	
Research, Monitoring, and Evaluation		
All Four LSR Dams	●	●
Other		
Off-site Habitat Mitigation		●
Advanced Planning for Breaching		●

The recommended plan (preferred alternative) incorporates some additional improvements that are not included in the NMFS 2000 Biological Opinion RPA, such as continued research and testing of BGS and SBC technology. The Corps believes the continued work on these improvements is biologically justified. See further discussion on this in Section 6.2.7.

6.1.3 Mitigation

Mitigation measures covering the range of impacts of the selected recommended plan (preferred alternative) are discussed throughout the FR/EIS and associated appendices. For example, various monitoring and evaluation measures are continuous efforts by the Corps to ensure that current and proposed operations or structural modifications are implemented in a manner that minimizes adverse impacts. However, unavoidable adverse impacts (i.e., erosion and sedimentation) result from competing needs among resources, project uses, and the mere fact that the dams and reservoirs exist. Impacts may result from operational changes that disrupt established uses dependent upon certain circumstances within a system. The ability to mitigate some unavoidable adverse impacts is limited due to the physical processes associated with the impact.

Since a portion of the recommended plan (preferred alternative) consists of existing system components, mitigation measures for current operations and structures are included. These measures include modifying dam operations to allow for spill, adjusting Dworshak flow for temperature control, adjusting the timing of barging juvenile salmon, and implementing modifications to structures to reduce negative effects to juveniles (i.e., TDG).

The recommended plan's (preferred alternative's) near- and long-term improvements have been reviewed for ways to mitigate adverse impacts. The impacts of the proposed structures have been found to have positive impacts on the environment (i.e., water quality and fish passage). However, potential impacts have been analyzed and conditions will be included to minimize adverse impacts to the extent possible. For example, the discharge of dredged or fill material into waters of the United States includes the implementation of mitigation measures that relate to placement of sidecast-dredged material, excavation, pre-casting concrete, dewatering areas by a cofferdam/bulkhead, water quality monitoring, actions such as controlling the amount and duration of discharge, and minimization of discharges and the performance of work in the winter months to minimize impacts to water quality. For further details, see Appendix T, Clean Water Act Section 404(b)(1) Evaluation.

In determining the appropriate mitigation measures to implement, the Corps considered the extent to which mitigation for the hydrosystem impacts is already occurring or is planned through other ongoing efforts and programs. Numerous other programs and actions are discussed throughout this document and its associated appendices. For example, the NMFS 2000 Biological Opinion sets forth almost 200 actions relating to the survival and recovery of the salmon. Many of these actions focus not only on the hydropower facilities, but also on habitat, hatcheries, and harvest activities. The Corps and the other Action Agencies have developed implementation plans to address the RPA action items listed in the NMFS and USFWS Biological Opinions.

6.2 Plan Selection Rationale

This section discusses key factors considered in selecting the recommended plan (preferred alternative). Many factors were considered during plan selection and some of the key factors are described in the following subsections.

6.2.1 High Current Juvenile Salmon Survival Rates Through the Lower Snake River Project

The Lower Snake River Project currently has high in river survival rate for juvenile spring/summer chinook salmon and steelhead. This was an important factor when determining what actions to take with four projects affecting only a small portion of a river system troubled with numerous other areas of concern for the salmon.

Snake River fall chinook salmon Lower Snake River Project survival has remained relatively low for in river passage, which is why transport is maximized for this stock. Project survival rates for Snake River spring/summer chinook salmon, fall chinook salmon, and steelhead are shown in Table 6-2. These data were taken from the NMFS 2000 Biological Opinion.

Table 6-2. Juvenile Survival by Dam (Percent Dam and Reservoir Survival)

Year	Lower Granite	Little Goose	Lower Monumental	Ice Harbor	McNary	John Day	The Dalles	Bonneville
Snake River Spring/Summer Chinook Salmon								
1994	93.6	83.0	84.7	89.0	85.8	77.3	84.5	82.9
1995	90.6	88.2	92.5	93.6	93.6	85.2	87.2	86.9
1996	97.9	92.6	92.9	87.0	87.0	84.4	86.9	87.0
1997	91.3	94.2	89.4	89.3	89.3	83.3	86.5	86.9
1998	92.4	98.5	85.3	95.7	95.7	82.2	87.7	88.0
1999	94.1	95.0	92.5	95.1	95.1	85.3	89.3	91.1
6-yr avg.	93.3	91.9	89.5	91.6	91.1	82.9	87.0	87.2
Snake River Fall Chinook Salmon								
1994	No data collected in 1994							
1995	66.8	89.0	79.5	87.8	82.0	73.8	81.5	80.4
1996	47.9	89.8	78.2	87.3	82.8	72.7	81.1	79.1
1997	35.3	56.6	64.4	63.5	54.6	34.0	63.9	50.4
1998	55.8	77.1	92.1	87.8	83.0	73.7	81.5	80.2
1999	76.6	66.5	89.0	80.4	74.3	59.5	76.2	70.3
5-yr avg.	56.5	75.8	80.6	81.4	75.3	62.7	76.8	72.1
Snake River Steelhead								
1994	90.0	84.4	89.2	90.8	88.2	81.3	85.8	85.0
1995	94.4	88.9	95.0	92.7	92.6	88.4	88.1	88.7
1996	93.4	93.8	93.7	88.9	88.9	86.0	87.3	87.8
1997	96.3	96.6	90.2	91.3	91.4	85.1	87.0	88.0
1998	92.5	93.0	88.9	89.3	89.3	83.1	89.7	91.8
1999	90.8	92.6	91.5	91.3	91.3	92.0	84.0	81.2
6-yr. avg.	92.9	91.7	91.4	90.7	90.3	85.8	87.0	86.9

Source: NMFS 2000 Biological Opinion, Table 6.2-7.
Values shown are estimates, based on juvenile survival studies by dam rather than adult returns, representing the expected performance of mixed (wild + hatchery) runs. Spring/summer chinook salmon and steelhead are yearling migrants and fall chinook salmon are subyearlings.

Even with the current (1994 to 1999) survival rates averaging 59 to 79 percent (83 to 99 percent per dam) for spring/summer chinook salmon, 8 to 42 percent (34 to 92 percent per dam) for fall chinook salmon; and 62 to 77 percent (81 to 97 percent per dam) for steelhead through this part of the lower Snake River (NMFS 2000 Biological Opinion, Table 6.2-7), future structural efforts to improve the migration is not expected to reverse the overall decline of the listed species. The CRI matrix analyses indicate the improvements in in river survival cannot, by themselves, reverse population declines in Snake River spring/summer chinook salmon. If any one of the considered hydropower alternatives is to reverse the population decline in Snake River spring/summer chinook salmon by itself, it would have to result in the survival of roughly an additional 5 to 10 percent of smolts that are currently dying in the estuary. The Corps is currently testing structural modifications to these dams (i.e., BGS, RSW) that have the potential to improve the passage over spillways. The planned improvements are expected to improve survival and assist in recovery. See Section 6.1.1.1, Structural Measures, for further details.

The PATH analyses suggest that breaching is more likely than any other change in the hydropower system to meet survival and recovery criteria for the listed species across the widest range of assumptions and scenarios. However, the PATH analyses did not determine whether breaching is necessary and/or sufficient for recovery. Under current conditions, focusing on reductions in mortality in the estuarine environment, or in the first year of life, may be more productive. The other areas adversely affecting salmon (habitat, hatchery, harvest) are discussed in the NMFS 2000 Biological Opinion. A key factor of fish survival research is the magnitude of the biological uncertainty. See Section 6.2.2 for further discussion.

6.2.2 Effectiveness of Structural Modifications

Consideration was given to the effectiveness of past efforts by the Corps. Since the 1970s, improvements and structural modifications have greatly reduced rates of decline in the listed species. The data indicate that the past improvements on these four dams have been and continue to be effective.

> "If such improvements *(past harvest, engineering improvements, and transportation program)* had not been made, rates of decline would likely have been 50 to 60 percent annually (Figure 8-9), and spring/summer chinook salmon could have disappeared from the Snake River. Hence, past management actions have reduced in river mortality, but have not reversed population declines (Kareiva et al., 2000)" – Appendix A, Anadromous Fish, page A8-35.

The common question is this: Is there sufficient biological rationale to continue to upgrade these facilities, or should the effort be focused on other projects (i.e., lower Columbia River projects)? The information indicates sufficient rationale to continue with some upgrades, but long-term efforts need to be tested and evaluated in a limited but highly focused timeframe before implementation at the lower Snake River dams. This is reflected in the recommended plan (preferred alternative). The NMFS 2000 Biological Opinion check-in points of 2003 and 2005 may also influence any future decisions for significant structural modifications.

The CRI analysis concluded that further improvements in spill and bypass systems or in transportation are unlikely to be adequate in themselves to rebuild the listed Snake River salmonid populations.

The improvements incorporated into the Adaptive Migration Alternative were formulated to improve survival and perhaps reduce stress in juvenile salmon and steelhead by:

- Maximizing operational flexibility by optimizing in river migration conditions and collection and transport conditions
- Improving the operational reliability of juvenile and adult fish passage facilities
- Reducing detrimental effects of TDG on juveniles by reducing the volume of voluntary spill.

There are several features that are included in the Corps' recommended plan (preferred alternative) that do not appear in the NMFS 2000 Biological Opinion. Most prominent among these are BGSs and SBCs with dewatering to allow for collection and transport at Lower Granite and Lower Monumental Dams. These two dams were chosen for these structures because Lower Granite is the first dam encountered by most outmigrating Snake River juveniles and additional fish enter the system at Lyon's Ferry Fish Hatchery and the Tuccanon River above Lower Monumental Dam. These passage structures, along with RSWs, have potential to improve juvenile fish passage survival and may be necessary in order to obtain the maximum amount of flexibility in the system. Regardless of the outcome of ongoing research to assess the benefits of fish transportation, there will be times when in river migration will be the best option for migrating fish. For example, recent transport research has shown a trend whereby fish that migrate in river tend to return at higher rates during the early part of the outmigration, while fish transported later in the season have a higher survival than in river migrating fish. During times when in river migration is the best strategy, it is desirable to have a bypass system that will pass a relatively large percentage of fish with a comparatively small amount of water. During times when in river migration is desired, the SBC would be shut off and used, along with the BGS, as a powerhouse occlusion device to direct fish to an RSW for passage to the tailrace. When maximum transport is desired, an SBC would be used, along with the existing turbine intake screen system, to maximize collection for transport.

Although the existing turbine intake screen systems currently divert a large percentage of fish, the addition of SBC technology is thought to offer several additional benefits. Prototype testing at Lower Granite revealed that an SBC could increase the percentage of fish collected by 7 to 14 percent for spring outmigrants. In addition to increasing collection efficiency, the SBC is thought to offer a less stressful route of collection and may result in less forebay delay for migrating fish. Fish collected and transported via SBC may experience less differential delayed transportation mortality due to reduced stress during collection. The SBC benefits may be even more dramatic for summer migrants. During testing in 1998, overall passage efficiency was increased by 16 percent with the addition of the BGS and SBC (Adams and Rondorf, 1999).

The RSW is projected to be installed in two spillway bays of all four lower Snake River dams (dependent upon future research on the effectiveness of these structures) to provide in river passage when desired. The RSW concept is being tested at Lower Granite Dam in 2002. If tests are positive, the RSW will pass a large percentage of fish with a

relatively small percentage of water. This will result in reduced dissolved gas levels in the river during periods of low to moderate flows in the spring. Fish passed over an RSW may also experience less stress and forebay delay than those passed through conventional spillways or bypass systems. Existing spillway passage requires fish to sound 50 feet and pass under a tainter gate at high speed, where the fish experience a dramatic pressure change. The RSW is an overflow weir that fish pass over at the same shallow depths at which they are naturally migrating. The RSWs at Lower Granite, Little Goose, and Lower Monumental would be used only when in river migration is desired (or when spread-the-risk strategy is being employed). The RSW at Ice Harbor Dam would be used during most or all of the outmigration since there is no provision for collection and transportation at Ice Harbor Dam.

Due to the presence of the navigation lock on the south side of the river at Little Goose, it was determined that a BGS would not work there. In lieu of a BGS, a "powerhouse occlusion" system could be installed that would discourage fish from entering the turbine intakes and allow them to discover the overflow passage of the RSW when in river passage is desired. The existing turbine intake screen system would be used for collection and transport at Little Goose Dam.

6.2.3 Uncertainty in Current Biological Information

There is a high level of biological uncertainty associated with the biological modeling information available. This magnitude of uncertainty was a key factor in the selection process. NMFS, in Appendix A, Anadromous Fish Modeling, discussed uncertainties and this section describes a few of the uncertainties that are considered to be critical.

The PATH and CRI analyses highlight differential delayed transportation mortality and extra mortality as critical uncertainties in the analyses. The efficiency of dam breaching for spring/summer chinook salmon is strongly affected by these two uncertainties. Dam breaching eliminates smolt transport from Lower Snake River Project, so differential delayed transportation mortality would not exist. Extra mortality would likely persist with breaching and the outmigrant population would be much more susceptible to seasonal flows and other factors.

The CRI analysis also highlighted an additional suite of critical uncertainties due to lack of data, including the possibility of attaining increased productivity with habitat management and of enhancing survival via improved hatchery practices or the control of salmonid predators. This analysis emphasized that apart from uncertainty about the effectiveness of different management actions, there is also uncertainty about the status and trend of wild salmon populations. The reason for this uncertainty involves the contribution hatchery fish make to recruits to natural spawning grounds.

There are a number of possible impacts associated with breaching that should be further addressed if dam breaching is reevaluated. These impacts include the effect on juveniles migrating through the lower Snake River during the same time that large amounts of sediments may also be present due to breaching. The amount of resuspended sediment may also affect adults returning to spawn. The effect of the proposed short-term trap-and-haul program (during dam breaching construction) on the survival of returning adults is yet another uncertainty.

The Corps reviewed, analyzed, and documented the best scientific information available at this time. The Corps has considered the uncertainties associated with the biological information and other information and has determined that there is sufficient information to proceed with selecting the recommended plan (preferred alternative).

6.2.4 Economic Effects

The evaluation of alternatives required a thorough assessment of the costs and benefits associated with each alternative. The most common areas of economic discussion relate to the loss of hydropower production, loss of navigation, loss of water supply, and the projected increase of recreational opportunities under a Alternative 4—Dam Breaching. These and other impacts are discussed in more detail in Chapter 5 of the FR/EIS. The recommended plan (preferred alternative was determined to minimize the net economic impacts in these areas.

In addition, the Basinwide Recovery Strategy, prepared by the Federal Caucus, references breaching on the Lower Snake River Project and states:

> ". . . its high cost could preclude other actions needed throughout the basin. The option of Snake River drawdown ranks as a lower priority than other available options because of the likely long time to implement, narrow benefits, biological uncertainties, and high costs."

6.2.5 NMFS and USFWS 2000 Biological Opinions

One of most critical factors in selecting an alternative was how it fits with the region's ongoing recovery efforts regarding salmon and other listed species. Many of these efforts are described in the NMFS and USFWS 2000 Biological Opinions. The Biological Opinions set forth RPA action items for the Action Agencies to implement these efforts. The alternatives were evaluated for consistency with the RPA action items and the Biological Opinions, in general. The NMFS 2000 Biological Opinion sets forth an aggressive non-breach agenda with almost 200 actions.

Of all the alternatives evaluated in the FR/EIS, the recommended plan (preferred alternative) most closely aligns with the measures in the NMFS 2000 Biological Opinion on the FCRPS for the Lower Snake River Project. For further information on consistency of the recommended plan (preferred alternative) with the Biological Opinions, see Section 6.1.2, Consistency with Biological Opinions.

6.2.6 Environmental Effects

The environmental effects, in addition to effects on anadromous fish, were considered in the selection of the recommended plan (preferred alternative) and are discussed in Section 6.4, Comparison of Alternatives, and in further detail in the rest of this FR/EIS and the appendices. The Summary Comparison chart in Section 6.4.2 shows a composite of the alternatives compared to the Existing Conditions. The environmental resource area that is the most controversial relates to water quality. Several of the issues and concerns involve potential sediment-related problems and the current water temperature and TDG conditions in the lower Snake River. These areas are individually discussed in Section 6.4.2. There is no single equation or formula that can be used to weigh and consider each of these resource areas and decide upon the proper balance or comparison. The degree to which each resource area is affected (directly, indirectly, or cumulatively)

was considered in the selection of the recommended plan (preferred alternative). Also, consistency and compliance with the NMFS and USFWS 2000 Biological Opinions was a critical component considered.

6.2.7 Social, Community, and Native American Indians

The selection of the recommended plan (preferred alternative) included consideration of impacts to the social structure of the project area and the tribal values of local Native American tribes.

Social analysis assessed the effects on the regional areas and local communities. Many factors were considered, such as jobs and environmental justice concerns. Based on the best information available, Adaptive Migration should have minimal overall social and community impacts.

The alternative selection process took into account the Northwest Treaty Tribes' fishing rights, the United States' trust responsibility to Tribes and its responsibility to act in a manner consistent with the trust responsibility. The actions that the Corps will implement under the recommended plan (preferred alternative) are designed to improve fish passage, increase fish survival, and assist in the recovery of the listed salmon species with beneficial results to the Treaty Tribes' fishery and benefits to the Northwest Region as a whole.

6.2.8 Regional Acceptability and Public Comments

The rationale for selecting the recommended plan (preferred alternative) was also based on analyses that addressed whether the alternatives were regionally acceptable and consistent with state and local laws and regulations. The acceptability of this alternative selection by states, other Federal agencies, stakeholders, special interests, local governments, tribes, and the general public was assessed through the public process, wherein comments of the parties were considered. The controversial nature of the alternatives lead to many diverse opinions concerning acceptability. The most common message from comments received was that efforts need to be made in the region to save the salmon from extinction and they need to be made in a timely manner. The second part of that message was there needs to be a solution where both salmon recovery and regional economics associated with hydropower can coexist. Northwest governors and other elected officials strongly support salmon recovery with economic stability. The many stakeholder organizations have definite opinions and either strongly support a non-breach or a breach alternative, as does the general public. The tribes generally support the breaching of these four dams. For review of these comments and responses, see Appendix U, Response to Public Comments. In an environment and societal context as described above, the recommended plan (preferred alternative) will be acceptable to some and not to others. Regarding state or local laws and regulations, the actions in the recommended plan (preferred alternative) are considered to be consistent. See Chapter 9 for more specifics. The most prominent issue relates to the Corps' responsibilities under the Clean Water Act. See the Water Quality Plan discussion in Section 6.5, Implementation, for further details.

6.2.9 Other Considerations

Other important factors that were considered include, but are not limited to:

- How the alternatives affect long-term and short-term productivity
- If there are irreversible and/or irretrievable commitment of resources
- If there are unavoidable adverse impacts
- If mitigation is needed or required
- Whether the best information or science was available
- Which alternative is environmentally preferable
- Whether the recommended plan (preferred alternative) is in accordance with declared policies of NEPA and in compliance with Federal laws and regulations.

Other factors involving technical feasibility were considered. Even though this is a very basic criterion, it is an extremely important one, in that the recommended plan (preferred alternative) must be constructible and implementable. Adaptive Migration as the recommended plan is both of these. Other factors regarding Alternative 4—Dam Breaching involved the ramifications of a lengthy implementation time and the cost of construction.

The rationale for selecting Adaptive Migration is a composite of analyses, information briefings, evaluations, hundreds of years of combined technical expertise, and comments concerning the factors that may or may not be affected by the alternatives discussed in the FR/EIS. The selection of the recommended plan (preferred alternative) resulted from the evolution and development of the extraordinary collection of scientific data and information presented in this FR/EIS, its associated appendices, and supporting research materials and reports. Although not without uncertainties, the information contained herein was the result of a phenomenal effort by thousands of people and, in the Corps' judgment, is the best available science and information to date and contains sufficient rationale for selecting this plan/alternative.

6.3 Plan Selection Process

This FR/EIS identifies a recommended plan (preferred alternative) and makes recommendations on implementation. This recommendation has been through rigorous technical, legal, and policy review and has been determined by the Corps to be consistent with appropriate methodologies, laws, regulations, and policies. However, the actual decision will not be made until a final public and agency review is completed and the comments received are considered in the preparation of a ROD.

The Corps decisionmaking process for civil works water resource projects is well established and hierarchical in nature. Typically, the process works from the bottom up. The initial recommendation contained in this report was made by the Walla Walla District Engineer because the FR/EIS was managed and prepared by the Walla Walla District. It should be noted that the recommended plan (preferred alternative) in this FR/EIS is consistent with existing project authorities. The Corps has the necessary Congressional authority to implement all the measures associated with the recommended plan (preferred alternative) and will not need additional authority.

Following the final public and agency review, the process goes to the Northwestern Division Engineer and, if appropriate, to Corps Headquarters (Chief of Engineers) and the Office of the Secretary of the Army for approval. The Assistant Secretary of the Army has the authority to delegate the development and signing of the ROD at a lower level when Congressional authorization is not necessary. It is assumed that the Northwestern Division Engineer, barring any significant changes in the recommended plan (preferred alternative), will sign the ROD, thereby designating the Division Engineer as the ultimate decisionmaker.

The project team, which assessed the effects and prepared the FR/EIS, has provided updates on the most current science and information throughout the study. This culminated in a number of executive briefings to ensure that the decisionmakers were fully aware of the effects and uncertainties for resources and users.

As noted above, this process incorporated significant input from tribes, agencies, and the public. The process to formulate a recommended plan (preferred alternative) started with the first public scoping meeting in July 1995. Since that time, the exposure to this study has been conducted in a variety of ways, including approximately 225 public meetings, workshops, tribal coordination/consultation meetings, public forums, and public speaking engagements. These meetings not only served to inform the tribes and public but also facilitated input that shaped the alternatives and effects on resource areas used in the selection process. Over 230,000 comment documents were received and reviewed on the Draft FR/EIS, which shows the extent of the interest in this study. The fact that each and every comment was considered before the determination of the recommended plan (preferred alternative) shows the importance of the involvement.

It was recognized early in the process that it was important to offset real or perceived biases internal to the Corps. To accomplish this, the Corps sought specific input from outside the organization on key resource areas. For example:

- Biology—the Corps relied on PATH and the NMFS Science Center for biological modeling to help quantify the biological effectiveness of the alternatives with regard to salmon. The USFWS Coordination Act Report provided extensive information evaluating the effects of alternatives on other fish and wildlife.
- Economic and Social Analysis—the Drawdown Regional Economic Workgroup (DREW) assisted the Corps in identifying important components, methodologies, and assumptions for the analysis.

Although not directly a part of the selection process, quality control and assurance procedures ensured that the information used in the selection process was appropriate and accurate. A multiple-layered approach was used to assure quality control. The key components consisted of the Independent Economic Advisory Board (IEAB) review of the economic and social analysis, an independent (private consultant) review of the engineering analysis for dam breaching, and an overall independent technical Corps review of the entire document. The FR/EIS also went through an intensive internal legal and policy review to ensure that the process was consistent with existing laws, regulations, and Corps policies.

6.4 Comparison of Alternatives

6.4.1 General

The method used to identify a recommended plan (preferred alternative) is similar to an environmental restoration study. The study's objective was to screen and evaluate structural alternative measures to improve migration of juvenile anadromous fish through the Lower Snake River Project. In addition, the results of the study are intended to assist in the recovery of ESA-listed salmon and steelhead stocks. Restoration studies differ from traditional studies only in that not all benefits are expressed in terms of monetary outputs. This is particularly appropriate when dealing with biological outputs related to species listed under the ESA.

Typically, the Corps bases plan selection on the Federal objective established in the Water Resource Council's Economic and Environmental Principles for Water Related Land Resources (February 3, 1983). The Federal objective is to contribute to national economic development (NED) "consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements." The intent is to select the plan that maximizes contributions to NED, referred to as the NED plan. This guidance is intended to ensure the development of sound economic and environmental water resource projects. Although a NED plan is not identified here, NED analysis was conducted and NED outputs are recognized. Cost efficiency, using both biological and NED monetary outputs, becomes an important consideration in the selection of a plan that has economic and environmental constancy.

Uncertainty is inherent in any planning effort, especially when the period of analysis spans 100 years as in this FR/EIS. Many of the potential biological, economic, and social effects of the alternatives are not known with certainty. Information might be unavailable, incomprehensive, 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. The relative importance of uncertainties depends on how they influence efforts to compare the potential benefits and costs of the alternative actions. Because of these unknowns, uncertainty in resource valuations was included to reflect lack of knowledge about true values, natural variability, or both.

Selection of a recommended plan (preferred alternative) is based upon the comparison of alternatives or trade-off analysis. This comparison process was developed to be transparent, easy to follow, and easy to understand. In the trade-off analysis, the effects (direct, indirect, and cumulative) associated with each alternative plan are explicitly compared and ranked (best to worst). Once the various differences have been described, it is possible to identify the plans from best to worst. For example, if one plan dominated all others by being the best in all categories, it is the best plan. A plan that is last in all categories is the worst plan. However, if no one plan dominates, this selection and ranking process fundamentally becomes unclear, and the default in this instance is to select the plan that is most consistent with or best supports the NMFS 2000 Biological Opinion RPA.

6.4.2 Trade-Off Analysis

This section summarizes and compares the differences between each alternative plan by each specific resource area. As mentioned earlier, the effects associated with each alternative plan are explicitly compared and ranked (best to worst).

There are dozens of resources and users affected by the various alternative plans. Each alternative studied was evaluated using an interdisciplinary approach, which integrated natural and social sciences, on how it would affect the resources and users of the Lower Snake River Project. These effects were considered and compared as part of this trade-off analysis. The point was to identify the differences among plans. The discussions below explain these differences, their significance, and critical components in the identification of a recommended plan (preferred alternative).

In most cases, the resource and user effects were quantified; however, there was no one unit of measure to quantify all of these effects. Since these units are not all commensurate, the trade-offs associated with the resources and users become an important part of the plan selection process. Some resource effects used intangible or unquantifiable units or scales, such as tribal land use, cultural resources, aesthetics, etc.

6.4.2.1 Aquatic Resources—Anadromous Fish

Aquatic resources are divided into two sections—anadromous fish and resident fish. This section focuses on anadromous fish, specifically the ESA-listed species. A summary comparison of the alternatives with respect to the effects on anadromous fish is shown in Table 6-3.

Endangered and Threatened Salmon Populations

The purpose and need of this study is to improve ESA-listed salmon migration through the Lower Snake River Project and assist with recovery. In order to do this, the actions implemented must be capable of achieving performance goals set forth for these species by the NMFS 2000 Biological Opinion. The identification of a recommended plan (preferred alternative) is extremely difficult because of the problems with quantifying the effects of each alternative due to the uncertainties. Numerous positions exist on the subject; however, the science has not presented an overriding "silver bullet" preference among the alternatives. The uncertainties described by PATH and NMFS, along with the narrow focus of hydropower actions alone without the other Hs, and the modeling process in general, add to the difficulty. It should be noted that, in general, the scientific modeling process uses a wide array of assumptions to characterize non-specific or missing data for biological processes and effects, which compounds uncertainties. The more complex the model, the greater the number of assumptions that must be described and validated. In contrast, a model that is too simple could lack the most important variable or process needed to predict life stage survival or likelihood of recovery.

During the 1970s when all the lower Columbia River and lower and middle Snake River dams (Federal and non-Federal) were completed, the estimated in river survival rate for spring/summer chinook salmon was 5 to 40 percent. However, system survival rates for 1999 indicate in river passage survival has increased to a rate of 45 to 62 percent for spring/summer chinook salmon and 42 to 54 percent for steelhead. This is as high as it was in the 1960s when only four dams (Bonneville, The Dalles, McNary, and Ice Harbor) were in place for Snake River fish to pass on their way to the ocean (NMFS,

1999a). With the addition of the juvenile fish transportation program and structural improvements, direct survival within the hydrosystem increased significantly, particularly within the Lower Snake River Project.

Implementation of numerous measures can account for the improvements seen in survival. These include increased spill, increased flow, the juvenile fish transportation program, operation of turbines at peak efficiencies, flow deflectors, new extended-length screens, modifications to fish bypass facilities, and extended operations of bypass screens. Even with these improvements and the increased numbers of fish being successfully passed to below Bonneville, the numbers of wild adults continue to remain low. Current direct mortality rates cannot explain why wild adult returns are low. As a result, indirect mortality has become a critical factor and uncertainty in hydrosystem migration evaluations.

The Corps supports NMFS' anadromous fish evaluation documented in Appendix A, Anadromous Fish Modeling. As part of this Feasibility Study effort, NMFS primarily utilized the quantitative and qualitative efforts by PATH to analyze a series of alternatives using two passage models to compare passage success through the lower Snake River and one model to analyze the lifecycle of the salmon. NMFS interpreted the information developed by the PATH process, incorporated current (since 1990) empirical research in salmon and steelhead returns, and developed the CRI. Their conclusions are presented in Appendix A, Anadromous Fish Modeling, and summarized below.

The PATH Analyses

The PATH analyses suggest that breaching is more likely than any other change in the hydropower system to meet survival and recovery criteria for the listed species across the widest range of assumptions and scenarios. However, PATH analyses did not determine whether breaching is necessary and/or sufficient for recovery. The critical issue in the PATH conclusion concerns inclusion of: (a) the assumption that transportation of fish in barges leads to a significant differential delayed transportation mortality after the fish are released below Bonneville Dam, and (b) that passage through the hydrosystem by non-transported fish causes a significant extra mortality after fish have passed Bonneville Dam and moved into the estuary and ocean. Refer to Appendix A, Anadromous Fish Modeling, for further details.

The CRI Analyses

To complement the PATH process, NMFS undertook an additional analytical approach referred to as the Cumulative Risk Initiative (CRI). The CRI was intended to focus on areas not addressed by the PATH process. One such area includes providing an estimate of the risk of extinction for index populations. A second area of consideration was a more comprehensive set of potential management actions, which included actions outside the hydrosystem.

Unlike PATH, the CRI analyses suggest that no single management action is likely to result in sufficiently improved conditions for spring/summer chinook salmon. For dam breaching alone to recover spring/summer chinook salmon, it would have to produce improvements in estuarine and early ocean survival substantially (from approximately 2 to 10 percent), which is highly unlikely. The CRI analyses suggest that a combination of

improvements spread throughout the lifecycle and attained by a mixture of different management actions could promote adequate annual population growth for spring/summer chinook salmon. Numerical experiments indicate that small improvements in survival in the first year of life in the freshwater streams and the first year spent in estuarine and ocean areas will yield the greatest rewards in terms of enhanced population growth. Moreover, if many improvements are added together, CRI analyses suggest that annual rates of population growth could be increased enough that stocks of spring/summer chinook salmon could rebuild. The management actions that might produce these improvements include restoring habitat, reducing predation pressure in reservoirs and the estuary, potentially manipulating the time and release position of downstream migrants, improving water quality, mitigating for negative hatchery impacts, continuing harvest restrictions, and dam breaching. However, no single "silver bullet" solution is supported by the data when it comes to spring/summer chinook salmon.

Biological Conclusions

There is some degree of uncertainty associated with the information available to conduct the biological modeling and to predict future outcomes of the analyzed alternatives. The following conclusions are documented in Appendix A, Anadromous Fish Modeling:

- The PATH analyses suggest that breaching is more likely than any other change in the hydropower system to meet survival and recovery criteria for the listed species across the widest range of assumptions and scenarios. However, the PATH analyses did not determine whether breaching is necessary and/or sufficient for recovery.
- The CRI matrix analyses indicate the improvements in in river survival cannot, by themselves, reverse population declines in Snake River spring/summer chinook salmon. However, past improvements have greatly reduced rates of decline. Under current conditions, reductions in mortality on the order of 5 to 10 percent are needed in the estuarine environment or in the first year of life. What this means is that, if the removal of four lower Snake River dams is to reverse the population decline in Snake River spring/summer chinook salmon by itself, it would have to result in the survival of roughly 5 to 10 of every 98 smolts that are currently dying in the estuary.
- The CRI analyses conclude that further improvements in spill and bypass systems or in transportation are unlikely to be adequate in and of themselves to rebuild the threatened and endangered lower Snake River salmonid populations.
- Both PATH and CRI analyses highlight differential delayed transportation mortality and extra mortality as critical uncertainties in the analyses. The efficiency of dam breaching for spring/summer chinook salmon is strongly affected by these two factors.
- The CRI analyses highlight an additional suite of critical uncertainties due to lack of data, including the possibility of attaining increased productivity with habitat management, and enhancing survival via improved hatchery practices or the control of salmonid predators.

Table 6-3. Resource Valuation for Aquatic Resources—Anadromous Fish

	Criteria	Scale	Best	Existing Conditions	Alternatives [a/] Maximum Transport	Adaptive Migration	Dam Breaching
Anadromous							
S/S Chinook Salmon							
Population Growth Index	Lambda[b/, c/]	0.98 to 1.10	> 1.0[d/]	0.98-1.01/ 0.88-1.05	1.03-1.08/ 0.93-1.13	1.03-1.08/ 0.93-1.13	1.04-1.10/ 0.95 1.14
System Juvenile Survival (T)[e/]	Percent[f/]	27.0 to 65.0	100	27-52(50-64)/Lo	35-62 (51-65)/Med	35-62 (51-65)/Med	40.5-63.7(n/a)/Med
System Adult Survival	Percent	83.0 to 86.0	100	83/75-87	86/78.5-90.5	86/78.5-90.5	86/88.0-93.3
Critical Habitat[h/]	Percent Change	-35.0 to 0.0	+100	P: -35 to -15/Hi	p: -35 to -25/Hi	P: -25 to -10/Med	P: -10 to 0.0/Lo
Fall Chinook Salmon							
Population Growth Index	Lambda [b/, c/]	0.87 to 1.05	> 1.0[d/]	0.87-0.92/NAD[g/]	0.93-1.03/NAD	0.93-1.03/NAD	0.95-1.05/NAD
System Juvenile Survival (T)[e/]	Percent[f/]	0.5 to 37.0	100	0.5-16(6-16)/Med	1-22(8-16)/Med	1-22(8-16)/Med	23-37(n/a)/Med
System Adult Survival	Percent	71.0 to 74.0	100	71/60.7-81.3	74/63.7-84.3	74/63.6-84.3	74/77.9-90.2
Critical Habitat[h/]	Percent Change	-45 to 0.0	+100	P: -40 to -20/Hi	P: -45 to -25/Hi	P: -25 to -15/Med	P: -20 to 0.0/Med
	Percent Change	-70 to -10	+100	R: -60 to -40/Med	R: -70 to -50/Hi	R: -40 to -25/Med	R: -30 to -10/Med
	Percent Change	-95 to -10	+100	S: -90 to -90/Lo	S: -95/Lo	S: -90/Lo	S: -20 to -10/Med
Steelhead							
Population Growth Index	Lambda [b/, c/]	0.74 to 0.94	> 1.0[d/]	0.74-0.83/NAD	0.77-0.90/NAD	0.77-0.90/NAD	0.75-0.94/NAD
System Juvenile Survival (T)[e/]	Percent	32.0 to 65.0	100	32-46(45-52)/Med	42-58(46-55)/Med	42-58(46-55)/Med	41-65(n/a)/Hi
System Adult Survival	Percent	77.3 to 80.3	100	77.3/73-79.6	80.3/76-82.6	80.3/76-82.6	80.3/88.4-2.2
Critical Habitat[h/]	Percent Change	-35 to 0.0	+100	P: -35 to -15/Hi	P: -35 to -25/Hi	P: -25 to -10/Med	P: -10 to 0.01/Lo
	Percent Change	-45 to -5	+100	R: -40 to -20/Hi	R: -45 to -25/Hi	R: -25 to -15/Med	R: -10 to -5/Med
Sockeye Salmon	Impacts	Hi, Med, Lo	Lo	Med/Med	Med/Hi	Med/Med-Hi	Lo/Hi
Lamprey	Impacts	Hi, Med, Lo	Lo	Hi/Hi	Hi/Hi	Med/Med	Lo/Lo

a/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a percent with 0% the least uncertainty; or as Hi, Med, Lo, with Lo uncertainty the best; or, in the case of lambda, there was a range of uncertainty around the values presented. The slanted line separates the effect and the uncertainty.

b/ Lambda numbers are based on average lambda of the index stocks as reported in Table 9.7-6, NMFS 2000 Biological Opinion. The low number represents assumption that hatchery origin natural spawners have been 80% effective as wild spawners historically. The high number represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.

c/ The range reflects lowest and highest lambda of the index stocks. Uncertainties in lambda do not include uncertainties in D. The uncertainty is based on empirical PIT-tag evaluations for non-breaching alternatives, but based on survival per kilometer estimates for Dam Breaching.

d/ A lambda >1.0 indicates an increasing population growth index; a lambda <1.0 indicates a declining population growth index.

e/ The number outside the parentheses represents percent system juvenile survival without transportation; the number in the parentheses represents percent system juvenile survival with transportation. Ranges come from Table 9.7-5 in NMFS 2000 Biological Opinion.

f/ First number is in river average, parentheses are total system with low and high D. However, for dam breaching there is no D and there is a range for in river survival. See Table 9.7-1 in NMFS 2000 Biological Opinion.

g/ NAD indicates No Available Data. (n/a) indicates not available.

h/ Percent critical habitat is described in terms of passage (P), rearing (R), and spawning (S). The numbers represent a change from pre-dam conditions. The numbers can range from a percent loss (-) in habitat to a percent gain (+) in habitat. Pre-dam condition is represented by 0.0.

- The CRI analyses emphasize that, apart from uncertainty about the effectiveness of different management actions, there is also uncertainty about the status and trend of wild salmon populations. The reason for this most basic uncertainty is uncertainty about the contribution hatchery fish make to recruits to natural spawning grounds.
- There are a number of possible impacts associated with breaching that NMFS has not adequately accounted for in the CRI analysis or other analyses. These include the effect of sediment on not only juveniles migrating out of the lower Snake River while excess sediments are moving out, but also the effect on adults attempting to return up the lower Snake River to spawn, and the effect of the trap-and-haul program on the survival of returning adults during dam breaching construction activities.

The NMFS 2000 Biological Opinion

The NMFS has determined the current operation and configuration of the FCRPS are likely to jeopardize the continued existence of the listed ESUs and adversely modify designated Critical habitat. As a result, the NMFS 2000 Biological Opinion has recommended an RPA which identifies actions that, combined with other ongoing and anticipated measures, will likely ensure survival and recovery.

The following two alternatives are not compatible with implementation of the RPA in NMFS 2000 Biological Opinion:

- Alternative 1—Existing Conditions does not meet non-jeopardy guidelines as set forth in the NMFS 2000 Biological Opinion RPA. NMFS has determined in the 2000 Biological Opinion that the operation and configuration of the FCRPS is likely to jeopardize the continued existence of the Snake River spring/summer chinook salmon, the Snake River fall chinook salmon, the Snake River steelhead, and the Snake River sockeye salmon ESUs and to adversely modify their designated critical habitat.
- Alternative 2—Maximum Transport of Juvenile Salmon does not fulfill the 2000 Biological Opinion RPA hydropower actions performance standards. NMFS has identified a set of hydropower actions that would achieve the FCRPS hydropower performance standards. Included are spillway improvements that will allow for enhanced spill, which leads to continuation of spill at collector projects to maximize the survival rate of in river migrants. Maximum transport calls for minimizing in river migration and eliminating voluntary spill, which conflicts with the hydropower performance standards. In addition, the delayed differential transportation mortality values evaluated in the region have such high uncertainty associated with them that additional data collection and monitoring is needed to resolve the uncertainty.

The USFWS 2000 Biological Opinion

USFWS recommended changes in operation of the FCRPS that were focused on the upper Columbia River due to impacts to bull trout and Kootenai River white sturgeon in the upper reaches of the basin. The USFWS concurred with action agency determination of "not likely to adversely affect" for the listed mammal and plant species. The listed invertebrate species have previously been consulted upon by BOR; however, further discussions will occur between the USFWS and BOR on these species.

Very little is known about the lifecycle requirements for lamprey as associated with reservoirs. The USFWS Coordination Act Report has identified a number of monitoring actions at the dams and has set the need for lamprey research, which will help with understanding the needs of lamprey. However, it is anticipated that a more natural river system would be better for the lamprey. Bull trout are addressed in the following section.

6.4.2.2 Aquatic Resources—Resident Fish

Resident fish were chosen to represent other aquatic resources because they could represent the productivity of the system in terms of biomass, which would be reflective of all aquatic organisms. The results of the various analyses identified that biomass density would likely increase by 60 percent (Table 5.4-8) under Alternative 4—Dam Breaching; however, the total biomass would probably decline because the surface area of the lower Snake River would decrease by about 58 percent (Section 5.4.2.4). The change in biomass between alternatives is negligible, making this resource area not critical to plan selection. However, it is generally anticipated that native species would benefit from dam breaching.

Research concerning non-anadromous ESA-listed species (e.g., bull trout) within the Lower Snake River Project is limited, and further work is needed.

The USFWS 2000 Biological Opinion has identified a number of monitoring actions at the dams and has set the need for bull trout research, which will help with understanding the location and needs of bull trout. However, it is expected that a more natural river system would be better for bull trout. Table 6-4 summarizes resource valuation for aquatic resources.

6.4.2.3 Water Resources

Water is an extremely important resource and its quality is a key factor in formulating a recommended plan (preferred alternative). Elements of water resources that were considered include, but are not limited to, those specifically discussed here: sediment, temperature, dissolved gas, and contaminants. Resource valuation for water resources is presented in Table 6-5.

Table 6-4. Resource Valuation for Aquatic Resources—Resident Fish

				Alternatives [1/]			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Adaptive Migration**	**Dam Breaching**
Resident							
Native Species	Native Species	Percent	100	79/Lo	79/Lo	79/Lo	86/Lo
Recreational Fishery	Potential	Hi, Med, Lo	Hi	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo
ESA Fish Species (Bull Trout)	Impact	Hi, Med, Lo	Lo	Lo/Med	Lo/Med	Lo/Med	Lo/Med

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as Hi, Med, Lo, with Lo being the least uncertain. The slanted line separates the effect and the uncertainty.

The effect of sediment is considered significant in the short term under Alternative 4—Dam Breaching. An estimated 50 percent of the 100 to 150 million cubic yards (MCY) of sediment behind the lower Snake River dams would be eroded, resuspended, transported, and re-deposited in Lake Wallula behind McNary Dam. Sediment transfer would be at its highest levels during the first 2 to 3 years following breaching; however, it could continue for up to 10 years after breaching, until the river system stabilizes. The impact of sediment movement in potentially large waves or smaller waves drawn out over time would adversely effect the anadromous fish species in the lower Snake River and potentially those reservoirs below the lower Snake River. Over time, Lake Wallula may require increased dredging operations for the purposes of clearing navigation lanes and water intakes. The non-breach alternatives would continue to have incoming sediment (3 to 4 MCY per year), but would not increase the movement within the lower Snake River system.

The water temperature has historically been seasonally high in the lower Snake River due to high water temperatures contributed by the Salmon, Grande Ronde, and upper Snake Rivers. The number of 20 ^{o}C exceedance days is likely to be similar under all alternatives. The difference between non-breach and breach alternatives is a shift in the temperature regime. The existence of the dams and reservoirs shift, the warming of temperatures a few weeks later into the year than they occurred historically. Pre-reservoir conditions have been documented as having higher maximum temperatures than occurs currently. The temperatures currently do not rise as high but stay warm longer in the summer and fall. Figure 6-1 shows temperature with and without dams since Dworshak flow augmentation.

The cold-water releases from Dworshak Dam have had a cooling effect on temperatures in the upper part of Lower Granite Lake; however, this is not without complications. There are concerns about the negative effect to outmigrating fall chinook salmon in the Clearwater River, which tend to hold rather than migrate because of the cold water augmentation. Dissolved gas would be reduced under Alternative 4—Dam Breaching because of the elimination of all dam-related spill operations (voluntary and involuntary). The occurrence of TDG above 110 percent is expected to be geographically localized and would occur much less frequently and for shorter durations. This benefit to spring/summer chinook salmon is important; however, it is not a strong contributor to survival of migrating salmonids. NMFS continues to affirm in the 2000 Biological Opinion that a spill program, even with occasional concentrations higher than 120 percent TDG in the tailrace, will would increase the survival of migrating salmonids. Both Alternative 2—Maximum Transport and Alternative 3—Major System Improvements (Adaptive Migration) reduce voluntary spill requirements, thus reducing the frequency of exceedence above 110 percent.

Chemicals of concern that are located in the reservoir sediments include total DDT, ammonia, dioxin TEQ, and manganese. As long as these chemicals are not resuspended, as with the non-breach alternatives, there is little concern or effect. However, dam breaching could lead to resuspension. Of the chemicals of concern identified, ammonia could prove to have the greatest toxic effect to the aquatic environment. Other contaminants would be monitored over time due to shifts in land use practices (i.e., changing agriculture products).

Of these four elements measured, dissolved gas and sedimentation may have an effect on selection criteria. Contaminants need to be monitored for conditions under which they can have either harmful or lethal effects. A more comprehensive chemical/contaminant analysis would be required before dam breaching could be implemented. Temperatures in the lower Snake River have historically been warm and the alternatives considered are not believed to alter the historical trend in a significant way.

The Clean Water Act Appendix includes the 404(b)(1) evaluation (Appendix T). Impacts from actions (which include a discharge of dredged or fill material) proposed in the recommended plan (preferred alternative) were analyzed for consistency with the 404(b)(1) guidelines and were found to be consistent.

The most current water resources controversy is regarding the Clean Water Act. This controversy is the focus of a lawsuit, *National Wildlife Federation* v. *U.S. Army Corps of Engineers*, Civ. #99-442-FR (D. Or., 2001). This lawsuit challenges the Corps' Clean Water Act compliance in the Lower Snake River. It is the Corps' belief that its actions are in compliance with the Clean Water Act. Alternative 1—Existing Condition will not change this determination. Alternative 2—Maximum Transport would reduce TDG due to the reduced need for voluntary spill and Adaptive Migration would add structural modifications that would actually improve water quality conditions. Alternative 4—Dam Breaching is the least predictable and further study on water quality parameters would need to be completed before implementation of dam breaching.

6.4.2.4 Air Quality

Of the air quality parameters evaluated, three key areas are included here: fugitive dust emissions, emissions associated with replacement power generation, and changes in transportation-related emissions. For all of these parameters, there would be no change for the non-breach alternatives. Alternative 4—Dam Breaching results in increases in all these areas. Resource valuation for air quality is shown in Table 6-6.

Fugitive dust emissions would occur during dam breaching construction, but this is a short-term effect that occurs in a fairly localized area. Another short-term effect is related to exposure of previously inundated land masses with large amounts of available erodible material. It is estimated that this would result in an overall 1 percent increase of fugitive dust sources. This is not considered to be significant when compared to current background level in this highly agricultural area.

Transportation-related emissions would change very little even though there is a shift in mode of transportation-reduced barge traffic and increased truck and train traffic. The change is considered negligible.

Breaching would result in an estimated increase of 1 percent in carbon dioxide (CO_2) emissions for all regions of the Western System Coordinating Council (includes the western United States and parts of Canada and Mexico). This is associated with replacement power generation facilities. Although a small increase, it remains a concern because of the potential increase in greenhouse gases within the region. The actual siting of power generation facilities can have a more localized effect, but siting cannot be accurately predicted within this study. Because of the potential for replacement power generation facilities to impact regional air quality, air quality resources may somewhat influence the selection criteria.

Table 6-5. Resource Valuation for Water Resources

	Criteria	Scale	Best	Alternatives [1/] Existing Conditions	Maximum Transport	Adaptive Migration	Dam Breaching
Temperature	Days Exceedence	Above 20 °C	0	50-70/10-20%	50-70/10-20%	50-70/10-20%	55-65/10-20%
Dissolved Gases	Days Exceedence	Above 110%	0	130-170/70-80%	30-50/40-50%	30-50/40-50%	0/10%
Sediment							
Short-term (2-5 years)	TSS mg/L	20 - 9,000	0	20-1,000/40-70%	20-1,000/40-70%	20-1,000/ 40-70%	5,000-9,000/40-70%
Long-term	TSS mg/L	20 - 9,000	0	20-1,000/40-70 %	20-1,000/40-70 %	20-1,000/40-70 %	20-1,000/40-70 %
Total Volume Transported	MCY Above Annual Load	0 - 75	0	0/0%	0/0%	0/0%	50-75/10-20%
Contaminants							
DDT	mg/L Resuspended	0 - 1.7	0	0/0%	0/0%	0/0%	1.6-1.7/50-70%
Ammonia	mg/L Resuspended	0 - 5	0	0/0%	0/0%	0/0%	3-5/50-70%
Manganese	mg/L Resuspended	0 - 1,400	0	0/0%	0/0%	0/0%	400-1,400/ 50-70%
Zinc	mg/L Resuspended	0 - 38	0	0/0%	0/0%	0/0%	14-38/50-70%

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a percent with 0% the least uncertainty. The slanted line separates the effect and the uncertainty.

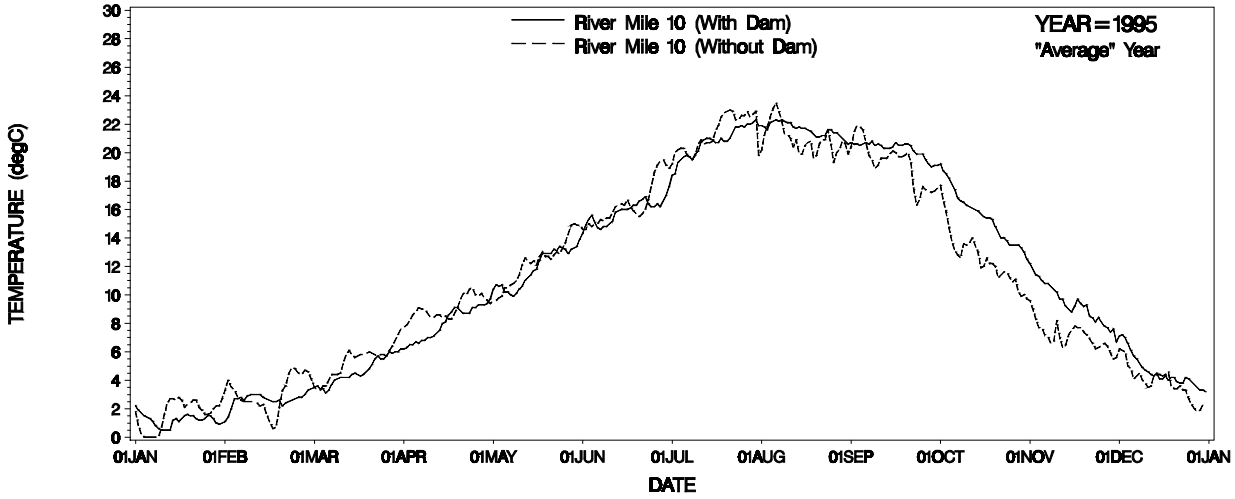

Figure 6-1. Lower Snake River Water Temperatures for an "Average" Water Year at River Mile 10. Predicted By RBM10, with and without Lower Snake River Dams, for Years Since Dworshak Flow Augmentation

Table 6-6. Resource Valuation for Air Quality

				Alternatives [1/]			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Adaptive Migration**	**Dam Breaching**
Fugitive Dust	PM_{10}	% Increase	0	0/Lo	0/Lo	0/Lo	1/Med
Greenhouse Gases	CO_2	% Increase	0	0/Lo	0/Lo	0/Lo	1/Lo
Transportation Emissions	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Med/Lo
AAQS	Compliance	Yes, No	Yes	Yes/Med	Yes/Med	Yes/Med	Yes/Med

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as Hi, Med, Lo, with Lo uncertainty the best. The slanted line separates the effect and the uncertainty.

6.4.2.5 Terrestrial Resources

Terrestrial resources are characterized by habitat and wildlife. Both habitat and wildlife effects at the existing dams and reservoirs on the lower Snake River are being mitigated per the existing Comp Plan (Appendix L, Lower Snake River Mitigation History and Status). Mitigation goals are described in terms of habitat units. These habitat units represent habitat quality and quantity prior to the Lower Snake River Project being developed. Under the non-breaching alternatives, mitigation goals would not likely change, nor would the approach to implementation of the goals. Whether full mitigation is likely to occur without additional efforts was considered. Alternative 4—Dam Breaching is thought to be more likely to meet mitigation goals. Resource valuation for terrestrial resources is summarized in Table 6-7.

Table 6-7. Resource Valuation for Terrestrial Resources

	Criteria	Scale	Best	Alternatives [1/]			
				Existing Conditions	Maximum Transport	Adaptive Migration	Dam Breaching
Habitat							
Wetlands	Acres	294 to 963		963	963	963	294
Riparian	Acres	1,804 to 3,285		1,804	1,804	1,804	3,285
Uplands	Acres	18,150 to 30,589		18,150	18,150	18,150	30,589
Wildlife							
Game Birds	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Hi-Lo/Lo-Med
Waterfowl	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Hi-Med/Lo-Med
Shore Birds	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Lo-Med/Lo-Med
Colonial Nesting Birds	Impacts	Hi, Med, Lo	Lo	Hi/Lo	Hi/Lo	Hi/Lo	Med-Hi/Lo-Med
Raptors	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Med-Lo/Lo-Med
Other Non-game Birds	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Hi-Lo/Lo-Med
Mammals	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Hi-Lo/Lo-Med
Amphibians & Reptiles	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Hi-Lo/Lo-Med
ESA Plant Species	Impacts	Hi, Med, Lo	Lo	Hi/Lo	Hi/Lo	Hi/Lo	Med/Lo
ESA Wildlife Species	Impacts	Hi, Med, Lo	Lo	Med/Lo	Med/Lo	Med/Lo	Lo/Lo

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a Hi, Med, Lo, with Lo uncertainty the best. The slanted line separates the effect and the uncertainty.

The change in terrestrial resources between alternatives is not a large one; however, there would be a short-term impact that would take 20+ years to recover from under Alternative 4—Dam Breaching.

Other known non-anadromous ESA-listed wildlife and plant species within the Lower Snake River Project are not anticipated to be further affected by any of the alternatives.

However, the presence of a reservoir does limit habitats conducive to some listed wildlife and plant species. A near-natural river would likely support these listed species better than a reservoir.

6.4.2.6 Cultural Resources

There are numerous cultural resource sites within the Lower Snake River Project. Non-breach alternatives would keep these cultural resource sites inundated and, thereby, protected but not preserved. Depending upon the location of the cultural resources, there are erosive processes and biochemical processes that will continue to degrade the resource with or without dam breaching. In addition, the resource is not accessible for either tribal culture purposes or scientific documentation. Alternative 4—Dam Breaching would have a higher rate of site exposure. Exposure of the sites could lead to vandalism, theft, erosion, bank slumping, lateral displacement, trampling by hoofed animals, climatic cycles, and biochemical soil changes. There are pluses and minuses to both conditions. Resource valuation for cultural resources is summarized in Table 6-8.

Table 6-8. Resource Valuation for Cultural Resources

				Alternatives [1/]			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Adaptive Migration**	**Dam Breaching**
Site Access							
Shore Zone/Reservoir Fluctuation Zone	Accessibility	Yes, No	Yes	Yes	Yes	Yes	Yes
Inundation Zone	Accessibility	Yes, No	Yes	No	No	No	Yes
Site Impacts							
Shore Zone	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Lo/Lo
Reservoir Fluctuation Zone	Impacts	Hi, Med, Lo	Lo	Hi/Lo	Hi/Lo	Hi/Lo	Lo/Lo
Inundation Zone	Impacts	Hi, Med, Lo	Lo	Med/Med	Med/Med	Med/Med	Med/Med

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a Hi, Med, Lo, with Lo uncertainty the best. If the first entry is Yes or No, there is no uncertainty identified. The slanted line separates the effect and the uncertainty.

6.4.2.7 Electric Power

The Lower Snake River Project has a peaking capacity of 3,033 megawatts (1,200 megawatts average annual generation), which accounts for approximately 5 percent of the energy produced in the Pacific Northwest. Alternative 2—Maximum Transport and Alternative 3—Major System Improvements (Adaptive Migration) would slightly increase the average annual power generation due to reduced voluntary spill for fish passage purposes. Alternative 4—Dam Breaching would eliminate all power production at these four dams. The average annual cost to replace the foregone power is approximately $270 million (estimated over the economic project life of 100 years). The power economic effects, by alternative, and the associated uncertainties are shown on Table 6-9.

6.4.2.8 Transportation (Navigation)

Approximately 4 million tons of cargo are shipped by barge through the Lower Snake River Project annually. The vast majority (78 percent) are grain products (wheat and barley). The non-breach alternatives would not change this navigation activity. Alternative 4—Dam Breaching would eliminate commercial navigation on the lower Snake River. This would require shifting from barge to truck and rail transportation, resulting in an estimated increase of $38 million in transportation costs annually for the 100-year economic project life. This cost and the associated uncertainties are shown on Table 6-9.

6.4.2.9 Recreation and Tourism

There are 33 developed recreation sites along the lower Snake River reservoirs. Approximately two million visitors currently use these sites annually. The non-breach alternatives would have no effect on recreation. Alternative 4—Dam Breaching would change regional recreation activities, resulting in an estimated $71 million in additional annual benefits for the 100-year economic project life. The recreation economic effects, by alternative, and the associated uncertainties are shown on Table 6-9.

6.4.2.10 Water Supply/Irrigation

There are 12 pumping stations near Ice Harbor Dam that irrigate approximately 35,000 acres. There are 8 other municipal and industrial pumping plants along the Snake River. In addition, some irrigation water comes from wells, which are influenced by the reservoirs. There would be no change to these users with the non-breach alternatives.

Alternative 4—Dam Breaching would result in an average annual economic cost of approximately $15 million due to the elimination and/or modification to these facilities for the 100-year economic project life. The economic effects, by alternative, and the associated uncertainties are shown on Table 6-9.

6.4.2.11 Commercial Harvest

Commercial fishing benefits were estimated as a result of increased fish runs for the various alternative actions. These estimates include the increased tribal commercial harvest as well. Compared to the other economic effects, those related to increased commercial fishing were not considered to be significant, with Alternative 4—Dam

Table 6-9. The NED Economic Valuations [1/]

	Criteria	Scale	Best	Alternatives [2/]			
				Existing Conditions	Maximum Transport	Adaptive Migration	Dam Breaching
Power Production	Minimize Cost	18,191 to 18,471 M	18,191	18,200.00	18,191.50	18,191.50	18,471.00 / 18,451-18,491
Navigation	Minimize Cost	182.40 to 220.20 M	182.4	182.40	182.40	182.40	220.20 / 210.2-237.1
Recreation	Maximize Benefit	51.50 to 121.70 M	121.7	51.50 / 40.8-85.5	52.80 / 41.7-87.5	52.80 / 41.7-87.5	122.75 / 62.5-372.7
Water Supply/Irrigation	Minimize Cost	0 to 15.40 M	0	0.00	0.00	0.00	15.40 / 13.9-16.9
Implement/Avoided Costs	Minimize Cost	84.4 to 110.72M	84.4	87.8 / 83.5-90.7	84.4 / 80.2-88.6	110.72 / 105.2-116.2	103.75 / 92.4-112
Commercial Harvest	Max. Benefit	2.80 to 5.01 M	5.01	2.80	3.14	3.13	5.01
Net [3/]	Minimize Cost		18,341.1	18,415.9 / 18,377.6-18,429.5	18,402.4 / 18,363.5-18,417.7	18,428.7 / 18,388.5-18,445.3	18,683.6 / 18,389.8-18,789.3

1/ These costs have been amortized over a 100-year economic life using a discount rate of 6.875%.
2/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect. The slanted line separates the effect and the uncertainty.
3/ Net costs are a summation of the economic costs minus benefits (recreation and commercial harvest).
M = millions of $

Breaching having approximately a $1 million per year benefit over the non-breaching alternatives. The commercial fishing benefits and related uncertainties are shown on Table 6-9.

6.4.2.12 Implementation and Avoided Costs

Implementation costs include those required to design, construct, and operate any of the alternatives. The avoided costs are those incurred under Alternative 1—Existing Conditions that would be avoided under the other alternatives. These include operation, maintenance, repair, and replacements costs and costs associated with the rehabilitation of existing infrastructure.

These costs have been annualized to make them commensurate with the other economic effects. These costs range from $84 million to $116 million per year over the 100-year economic life of the project. These costs and their uncertainties are shown on Table 6-9.

Costs associated with possible future actions regarding water quality have not been included in either implementation costs or avoided costs and, therefore, are not considered within this section. Water temperature and dissolved gas levels are water quality parameters that can affect fish and are sometimes found in the lower and upper Snake River at levels above state and tribal water quality standards. Until the Corps works through the process of developing a water quality plan and the States complete their TMDL process, it is premature to include costs. However, it is important to disclose publicly that these costs are an issue. Because of this, the costs of concept designs have been carried through the sensitivity discussion in the risk and uncertainty analyses. The average annual costs associated with actions or structural modifications relating to total dissolved gas can range from $1 to $55 million. These added costs would only be attributable to the non-breach alternatives (Alternatives 1 through 3). Regarding temperature, the Corps knows of no other measures to reduce temperature other than what is currently being done with Dworshak flows.

6.4.2.13 Social Effects

Social effects include the impacts caused by actions affecting the social fiber, yet are difficult to quantify in terms of specific dollar value. In addition, Environmental Justice focuses on impacts to low income and minority populations and those impacts are identified in the FR/EIS. Social and community elements were considered with three key areas listed here: community views, impacts to low income and minority populations, and increase in traffic safety. Resource valuation for social resources is shown in Table 6-10.

Six community types within 17 communities were assessed for their perceptions of the future with Alternative 1—Existing Conditions, Alternative 2—Major System Improvements (Adaptive Migration), and Alternative 4—Dam Breaching. Overall, there was significant concern for the negative impacts to people, jobs and wealth, place, and vision and vitality that would accompany Dam Breaching.

In terms of jobs lost and gained, the numbers did not show a significant overall loss of jobs in the regions for Dam Breaching compared to Adaptive Migration. However, the farm workers would take a large decrease in jobs, associated with the possible loss of irrigation along the Ice Harbor reservoir. This is a concern because 84 to 90 percent of the farm workers employed in this area are Hispanic. An estimated 2,000 jobs could be

Table 6-10. Resource Valuation for Social Resources

				Alternatives [1/]			
	Criteria	Scale	Best	Existing Conditions	Maximum Transport	Adaptive Migration	Dam Breaching
Low Income/Minority Populations							
Tribal Members	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Lo/Lo
Farm Workers	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Hi/Lo
Community Assessments							
Downriver Subregion	Rating	1 to 5	5	4	No Estimate	4	1
Reservoir Subregion	Rating	1 to 5	5	4	No Estimate	4	1
Upriver Subregion	Rating	1 to 5	5	3	No Estimate	2	2 to 4
Southern Idaho Subregion	Rating	1 to 5	5	3	No Estimate	2	2 to 4

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a Hi, Med, Lo, with Lo uncertainty the best. For Community Assessments, uncertainties were not captured. The slanted line separates the effect and the uncertainty.

lost in the long term. Therefore, persons of Hispanic origin would be disproportionately affected.

Another element of social effects is the issue of change in mode of transportation for distribution of commodities if Dam Breaching were implemented. There could be an increase in traffic accidents with the shift of commodities primarily to trucks. Using the annual Washington State estimate for fatalities would result in an increase in 0.06 deaths per year.

The fact that Dam Breaching would disproportionately affect persons of Hispanic origin was considered in the selection of the recommended plan (preferred alternative).

6.4.2.14 Native American Indians (Tribal Values)

The Northwest tribes have historically fished the Columbia River Basin and are concerned about the decreasing fish runs. It is the tribes' position that fish runs would increase with Alternative 4—Dam Breaching. If this were to occur, then the tribes stand to benefit significantly from more harvest, which increases the distribution of salmon as food and expands the fundamental economic base of tribal well-being. The 1998 PATH analyses indicated that there would be increasing numbers of returning fish with both Alternative 2—Major System Improvments (Adaptive Migration) and Alternative 4—Dam Breaching. NMFS CRI analyses estimated the best dam breaching would do is improve salmon population growth by 10 percent over non-breach alternatives, but that would not be enough to prevent extinction of fish runs.

Ceremonial and subsistence harvests, as well as cultural land use, compose this resource area. Cultural land use is related to the ability of the tribe to carry on accustomed activities. Alternative 4—Dam Breaching would expose more land on which to conduct cultural/traditional customs or ceremonies, as well as for hunting and fishing at usual and accustomed locations. Resource valuation for Native American Indians is summarized in Table 6-11.

Table 6-11. Resource Valuation for Native American Indians

	Criteria	# of Fish Scale	Best	Alternatives 1/			
				Existing Conditions	Maximum Transport	Adaptive Migration 2/	Dam Breaching
Harvest							
Spring/Summer Chinook Salmon							
0 Year (Baseline)	Wild Fish Returns	284		284	284	No Estimate	284
10 Year (Short-Term)	Wild Fish Returns	615 to 696		655 (130.0)	615 (116.5)	No Estimate	696 (145.1)
50 Year (Long-Term)	Wild Fish Returns	1,183 to 4,471		1,538 (441.5)	1,183 (316.5)	No Estimate	4,471 (1,474.3)
Fall Chinook Salmon							
0 Year (Baseline)	Wild Fish Returns	172		172	172	No Estimate	172
10 Year (Short-Term)	Wild Fish Returns	848 to 1,243		848 (393.0)	848 (393.0)	No Estimate	1,243 (622.7)
50 Year (Long-Term)	Wild Fish Returns	1,086 to 6,745		1,086 (531.4)	1,086 (531.4)	No Estimate	6,745 (3,821.5)
Steelhead							
0 Year (Baseline)	Wild Fish Returns	3,185		3,185	3,185	No Estimate	3,185
10 Year (Short-Term)	Wild Fish Returns	4,253 to 4,795		4,406 (38.3)	4,253 (33.5)	No Estimate	4,795 (50.5)
50 Year (Long-Term)	Wild Fish Returns	5,397 to 11,612		5,899 (85.2)	5,397 (69.5)	No Estimate	11,612 (264.6)
Traditional Places	Accessibility	Hi, Med, Lo	Hi	Med/Lo	Med/Lo	Med/Lo	Hi/Lo

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a Hi, Med, Lo, with Lo uncertainty the best. The slanted line separates the effect and the uncertainty.
2/ Meyer Resources (1999) did not evaluate Alternative 3—Major System Improvements (Adaptive Migration).

6.4.2.15 Geological Resources

Geological resources are described by the likelihood of soil movement either by hill slope sloughing, wave-induced erosion, or embankment failures. Under the non-breach alternatives, the amount of hill slope sloughing would not change. With Alternative 4—Dam Breaching, wave-induced erosion would increase in the short term, contributing to increased total suspended solids (TSS). This would continue until streambank and mudflats begin to revegetate and stabilize. The exposure of 14,000 acres of inundated lands is the largest contributor to wave-induced erosion. However, the greatest concern

is with embankment failure that would occur as a result of dam breaching and the change in pressures associated with highway and railroad embankment exposure. A plan of action has been considered to diminish the problem; however, the period of most concern would be the time between appearance of newly exposed saturated embankments and placement of adequate bank protection. The long-term change in geological resources and its contribution to water resources would stabilize over time; therefore, geology is not a key factor in selection criteria. Resource valuation for geological resources is shown in Table 6-12.

Table 6-12. Resource Valuation for Geological Resources

				Alternatives [1/]			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Adaptive Migration**	**Dam Breaching**
Erosion	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Hi-Med/Med
Embankment Failures	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Hi/Med
TSS Contribution	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Hi-Med/Med

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as Hi, Med, Lo, with Lo uncertainty the best. The slanted line separates the effect and the uncertainty.

6.4.2.16 Aesthetic Resources

No strong impacts to the aesthetic resource are expected. There would be significant short-term effects associated with Alternative 4—Dam Breaching, especially during the breaching implementation period. Much of what is considered pleasing or not so pleasing would depend on the values of the user. The long-term effects would be the concrete remnants of the four dams, along with possible abandoned grain elevators and irrigation intakes that would be visible along the shorelines. In addition, the lower Snake River would never be a natural or totally free-flowing river because it would continue to be regulated by dams above the lower Snake River. It would also be controlled by levees or riprap-lined embankments for the protection of transportation infrastructure. Historical records indicate that the river can fluctuate in a natural-like condition more than 20 feet in a high flow year. Resource valuation for aesthetic resources is summarized in Table 6-13.

6.4.2.17 Summary Trade-Off Analysis

The summary effects of the four alternatives have been compared and the differences displayed by resource area, as presented in Table 6-14. A decision model was not used for this trade-off analysis; rather, consideration was given to the amount of uncertainty associated with the values generated for each resource area. Based on the values of the resource and the amount of uncertainty with that value, it was determined which resources would influence the selection. A number of resource areas displayed short-term impacts for Alternative 4—Dam Breaching, which were not an issue with the non-breach alternatives. These short-term effects are also shown on Table 6-14.

Table 6-13. Resource Valuation for Aesthetic Resources

				Alternatives [1/]			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Adaptive Migration**	**Dam Breaching**
Physical Factors	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Hi-Med/Med
Views	Impacts	Hi, Med, Lo	Lo	Lo/Lo	Lo/Lo	Lo/Lo	Hi-Med/Med

1/ The first entry under each alternative references the effect of the alternative on the resource as defined by the Criteria and Scale. The second entry references the uncertainty associated with each effect as a Hi, Med, Lo, with Lo uncertainty the best. The slanted line separates the effect and the uncertainty.

The difference between alternatives is shown relative to Alternative 1—Existing Conditions. The comparison of effects was used to narrow the focus to those that were important or influenced the selection. A total of 25 resource or sub-resource areas and uses were compared. Of those, 8 showed no difference between alternatives or only small, short-term differences. These were determined to be insignificant to the decisions and eliminated from further consideration. Of the remaining 17 resource areas, 14 had significant differences (which are highlighted in bold on Table 6-14). Of these 14, Alternative 2—Major System Improvements (Adaptive Migration) had a slight edge over the other plans, showing positive effects in 5 resources areas and only one negative effect. Alternative 3—Maximum Transport showed only 2 positive resources effects and no negative differences. The negative effects tended to stack up against Alternative 4—Dam Breaching, particularly in the short term. In the long term, Alternative 4—Dam Breaching had positive effects in 6 resource areas and negative effects in 8 other areas. The short-term effects resulted in only 2 positive and 12 negative effects.

Although there was no clear winner (no one plan dominated the resource areas), Alternative 2—Major System Improvements (Adaptive Migration) was slightly better than the other plans. This is particularly true when you factor in some of the key uncertainties.

Alternative 2—Major System Improvements (Adaptive Migration) was also considered to be the most cost-efficient alternative. This was based on a comparison of the anadromous fish biological outputs to the combined economic outputs for the various alternatives. The biological outputs included the population growth indexes (lambdas) and juvenile and adult system survival estimates. The economic outputs included the NED effects on power, transportation, irrigation, implementation/avoided costs, recreation, and commercial harvest. Alternative 3—Maximum Transport may have been considered to be cost efficient; however, it did not meet the basic biological requirements in the NMFS 2000 Biological Opinion and was ranked lower than Alternative 2—Major System Improvements (Adaptive Migration) and Alternative 4—Dam Breaching. Although the biological outputs for Alternative 4—Dam Breaching generally were slightly higher than Alternative 2—Major System Improvements (Adaptive Migration), the economic costs were measurably larger. This made Alternative 4—Dam Breaching less cost efficient than Alternative 2—Major System Improvements (Adaptive Migration).

Table 6-14. Summary Resource Comparisons

Resource List	Alternative 2 Maximum Transport	Alternative 3 Adaptive Migration	Alternative 4	
			Dam Breaching Short Term	Dam Breaching Long Term
Aquatic Resources—Anadromous Fish				
Spring/Summer Chinook Salmon Passage	◒	●	○	●
Fall Chinook Salmon Recovery Passage	◒	●	○	●
Steelhead Passage	◒	●	○	●
Sockeye Salmon	◒	●	○	●
Aquatic Resources—Resident Fish				
Resident Fish	◒	◒	○	◒
Lamprey	◒	◒	○	●
Bull Trout	◒	◒	○	●
Water Resources				
Sediment	◒	◒	○	○
Temperature	◒	◒	◒	◒
Dissolved Gas	●	●	●	●
Contaminants	◒	◒	○	◒
Air Quality				
Fugitive Dust Emissions	◒	◒	○	◒
Transportation Emissions	◒	◒	◒	◒
Replacement Power Emissions	◒	◒	○	○
Terrestrial Resources	◒	◒	○	◒
Cultural Resources	◒	◒	◒	◒
Electric Power	●	●	○	○
Transportation (Navigation)	◒	◒	○	○
Recreation and Tourism	◒	◒	○	●
Water Supply/Irrigation	◒	◒	○	○
Commercial Harvest	◒	◒	○	◒
Implementation/Avoided Costs	◒	○	○	○
Native American Indians (Tribal Values)	◒	◒	●	●
Social Effects				
Community Views	◒	◒	○	○
Low Income and Minority Pop.	◒	◒	○	○
Traffic Safety	◒	◒	◒	◒
Geological Resources	◒	◒	○	◒
Aesthetic Resources	◒	◒	○	◒

● A Positive effect

◒ Minimal or No notable change in effect

○ A Negative effect

Bolded resources indicate those that would have the greatest impact or potential effect. Table reflects relative change as compared to Alternative 1—Existing Conditions.

6.4.3 Other Considerations

6.4.3.1 Regional Acceptability

The regional debate on how to recover salmon is highly diversified. The Corps used this diversity as a factor in gauging regional acceptability. When the Draft FR/EIS was released in December 1999 without a recommended plan (preferred alternative), it gave the Corps an opportunity to hear what the region had to say, specifically with regard to each of the four alternatives being proposed. The Corps received an overwhelming response of approximately 230,000 comment documents from throughout the region and across the United States (Appendix U, Response to Public Comments). The general consensus is that efforts need to be made in the region and they need to be made in a timely manner to save the salmon from extinction. The second part of that message was that there needs to be a solution where both salmon recovery and regional economics associated with hydropower can coexist. Regional Governors and other elected officials strongly support salmon recovery with economic stability. The many stakeholder organizations have come out strongly on both sides of the non-breach/breach issue, as has the general public. The tribes generally support the breaching of dams.

The NMFS 2000 Biological Opinion set forth an RPA which, when combined with ongoing and anticipated measures in the Columbia River basin as outlined in the Basinwide Recovery Strategy, is likely to ensure a high probability of survival with a moderate-to-high probability of recovery for each of the listed species. Implementation of the RPA would allow the FCRPS to avoid jeopardizing the continued existence of the listed species or adversely modifying their critical habitat. The NMFS 2000 Biological Opinion did not focus on the need to remove the dams in order for survival and recovery to occur. It did however, reserve the right to reconsider breaching as the option for survival and recovery if the hydropower, harvest, hatchery, and habitat actions described therein do not provide the anticipated survival rate increases, or if subsequent information shows the predicted improvements are inadequate. Although this approach to recovery seems to be acceptable to the region, a recently filed lawsuit challenging the NMFS 2000 Biological Opinion is ongoing.

6.4.3.2 Implementation Duration

The time estimated to implement the various alternatives was another consideration in the selection of a recommended plan (preferred alternative). The actions associated with the non-breach alternatives can be implemented more quickly than Alternative 4—Dam Breaching, even with the recognition that the long-term improvements associated with Alternative 3—Major System Improvements (Adaptive Migration) could take up to 10 years to fully implement. This is due, in part, to the fact that these actions do not require Congressional authorization. In addition to Alternative 4—Dam Breaching having the longest implementation time, this implementation has a high degree of uncertainty related to a high probability of unforeseen construction problems and requirements related to Congressional authorizations and appropriations. Also, it would be years before the benefits of breaching would be realized because of the short-term trap-and-haul requirements during construction and high sediment loads in the river during construction and the first few years of post construction.

6.4.3.3 Short-term Uses and Long-term Productivity

This analysis looked at the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. All of the alternatives evaluated would cause some mix of short-term impacts including, but not limited to, soil erosion, dust generation, degradation of water quality, disruption of fish and wildlife habitat, and damage to cultural resources. However, these are expected to be minimal with the non-breach alternatives. In general, the extent to which these would be long-term impacts would depend on how long a given operation or construction would occur. For example, under Alternative 4—Dam Breaching, dust generation is anticipated to be a short-term problem.

The recommended plan (preferred alternative) would produce few short-term impacts beyond what is currently present. However, some beneficial effects on long-term productivity would be in the continued availability of electric power, navigation, and irrigation. The intended benefits to anadromous fish, if realized, would be a long-term productivity gain.

6.4.3.4 Irreversible and/or Irretrievable Commitment of Resources

Irreversible commitments are decisions affecting renewable resources such as soils, wetlands, and riparian areas. Such decisions are considered irreversible because their implementation would further deteriorate a resource to the point that renewal can occur only over a long period, at a great expense, or because they would cause the resource to be destroyed or removed.

Regarding the implementation of the recommended plan (preferred alternative), no impacts are anticipated that would be an irreversible or irretrievable commitment of resources beyond what is currently happening with the existing projects. For example, the loss of soil due to erosion is an irreversible commitment because the current pools have some fluctuations that cause erosion. The recommended plan (preferred alternative) does not impact any wetlands or riparian areas beyond what already occurs.

6.4.3.5 Best Information or Science Available

As discussed previously in this chapter, there are substantial uncertainties and controversy in the scientific information regarding the biology as well as water quality impacts and economics (specifically power, recreation, transportation, passive use). However, it is the best information available to date and is sufficient to support the selection of Alternative 2—Major System Improvements (Adaptive Migration) as the recommended plan (preferred alternative).

6.4.3.6 Environmentally Preferable Alternative

The Council on Environmental Quality (CEQ) identified in 40 CFR §1505.2 requires that, in cases requiring environmental impact statements, identification of an alternative or alternatives that are considered environmentally preferable should be identified. The objective of the Feasibility Study was to screen and evaluate structural alternative measures and identify measures to improve juvenile salmon migration through the Lower Snake River Project. In addition, the measures taken as a result of the study were intended to assist in the recovery of ESA-listed species.

With the addition of improvements outside the scope of this Feasibility Study, it is possible to increase spring/summer chinook population growth according to the CRI analyses. The Federal Caucus has identified a number of such improvement combinations, which are being evaluated within the region and through other avenues such as the NMFS 2000 Biological Opinion and the Federal Caucus' Basinwide Recovery Strategy.

The Corps believes the alternative identified as the environmentally preferred alternative is the one with the greatest biological benefits and the least environmental impacts. Taking into consideration all the alternatives and the uncertainties in the current science, both Adaptive Migration and Alternative 4—Dam Breaching can be identified as environmentally preferred alternatives. Both of these alternatives have negative and positive attributes and short-term and long-term effects.

Short-term and Long-term Effects

Under Adaptive Migration, short-term implementation is presumed to result in near-term biological benefits. These biological benefits, compared to the turmoil the river system would be in immediately after breaching, support Adaptive Migration as an environmentally preferable alternative. However, in looking at the long-term biological benefits for Alternative 4—Dam Breaching (assuming the salmon survive the first few years after a breach), the benefits accrued from a near-natural river system would, in the long run, be more beneficial and could support Alternative 4—Dam Breaching as an environmentally preferable alternative.

Negative and Positive Attributes

Negative and positive attributes revolve around two areas of uncertainty. These include delayed mortality and sedimentation-related impacts. There is a need for continued study to resolve uncertainties.

The NMFS 2000 Biological Opinion has targeted the delayed mortality in salmon recovery for further study. Delayed mortality comes in two forms: the differential delayed mortality (D) of transported fish (compared with in river migrants), and the extra mortality of in river migrants. The estimates generated for D represent the best scientific information available at the time; however, they are based on relatively small numbers of returning adults and have large confidence intervals around each estimate. If future studies identified by the NMFS 2000 Biological Opinion were to document the presence of delayed mortality and to quantify the mortality so the amount of delayed mortality could be assigned unequivocally to the presence of dams, then Alternative 4—Dam Breaching may be better positioned as the best environmentally preferred alternative. To date, that certainty or even a defensible probability is not available. Even though Alternative 2—Major System Improvements (Adaptive Migration) improves on the current approach and more closely aligns with the objectives of the NMFS 2000 Biological Opinion, these uncertainties are a critical factor in determining which alternative is better environmentally.

Another area characterized by uncertainties relates to the sediment movement and resuspension during a breach condition. Several factors related to sediment could influence whether Alternative 4—Dam Breaching is the best environmentally. These include the amount of resuspended sediment that would be present and its chemical

composition. Would there be any contaminants to be concerned with and how would the large amount of TSS affect fish? Can they tolerate those high levels?

Depending on the scientific theory or hypothesis believed to be accurate, both Alternative 2—Major System Improvements (Adaptive Migration) and Alternative 4—Dam Breaching meet the criteria for an environmentally preferable alternative(s).

6.4.3.7 Accordance With Declared Policies of NEPA and Compliance With Federal Laws and Regulations

Compliance with numerous laws and regulations (i.e., Clean Air Act, Fish and Wildlife Coordination Act, Pacific Northwest Electric Power Planning and Conservation Act) are discussed in Chapter 8; however, it is important to discuss briefly the consistency with a few of these laws and regulations in this chapter.

National Environmental Policy Act (NEPA)

The Corps has evaluated the effects of the recommended plan (preferred alternative) utilizing this FR/EIS and associated appendices. The completion of this NEPA process involves printing and distributing the final documents, reviewing final comments, making any necessary modifications, and signing a ROD, if appropriate. The process followed in compiling this FR/EIS has met and, at times, exceeded the requirements set forth in NEPA. See Chapter 8 for further details.

National Historic Preservation Act (NHPA)/Native American Graves Protection and Repatriation Act (NAGPRA)

As part of the Feasibility Study, an evaluation was conducted on the known and potential effects of all alternatives on historic properties pursuant to the National Historic Preservation Act (NHPA), as amended. During the development of the 2001 ROCASOD, consultation occurred with the State Historic Preservation Officers (SHPOs) in the states of Oregon, Idaho, Montana, and Washington regarding the FCRPS. Consultation also occurred with the Advisory Council on Historic Preservation (ACHP) and with the 13 interested and affected tribes. The Corps established Reservoir Cooperating Groups to collectively evaluate the needs and priorities for historic property inventories, evaluations, and site preservation. These Reservoir Cooperating Groups consist of representatives from the Corps, interested and affected tribes, other state and Federal agencies, and any other interested parties. There are currently five Reservoir Cooperating Groups, three of which focus on individual reservoir projects, and two of which focus on multiple reservoir projects. These same Reservoir Cooperating Groups also address the requirements of the Native American Graves Protection and Repatriation Act (NAGPRA) following the procedures described in the U.S. Department of Interior (DOI) implementing regulations for the appropriate repatriation/disposition of Native American remains and objects specified by the NAGPRA.

Specifically, the effects of this particular alternative are being coordinated with the state SHPOs and the tribes. Consultation is to be concluded prior to signing of the ROD.

Clean Water Act

The Clean Water Act Appendix (Appendix T) includes the 404(b)(1) evaluation. Impacts from actions (which include a discharge of dredged or fill material) proposed in the recommended plan (preferred alternative) were analyzed for consistency with the 404(b)(1) guidelines and were found to be consistent.

Litigation is ongoing regarding the compliance with the Clean Water Act and the Lower Snake River Project, *National Wildlife Federation* v. *U.S. Army Corps of Engineers*, Civ. #99-442-FR (D. Or., 2001). The ROCASOD signed by the Northwestern Division Commander on May 15, 2001, and filed with the Court detailed the approach the Corps plans to take regarding water quality issues. It referenced a Water Quality Plan, which will investigate the issues and determine appropriate actions. It is the Corps' belief that its actions are in compliance with the Clean Water Act. See Section 6.5.4, Other Actions/Studies Outside this Process at the end of this chapter for further details.

Endangered Species Act (ESA)

Compliance with ESA and associated consultations with NMFS and USFWS are detailed in the 2001 ROCASOD. Since the majority of the components of the recommended plan (preferred alterative) are within the context of the recent consultation, only a few, if any, of the near-term actions will need to be coordinated with these agencies. However, the majority of the long-term actions will be reviewed for consistency with the ESA and analyzed to determine the need for further consultations.

6.5 Implementation Plan

The NMFS 2000 Biological Opinion outlines an annual process for developing 1- and 5-year implementation plans to achieve FCRPS hydropower performance. These plans also encompass the proposed actions described in the USFWS 2000 Biological Opinion. Included in that process will be the development of the hydropower configuration (capital) projects, most of which are funded and managed by the Corps. Another requirement is to coordinate the development of this "Implementation Plan" through the established Regional Forum, which includes the System Configuration Team. The initial 1-year implementation plan was completed in September 2001 and the 5-year plan is still in draft form.

The majority of the improvements that are part of the recommended plan (preferred alternative) have already been incorporated into the Implementation Plan. The ones that have not been included are: additional barges (with mooring facilities); new ESBSs at Ice Harbor; SBC with dewatering systems; and future operation changes (rules for transport, spill, flow augmentation). The reason these are not included is because they are not part of the NMFS 2000 Biological Opinion. The Corps has reserved the discretion to implement different actions than those identified in the Biological Opinions with the intent that the alternative measures result in achieving the Biological Opinion performance standards and/or as modified through the Action Agencies submittal of the 1- and 5-year implementation plans. These actions will be further coordinated with NMFS and, if determined to be effective in reaching Biological Opinion performance standards, they will be incorporated into this Implementation Plan. Table 6-15 identifies all the proposed improvements, their reference number in the Hydropower Appendix of the Implementation Plan, and an implementation schedule. For more detailed information related to implementation of any of these actions, refer to this appendix.

Many of these improvements require additional prototype testing and evaluation to determine if, where, how, and when they should be implemented on the Lower Snake River Project. This FR/EIS provides only basic NEPA coverage for the recommended plan (preferred alternative) improvements. The Implementation Plan will identify where and what type of supplemental NEPA coverage may be necessary to reflect new information resulting from this testing and evaluation.

6.6 Other Actions/Studies Outside this Process

This section discusses a few future actions/studies that are beyond the scope of this Feasibility Study but are considered to be potential actions traveling an adjacent or separate pathway. Examples of these actions/studies include the repairs needed in the Lower Monumental stilling basin, future powerhouse rehabilitations, a Water Quality Plan, and advanced planning and engineering for preparatory breach actions. Key examples of these future actions/studies follow.

Table 6-15. Relationship of Recommended Plan (Preferred Alternative) Hydrosystem Implementation Plan

Action	Implementation Plan Ref. No.	Implementation Date (FY)	Additional NEPA Coverage
Structural Modifications			
Flow Deflector Optimization			
Lower Monumental	33	2002-2004	EA
Little Goose	34	2002-2005	EA
Auxiliary Water Supply			
Lower Granite	46	2001-2002	Cat-X
Little Goose	47	2002-2003	Cat-X
Lower Monumental	48	2003-2004	Cat-X
Ice Harbor	49	2004-2005	Cat-X
New Juvenile Facility at L. Granite	24	2002-2006	EA
ESBSs			
Mods – L. Goose & L. Granite	14 & 15	2001-2003	Cat-X
Ice Harbor	NA		EA
Lower Monumental	16	2004-2008	EA
Additional Barges & Mooring	NA		EA
Separator Improvements (Rpt Only)	20	2001-2002	Cat-X
Turbine Rehabs. (Rpt Only)	23	2001-2003	EA
Cylindrical Dewater Screens	27	2002	Cat-X
Misc. Improvements	25, 26, 29	2001-2003	Cat-X
RSWs (w or w/o BGSs)	13, 18	2002-2004	EA
SBC w/dewatering			
Lower Granite w/dewatering	NA		EA
Lower Monumental w/dewatering	NA		EA
Little Goose (Occlusion Only)	NA		EA
Operational Improvements			
Flow Augmentation	21	2002-2004	None
Transportation	101	2002-2007	None

FY = Fiscal Year

6.6.1 Water Quality Plan

In developing the 2000 Biological Opinions, NMFS and USFWS, in coordination with EPA, the Corps, BOR, and BPA, considered respective ecological objectives of the ESA and the CWA. In many instances, actions implemented for the conservation of ESA-listed species will also move toward attainment of water quality standards (e.g., reducing TDG and temperature). However, the Corps recognizes that, at least in the short run, there will also be instances where implementation of actions for the conservation of ESA-listed species will result in exceedences of water quality standards. There are also additional actions that are appropriate for addressing water quality, but which are nonessential for the survival and recovery of the listed species and, thus, are not components of the NMFS 2000 Biological Opinion RPA. Any plan to address water quality issues is likely to require lengthy study and implementation exceeding the scope and duration of the NMFS 2000 Biological Opinion.

Therefore, Federal agencies proposed a process to address water quality and included it as Appendix B, Development of a Water Quality Plan for the Columbia River Mainstem: A Federal Agency Proposal, to the NMFS 2000 Biological Opinion. This appendix charts a course for development of a water quality plan for the mainstem Columbia and Snake Rivers to address CWA objectives. The scope of this plan is broader than the FCRPS and would include additional actions to improve mainstem water quality by reducing TDG and temperature. The Corps anticipates that some of these actions must and will be undertaken by entities other than the Federal Action Agencies.

Although Appendix B is not a water quality plan, it provides a procedure for development of a plan and identifies actions the plan would likely contain to move toward attainment of water quality standards for the FCRPS. Appendix B in the 2000 NMFS Biological Opinion refers to items also called for in the RPA for the FCRPS as a nucleus of actions for the water quality plan. These actions enhance the survival and recovery of the listed species and, thus, are components of the RPA. Appendix B also identifies actions for the FCRPS that further CWA objectives but are not also in the RPA. These actions are listed in Table B-3 of Appendix B. These are studies to investigate additional measures to reduce TDG and temperature that may be considered for implementation in the future. These studies are appropriate ESA conservation measures that will require further ESA consultation when they are developed, analyzed, and proposed for implementation. Most importantly, the water quality plan should establish quantifiable TMDL allocations covering temperature and TDG for FCRPS projects on the Columbia and Snake Rivers. It is also critical that any meaningful water quality plan must also include TMDLs for all activities significantly affecting TDG and temperature, not limited to the FCRPS projects. Subject to available funds and Congressional directives, the Corps is committed to implementing Appendix B of the NMFS 2000 Biological Opinion. The Corps will do so by working with the Action Agencies to develop and implement this water quality plan and by undertaking all practicable alternatives to accomplish the TMDL standards in the plan.

In summary, the Corps will seek to harmonize operations to comply with both the ESA requirements, (as reflected by the RPAs recommended by NMFS), and the states' and tribal water quality standards. To the extent this is not possible, the Corps, with NMFS assistance, will seek variances for TDG standards for voluntary fish passage spill. The water quality information the Corps has or develops will be provided to EPA, the states,

and appropriate tribes for their use in developing TMDLs. The Corps will continue to work with the Federal agencies and tribes to consider water quality issues along with ESA actions to benefit listed species, including ESA operations, studies, and construction activities. When the states, tribes, EPA, and other Federal agencies develop additional information, including TMDLs for the Columbia River Basin, the Corps will be able to determine what practicable actions it can take, subject to Congressional directive and appropriations, to achieve compliance with those water quality parameters. Until that time, the Corps, as it has in the past, will provide information on water quality at its dam and reservoir projects covered by the 2000 Biological Opinions in order to assist four Northwest states, tribes, EPA, and other Federal agencies in this process.

6.6.2 Lower Monumental Stilling Basin Repairs

Implementation of a voluntary spill for the fish program in 1994 increased the size of two hydraulic cavitations in the stilling basin at Lower Monumental. These eroded holes exist at the base of the two outside spillway bays that do not have flow deflectors. Spill passage survival of juvenile salmon at Lower Monumental has consistently been lower than at other lower Snake River dams. This was likely influenced by the rough concrete edges and exposed rebar that occurred due to the erosion of these holes. Probability of mortality to spilled fish will increase as the number of fish exposed to these abrasive conditions increase and the size of these holes increase. In addition, dam structural integrity is a concern. In the summer of 2001, emergency provisions that eliminated spill due to dam safety reasons were implemented.

Plans to repair this basin will be included in the Corps' implementation plan for future actions and coordinated through the regional process. Whether it receives a high priority and is funded is yet to be determined.

6.6.3 Powerhouse Rehabilitations

The need for powerhouse rehabilitations is becoming more of a necessity as the powerhouse facilities age. For example, since the Ice Harbor Turbine Unit 5 was out of service for about 1.5 years or two fish migration seasons (due to mandatory repairs), the turbine unit priorities and optimal operation for fish survival became compromised as reliability and flexibility in the powerhouse system decreased. Spill patterns and effective screening units had to be adjusted in an attempt to meet the existing operating criteria. The TDG levels were elevated during the Unit 5 outage due to the loss of powerhouse capacity. This resulted in higher seasonal indirect mortality to spring/summer chinook salmon and steelhead (smolts and adults).

The powerhouse rehabilitations will be considered as a long-term measure and will be implemented as appropriate and as funding become available.

6.6.4 Dredged Material Management Study

The Dredged Material Management Study is currently an ongoing study. It is evaluating alternative programs to maintain the authorized navigation channel and certain public-owned facilities in the lower Snake River and the McNary reservoirs for the next 20 years; evaluating measures to maintain the flow conveyance of the Lower Granite Lake for its remaining economic life (through 2074); and evaluating alternative programs for managing dredged material in a cost-effective, environmentally acceptable, and, wherever possible, beneficial manner.

The Draft Dredged Material Management Plan went out for public review and comment in December 2001.

6.6.5 Lower Snake River Project Management Plan (PMP) for Possible Re-evaluation Study/Supplemental Environmental Impact Statement (SEIS)

In NMFS 2000 Biological Opinion RPA Actions 147 and 148, NMFS requested the Corps (in cooperation with other Federal agencies) to develop a Project Management Plan (PMP) to reevaluate more intensive hydropower-related actions (including breaching) for the four lower Snake River dams:

> "Although breaching is not essential to implementation of the initial actions called for in the RPA which constitute a non-breach approach, the RPA requires that the Action Agencies prepare for the possibility that breaching or other hydropower actions become necessary. These actions will reduce the time needed to seek Congressional authorization, if necessary, and thus reduce the time needed for possible implementation" (NMFS 2000 Biological Opinion, page 9-131).

The PMP is to identify the scope, schedule, costs, tasks, products, and responsibilities for the reevaluation study and supplemental environmental impact statement (SEIS). This PMP will include, but not be limited to, plans to mitigate possible disproportionate impacts to communities, industries, and tribes; detailed water and air quality effects; implementation plans; and a complete public involvement program. The Biological Opinion indicates that the decision to start this reevaluation study/SEIS should result from NMFS check-in process scheduled for 2003, 2005, and 2008 and is expected to take 2 years to complete.

The Biological Opinion also requests the Corps to conduct detailed engineering and design work for improvements recommended in the general reevaluation report and SEIS. The engineering and design work would include only those activities on (or near) the implementation schedule critical path for the recommended actions, up to the award of the first construction contract. For the dam breach recommendation, the critical path activities shall include turbine physical modeling (for use as low level outlets), rock source explorations for embankment erosion protection (riprap), and hydraulic (physical) modeling for the embankment removal and channelization. The Corps plans to go forward with the PMP as stated in the RPA actions.

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Chapter 7

Regional Coordination and Public Outreach

7. Regional Coordination and Public Outreach

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Throughout the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study), the Corps has been diligent about facilitating two-way communication, input, and participation from involved Federal and state agencies, Native American representatives, elected officials, organizations, and the general public. This input is essential for the Corps to present an action alternative that reflects consideration of the wide range of resources and people in the region that would be affected by changes to the operation of the Lower Snake River Project and by changes in salmon and steelhead populations. This section describes activities the Corps has undertaken to involve other agencies and interested parties as they gather information, evaluate options, and develop a plan of action. It specifically addresses regional coordination efforts, the scoping process, the public outreach program, and the Draft FR/EIS public process. A more comprehensive discussion of the public outreach effort associated with the Feasibility Study can be found in Appendix O, Public Outreach Program.

7.1 Regional Coordination

The effects of this study's outcome are expected to be far reaching and involve a variety of entities in the region who are concerned about salmon recovery and effects on other resource areas. Because of this, the Corps has committed to working cooperatively with a variety of groups through a variety of mediums to exchange input and foster understanding. This section describes the Corps' role in those efforts.

7.1.1 Lead and Cooperating Agencies

Because the Corps operates the Lower Snake River Project, they are the lead agency conducting the Feasibility Study and producing the FR/EIS under the National Environmental Policy Act (NEPA) in compliance with the 1995 Biological Opinion issued by the National Marine Fisheries Service (NMFS). The U.S. Environmental Protection Agency (EPA), the U.S. Bureau of Reclamation (BoR), and the Bonneville Power Administration (BPA) are cooperating agencies of this study. Each of the cooperating agencies has special expertise regarding some aspect of the study. Representatives of the cooperating agencies worked with the study team and contributed their expertise to the various work groups conducting technical analyses.

7.1.2 Regional Roundtable Workshops

The Corps held a series of seven roundtable workshops around the region to encourage active participation and involvement in the study by public citizens, special interest groups, and communities. Workshops have been conducted in Portland, Oregon; Richland and Clarkston, Washington; and Boise, Idaho. Table 7-1 lists the locations, dates, and number of participants for each regional roundtable workshop. The workshops afforded the opportunity for interested publics to understand and to offer input on specific elements of the study.

Table 7-1. Regional Roundtable Workshops

Town	Date	Meeting Participants
Portland, OR	4/14/97	17
Portland, OR	6/11/97	40
Portland, OR	9/10/97	45
Clarkston, WA	11/12/97	37
Portland, OR	1/21/98	61
Richland, WA	3/18/98	85
Boise, ID	7/15/98	60
Total		**345**

7.1.3 Work Groups

Technical work groups (e.g., the Drawdown Regional Economic Workgroup [DREW] and the Plan for Analyzing and Testing Hypotheses [PATH]) produced some of the analyses conducted for the Feasibility Study. DREW focused most of its efforts on assembling and analyzing economic and social data through the many work teams. Several open focus meetings were held in the region that provided preliminary economic work team evaluations on hydropower, transportation, irrigation, as well as the regional and social analysis. Valuable input received from the stakeholders and public was used by work teams to clarify analysis parameters. PATH consisted of regional fisheries biologists who measured projected salmon and steelhead survival and recovery rates.

Additional work groups of engineers and fisheries biologists designed and tested specific structural changes that could help more salmon and steelhead pass safely through the dams. These work groups are crucial to the Feasibility Study and the Corps' regional coordination effort. Representatives from the Corps; the cooperating agencies; NMFS; USFWS; the Northwest Power Planning Council (NPPC); Native American tribes; state agencies in Washington, Oregon, Idaho, and Montana; academia; and interested organizations contributed their expertise and perspectives to the work groups. The public participated in some work group proceedings, and the Corps provided various work group products to the public via their web site.

7.1.4 Coordination with Other Regional Salmon Recovery Efforts

Throughout the Feasibility Study, the Corps has been working with others in the region to develop and analyze alternative management plans for fish and wildlife resources of the Columbia-Snake River Basin. In terms of an overall improvement in species survival throughout the basin, the Lower Snake River Juvenile Salmon Migration Feasibility Study is only part of the picture. The Corps has been and will continue to coordinate with other entities by sharing valuable technical information and insights as everyone moves closer towards a common vision on salmon recovery in the region. Some of the entities involved in related actions on the Columbia-Snake River System include the Federal Caucus, the Columbia River Basin Forum, and the Multi-Species Framework.

7.2 Public Outreach Program

The Corps has conducted an aggressive outreach effort throughout the Feasibility Study process, in order to both raise awareness and promote involvement. Public interest in the Feasibility Study has been high, and continual communication has been essential because the impacts could be far reaching. The public outreach program began with scoping

meetings in 1995, intensified in 1997 with the implementation of the Public Outreach Plan, and has continued on to this Final FR/EIS release using a variety of public information and public involvement techniques.

7.2.1 Public Outreach Plan

The Public Outreach Plan was developed through a cooperative effort involving study management, technical, and public involvement staff from the Corps; and contractor staff specializing in environmental compliance, communications, social science, and public involvement. The plan is based, in part, on current and recent public outreach efforts conducted for similar types of studies, as well as on the collective knowledge and experience of those responsible for drafting the plan. In addition, the plan reflects insights gained through telephone interviews with individuals from a variety of federal agencies, as well as sources representing state agencies, environmental groups, and river user interests in the Pacific Northwest. Those interviewed were asked what the key issues and concerns for the project are, how people obtain information about salmon and river use matters, who would be interested in the study, and what approaches might work best for communicating with interested parties.

The goal of outreach has been to inform and involve people in the region in the engineering, science, and planning process that would lead to a recommendation on the future operation for fish passage at the Lower Snake River Project. Everyone benefits when the public is informed and involved. Individuals and groups can ensure that their perspective is heard and factored into the decisions made, and the Corps ensures that it has considered all the factors and recommended a plan that has full public involvement. This outreach program supports the Corps, cooperating agencies, and the public in working openly and collaboratively toward a recommendation that can be effectively implemented.

Public outreach efforts for the Feasibility Study have engaged the public in two ways. When the outreach has taken the form of information, those involved have been an audience. When the outreach has taken the form of involvement, those involved have been participants. Groups targeted for outreach efforts include:

- General public
- Stakeholders
- Elected officials
- Native American Tribes (See Appendix Q, Tribal Consultation/Coordination)
- Media
- Academia
- Governments
- Agencies
- Government forums.

Specific public information and public involvement efforts aimed at these groups are described in the next two subsections.

7.2.2 Public Information Techniques

The Corps has worked to raise awareness through a multimedia, multitechnique information campaign. Public information is one-way information, with little or no opportunity for feedback. The purpose of raising awareness is to minimize or eliminate any surprises for decision makers or the public about the decision regarding the future of the lower Snake River. Those interviewed consistently and forcefully said that the Corps' greatest challenge will be making the public aware of the Feasibility Study. Consequently, much of the public outreach effort has been focused on raising awareness about the existence, purpose, and process of the Feasibility Study. Public informational efforts are a necessary foundation for public involvement efforts. The following sections describe the public information techniques the Corps has used.

7.2.2.1 Informational Video

To achieve widespread, consistent information dispersal, the Corps produced a 13½-minute video, *The Path of the Salmon,* that provided the public, user groups, political staffs, agencies, and the internal Corps audience with a factual representation of the study and explained the complexities involved in the recovery of the salmon runs. More than 500 copies of the video in VHS, BETA CAM, and CD-ROM formats have been distributed to an extensive variety of groups, schools, officials, and media.

7.2.2.2 Web Site

A web site page (http://www.nww.usace.army.mil/lsr) was established in 1997 to allow internet users access to detailed information about the Feasibility Study (see Annex A of Appendix O, Public Outreach Program). The web site has proven to be an effective tool for disseminating information to the scientific and educational communities, as well as to stakeholders and the public.

7.2.2.3 Mailing List

The Corps established a mailing list in 1995 to create a network of individuals interested in the study, and all subsequent public outreach activities and informational tools provided opportunities for the public to add their names to the list. The mailing list has steadily increased throughout the study to more than 3,175. The mailing list consists of elected officials, stakeholders, governmental organizations, special interest groups, and interested individuals. The mailing list database has been used to mail out periodic study newsletters and meeting notification cards, as well as for querying specific organizations and contact personnel. Notification of the Draft FR/EIS release and the public meetings was carried out using the mailing list.

7.2.2.4 Newsletter and Brochure

A series of ten newsletters has been produced and sent to the mailing list of parties interested in the Feasibility Study. The newsletters convey study progress and upcoming events to the stakeholders and various interested publics and focus on the issues surrounding the study. Newsletters have been available at public outreach events and have been sent out in response to information requests. Each issue is posted on pages available through the internet at the Corps' web site. The newsletter has proven to be a valuable tool to keep interested individuals throughout the region informed regarding the

study's progress and has also provided an effective means of notification of public meetings on the Feasibility Study.

In addition to the newsletters, a color brochure was produced early in the process to present a succinct summary of the scope of the Feasibility Study, the Corps' role in salmon recovery, and the alternative pathways being analyzed. The brochure accompanied the traveling display and all outreach activities so that interested individuals have written material to take with them.

7.2.2.5 Traveling Displays

Two identical portable traveling displays were produced early in the process to present basic study information including the timeline and the three alternative pathways and lower Snake River map. This four-panel foldout display creates a mural for a stand-alone exhibit that has been used in a variety of settings: county fairs, outdoor shows, office building foyers, libraries, meetings, and visitor centers. Over one million people viewed the displays throughout Washington, Idaho, and Oregon (see Annex C in Appendix O, Public Outreach Program).

7.2.2.6 Information Sheets and Information Packets

Information and facts about specific elements of the study were summarized into information sheets after release of the Draft FR/EIS. These two-page documents were designed as handouts and to be placed on the web site to provide a succinct overview of topics of interest. Information sheets on sediment transport, drawdown engineering, recreation/tourism, major system improvements, and community impact assessments were some of the topics included. Information sheets were developed to present the public with an introduction to various elements of the study and to help provide a general understanding of detailed study analyses.

Requests for information about the Feasibility Study have come from a wide variety of sources including students, media, elected officials, stakeholders, and interested citizens. Newsletters, *Salmon Passage Notes*, brochures, newspaper inserts, information sheets, and often copies of *Path of the Salmon* video have been enclosed and sent to interested groups upon request. Media packets have been developed for Media Day and to provide briefing information for visiting officials.

7.2.2.7 Media Coverage

The Walla Walla District Public Affairs Office has coordinated with local, regional, and national press as well as broadcasting networks on Corps news releases and requests for information on the Feasibility Study. In addition to developing news releases to keep the public informed and correct misinformation, coordination with other offices of the Corps and the area elected officials has been a formidable task accomplished by staff in the Public Affairs Office. Public Affairs Office staff and study team members have worked closely with radio stations and television networks to provide personal interviews, talk show guests, and source information on the Feasibility Study.

Through the annual Media Day in the spring of 1998, 1999, and 2000 the Public Affairs Office provided local and regional media opportunities to focus on the Feasibility Study. The media was afforded the opportunity to meet with Corps technical experts, view prototypes of the surface bypass collector and behavioral guidance structure, and

examine the juvenile bypass system and fish transportation barge at Lower Granite Lock and Dam.

7.2.2.8 Newspaper Insert and Advertising

An 8-page, full-color insert was designed and distributed in October and November 1998 in 150,000 copies of community and tribal newspapers throughout the lower Snake River region (see Appendix O, Public Outreach Program for a list of newspapers). The insert included study details about the four lower Snake River dams, the alternative pathways being considered, study milestones, public information meeting schedules, and sources for further information on the study. The inserts produced an immediate reaction in the form of a surge of requests to be added to the mailing list. The study web site page received an increase of several hundred visits after the insert was distributed. The newspaper insert has proved to be an effective, relatively inexpensive method of reaching a large public audience. In addition to the newspaper insert, the Corps has placed advertisements in various regional newspapers when appropriate to announce public meetings and other public outreach efforts.

7.2.3 Public Involvement Techniques

The public outreach program involved interested parties in a public dialog at key points in the Feasibility Study. Public involvement consists of two-way communication between the target audience and the Corps. The involvement techniques described below (i.e., public meetings, community assessment forums, briefings and presentations, tours, and personal communications) have allowed interested parties to provide the Corps with feedback on specific study issues and on the Feasibility Study and the alternative pathways in general (see Annex D to Appendix O, Public Outreach Program). Through these public involvement efforts, formal as well as informal input from the public has provided Corps staff with ongoing and cumulative perspectives that have shaped the overall study.

At each public involvement effort, the Corps identified how feedback would be used. The input was formally reviewed and, where appropriate, has been incorporated into the study. The input has provided the public with an opportunity to influence study scopes and has increased the opportunity for study team members to be exposed to, and to consider, a huge range of public perspectives.

7.2.3.1 Scoping Meetings

As part of the NEPA process, the Corps conducted a series of public scoping meetings in the region for the Feasibility Study and its associated FR/EIS in the summer of 1995. The purpose of the scoping period was to invite comments from interested and potentially affected parties regarding potential study content, direction, and process. Comments received from speakers, letters, and comment cards during the scoping process were reviewed throughout the Feasibility Study and helped to shape the study and the FR/EIS. The comments were classified into 10 general categories as follows:

- consider the range of alternatives
- evaluate the juvenile fish transport program
- incorporate related studies

- consider the loss of river services during dam breaching
- determine what other factors could be affecting salmon runs
- evaluate the cost-benefit of dam breaching
- consider the need for a dam breaching test
- coordinate with other agencies
- consider public opinion on alternative(s)
- offer analysis based on sound science.

7.2.3.2 Public Information Meetings

In addition to providing an opportunity for public participation in regional roundtable and work group meetings, the Corps conducted a series of two regional public information meetings in September 1997 and November 1998. The locations, dates, and number of participants from these public information meetings are listed in Table 7-2.

The objectives of these meetings were to:

- inform the public and stakeholders about the feasibility study status
- hear public concerns
- respond to questions
- stimulate public involvement.

Table 7-2. Public Information Meetings, September 1997 and November 1998

Town	Date	Meeting Participants
September 1997		
Boise, ID	9/17/97	45
Lewiston, ID	9/18/97	100
Kennewick, WA	9/23/97	185
Portland, OR	9/25/97	54
September 1997 Subtotal		***384***
November 1998		
Lewiston, ID	11/9/98	300
Richland, WA	11/12/98	300
Portland, OR	11/16/98	140
Boise, ID	11/19/98	85
Spokane, WA	11/23/98	220
November 1998 Subtotal		***1,045***
Total		**1,429**

A total of 1,429 people attended the two series of public information meetings. The meetings featured a general overview presentation, topical presentations, and question-and-answer sessions. Although formal recording of public comments and questions was not taken during the public information meetings, some study team members took notes on issues that were discussed. Issues raised from the September 1997 meetings were

categorized into four broad categories: fish, economics, regional, and study process. The issues identified from the November 1998 meetings were categorized into six broad categories: fish/biological, economic/social, regional concerns, study process, flood control, and engineering. Analysis of the issue categories and distribution has assisted in providing input to specific study technical evaluations, determining public perceptions, and preparing public outreach efforts.

7.2.3.3 Formal Public Meetings

Formal public meetings were conducted after the Draft FR/EIS was distributed for public review. The series of 15 formal meetings around the region (Table 7-3) in cooperation with the Federal Caucus, included presentations on the Draft FR/EIS, John Day Drawdown Study, and the Conservation of Columbia Basin Fish All-H Paper. These regional meetings held in February and March 2000 provided an opportunity for formal public questions and comments. A total of nearly 9,000 participants consisting of stakeholders, special interest groups, elected officials, and individuals from the public presented 1,786 oral and taped comments about the two studies and the Federal Caucus paper. Most meetings consisted of an open house, formal agency presentations, a question and answer session, and a public comment session. Oral and taped comments were limited to 3 minutes in length. At some of the meetings, the attendance was so large that not all those wishing to speak were able to do so; however, written comments were also accepted. In addition to oral and taped comments, the Corps received over 230,000 written comment documents from the public during the comment period. The comment period began December 1999 and extended through April 30, 2000. Written comments were received via mail, e-mail, fax, the Corps' web site, and hand-delivery. For a summary of the oral and written comments received and the responses to these comments, please see Appendix U, Response to Public Comments. Section 7.4 summarizes how public comments were reviewed prior to production of this Final FR/EIS.

Table 7-3. Formal Public Meeting Locations

Date	Location	Attendance
February 3, 2000	Portland, OR[1/]	1,200
February 8, 2000	Spokane, WA[1/]	800
February 10, 2000	Clarkston, WA[1/]	1,800
February 15, 2000	Astoria, WA	200
February 17, 2000	Pasco, WA[1/]	1,200
February 23, 2000	Boise, ID[1/]	1,100
February 29, 2000	Seattle, WA[1/]	550
March 1, 2000	Kalispell, MT	120
March 2, 2000	Missoula, MT	225
March 6, 2000	Ketchikan, AK	72
March 7. 2000	Sitka, AK	130
March 7. 2000	Idaho Falls, ID	520
March 8. 2000	Juneau, AK	151
March 8. 2000	Twin Falls, ID	600
March 9, 2000	Petersburg, AK	91
Total		**8,759**

[1/] two sessions

7.2.3.4 Community Assessment Forums

More than 1,140 community members throughout the lower Snake River Basin and southern Idaho were involved in a series of 26 interactive community forums (representing 28 communities) dealing with the Feasibility Study from late January to June 1999 (Table 7-4). The communities were selected to represent the variety of current conditions and potential social impacts in different sized agricultural, timber, recreational, and manufacturing based cities and towns with diverse geographic locations. These community forums were not structured like typical information meetings or public hearings; they were individually tailored for each community. Community members worked in groups during 4-hour, structured, interactive workshops aimed at identifying their perceptions of potential social and economic impacts associated with the study alternatives.

Table 7-4. Community Forum Participation

Town	Date	Number of Participants	Number of Public Observers[1/]	Total Attendance
Prescott, WA	1/20/99	51	10	61
Washtucna/Kahlotus, WA	1/26/99	71	124	195
Stanfield, OR	2/8/99	14	9	23
Adams, OR	2/8/99	10	3	13
Umatilla, OR	2/9/99	19	14	33
Burbank, WA	2/11/99	70	22	92
Riggins, ID	2/16/99	26	2	28
Enterprise, OR	2/17/99	23	4	27
Kennewick, WA	2/20/99	19	0	19
Colfax, WA	2/25/99	72	21	93
Pasco, WA	2/27/99	10	13	23
Pomeroy, WA	3/3/99	40	19	59
Weippe, ID	3/4/99	21	5	26
Genesee, ID	3/8/99	37	22	59
Lewiston, ID	3/9/99	33	12	45
Clarkston, WA	3/24/99	36	10	46
Orofino, WA	3/25/99	27	8	35
Salmon, ID	6/14/99	33	0	33
Ashton, ID	6/14/99	13	8	21
Firth, ID	6/15/99	15	21	36
Rupert, ID	6/15/99	21	7	28
Twin Falls, ID	6/16/99	18	18	36
Bliss/Hagerman, ID	6/17/99	21	12	33
Homedale, ID	6/17/99	9	2	11
Boise, ID	6/21/99	49	10	59
Cascade, ID	6/22/99	15	0	15
Total		**773**	**376**	**1,149**

1/ Only members of each specific community were invited to participate in that community's forum; people from other communities were classified as public observers. Public observers were, however, invited to provide written comments.

7.2.3.5 Briefings and Presentations

The Feasibility Study has received considerable attention from elected officials and interested organizations. The study team members have attempted to keep elected officials and their staffs informed about the study and some of its more controversial aspects through briefings and other contacts.

Study team members have also offered presentations and discussion sessions about the Feasibility Study to interested organizations such as special interest groups, stakeholders, service organizations, universities, and professional societies (see Appendix O, Public Outreach Program for a list). The outreach goal has been to meet all speaking requests to provide timely, firsthand, and accurate Feasibility Study information.

7.2.3.6 Tours of Facilities

Tours of the Walla Walla District hydropower facilities, especially Lower Granite Dam, have been carried out throughout the life of the Feasibility Study. Stakeholders, elected officials, special interest groups, governmental representatives, students, and the media have all toured facilities to better understand juvenile salmon passage issues. Tours are an opportunity to explain and to illustrate project improvements, innovative technology, and problem areas, as well as to discuss the feasibility study alternatives and their potential impacts.

7.3 Monitoring Public Outreach Effectiveness

Monitoring public outreach efforts has been accomplished in many ways, ranging from determining web site hits after a news release on meeting schedules to debriefing team members after presentations. Although no formal surveys were conducted to determine outreach effectiveness, there has been continued interest throughout the Feasibility Study expressed through e-mail, telephone and written questions, comments, and requests. Information packets, newsletters, and videos have been mailed out to provide interested individuals and organizations with timely, consistent, and accurate information.

Feasibility Study team members have made every reasonable effort to provide an open and effective public outreach effort. Despite busy work schedules, team members also made every effort to meet all requests for speaking engagements or special meetings.

7.4 Public Comment Process

The public comment period on the Draft FR/EIS began December 17, 1999, with the release of the FR/EIS and associated documents. The Corps announced the availability of the documents, announced the beginning of the comment period, and informed the public how to make comments on the FR/EIS in the following ways: 1) as required by NEPA, a notice of availability was published by the U.S. Environmental Protection Agency (EPA) in the Federal Register dated January 14, 2000; 2) the summary document, which was mailed out to 2,500 interested parties on the Corps' mailing list and made available by request, described the public comment period; 3) Newsletter No. 8, mailed in January 2000 to the Corps' mailing list, contained information on the public comment period; 4) an information paper was distributed to media contacts throughout the region in January 2000; 5) the Corps website (http://www.nww.usace.army.mil/lsr/) announced and explained the comment period and provided copies of the documents; and 6) the public was encouraged to provide comments at the series of 15 public meetings held in February and March.

Although the comment period was originally set to end on March 31, 2000, the Corps extended the deadline to April 30, 2000 in response to the high volume of interest and comments. Written public comments were received in a variety of forms, but most were mailed, faxed, or e-mailed. In all, the Corps received over 230,000 written comment documents. Examples of the original comment documents can be accessed at the Corps' Feasibility Study web site at http://www.nww.usace.army.mil/lsr/. A more comprehensive discussion of the public comment process associated with the Feasibility Study can be found in Appendix U, Response to Public Comments.

7.4.1 Processing the Comment Documents

All public comment documents received as a result of the public meetings, the FR/EIS, or the All-H Process were given a unique identification number and entered into a computer database. The Corps set up record retention and management files for all the comment documents.

Of the roughly 230,000 comment documents received, more than 90 percent were form letters, petitions, cards, faxes, or e-mails.

7.4.2 Evaluating the Comment Documents

It was the Corps' goal to ensure that each comment document was evaluated so issues of concern could be identified and addressed by technical experts. Form letters, petitions, cards, faxes, and e-mails were identified and grouped. The issues contained in each of these form comment documents were evaluated and incorporated into the issues and responses presented in Sections 4 and 5. The remaining unique comment documents were processed as summarized in the following sections. See Appendix U, Response to Public Comments, for a more detailed description of this very involved process.

7.4.2.1 Identifying and Categorizing Comments

Each unique comment document was reviewed by a trained member of the comment coding team and categorized in one of six categories: Federal Agency, State/Local Agency, Tribal Representative, Organization, Individual—Detailed, and Individual. To be placed in one of the first four categories, the document had to be received from an official representative of the agency/tribe/organization. Letters from individual members, etc., were not necessarily included in this category. Letters coded Individual—Detailed were from individuals with a specific expertise/training in a technical field who have provided their professional opinion in the form of specific comments on an aspect of the FR/EIS analysis. The Individual category was used to categorize comment documents from the general public.

Once the comment document was categorized, the coder determined whether or not it included Non-Lower Snake River comments. The comment documents that did not include lower Snake River comments were considered to be outside the scope of the FR/EIS and were coded Non-LSR.

The next step in the process was for the comment coder to read each comment document in its entirety, identify individual comments within the document, and assign a comment keyword. To be delineated as a comment and marked with a specific keyword the material had to be detailed and refer (directly or indirectly) to analysis, inconsistencies, inaccuracies, and/or omissions from the FR/EIS, associated documents, or associated

studies. If no detailed material was identified, the document received the comment code Non-specific. The majority of comment documents received this code. Although these documents did not provide specific feedback on the FR/EIS text or related analyses, coders did identify common themes, issues, questions, and concerns (along with those expressed in the form documents) to develop the General Issues and Responses provided in Section 4 of Appendix U, Response to Public Comments. Coded comments were sorted by keyword and forwarded, along with the corresponding marked letters, to the appropriate technical specialists for review and response to comments.

7.4.2.2 Responding to Comments

Appropriate technical specialists in each resource area represented in the FR/EIS (usually the authors of the FR/EIS sections and/or appendices) reviewed the general concerns raised in non-specific comment documents, form documents, and transcripts. They also reviewed each letter containing detailed comments coded for their resource areas, as well as issues identified in the public meeting transcripts. Because of the high volume of comments coded, the Corps opted to consolidate comments into issue statements. As all the material in their resource area was reviewed, technical specialists identified the issues raised in each comment, making sure each comment was rolled into an issue statement for the appropriate resource area. Once the issue statements were developed, technical specialists reviewed each issue statement and developed a response for each. Sections 4 and 5 in Appendix U, Response to Public Comments, detail these results and responses to the comment documents. Section 4 contains the more general issues raised primarily in non-specific comment documents, form documents, and transcripts; and Section 5 contains issues more specific to the FR/EIS.

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Chapter 8

Compliance with Applicable Federal Environmental Statutes and Regulations

8. Compliance with Applicable Federal Environmental Statutes and Regulations

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This section addresses Federal statutes, implementing regulations, and executive orders potentially applicable to the proposed lower Snake River actions. In each case, the text provides a brief summary of the relevant aspects of the law or order. The conclusions on compliance are based on the impact analysis presented in Section 5.0, Environmental Effects of Alternatives and the appendices.

8.1 National Environmental Policy Act

This FR/EIS was prepared pursuant to regulations implementing the National Environmental Policy Act (NEPA) (42 USC 4321 et seq). NEPA provides a commitment that Federal agencies will consider the environmental effects of their actions. It also requires that an EIS be included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The EIS must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, potential mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to

demonstrate that these factors have been considered by decisionmakers prior to undertaking actions.

This FR/EIS was prepared pursuant to NEPA for four alternative actions. In early 2000, the Corps held several series of public meetings to gather public opinions and comments on the alternatives in the Draft FR/EIS. Public comments received on the Draft FR/EIS are addressed in this Final FR/EIS.

8.2 Endangered and Threatened Species and Critical Habitat

The Endangered Species Act (ESA), (16 USC 1531-1544), amended 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a) of the ESA requires Federal agencies to consult with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats.

Section 7(c) of the ESA and the Federal regulations on endangered species coordination (50 CFR § 402.12) require that Federal agencies prepare biological assessments of the potential effects of major actions on listed species and critical habitat. The Corps has been and continues to consult with USFWS and NMFS concerning listed species that could be affected by the actions addressed in this FR/EIS. The most current biological opinions related to the FCRPS and this Feasibility Study are the NMFS and USFWS 2000 Biological opinions.

8.3 Fish and Wildlife Conservation

8.3.1 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) of 1980 (16 USC 661 et seq.) requires consultation with USFWS when any water body is impounded, diverted, controlled, or modified for any purpose. USFWS and state agencies charged with administering wildlife resources are to conduct surveys and investigations to determine the potential damage to wildlife and the mitigation measures that should be taken. USFWS incorporates the concerns and findings of the state agencies and other Federal agencies, including NMFS, into a report that addresses fish and wildlife factors and provides recommendations for mitigating or enhancing impacts to fish and wildlife affected by a Federal project. The Federal project must include justifiable measures that address USFWS recommendations and concerns. Federal agencies that construct or operate water-control projects are authorized to modify or add to the structures and operation of those projects to accommodate the means and measures for conservation of fish and wildlife.

The Corps has coordinated with USFWS throughout the Feasibility Study process. USFWS staff participated in the analyses conducted by several Corps study groups. USFWS completed the draft Fish and Wildlife Coordination Act Report, which is appended to the FR/EIS (Appendix M, Fish and Wildlife Coordination Act Report).

8.3.2 Fishery Conservation and Management Act of 1976

The Fishery Conservation and Management Act of 1976 (16 USC 1801-1882; 90 Stat. 331; as amended), also known as Magnuson Fishery Conservation and Management Act, established a 200-mile fishery conservation zone, effective March 1, 1977, and established the Regional Fishery Management Councils consisting of Federal and state officials, including the USFWS. The fishery conservation zone was subsequently dropped by amendment and the geographical area of coverage was changed to the Exclusive Economic Zone, with the inner boundary being the seaward boundary of the coastal States. Columbia River salmon and steelhead are found in this zone. Therefore, the potential effects of the alternatives on the fisheries in this zone have been examined in Section 5.0, Environmental Effects of Alternatives.

8.3.3 Migratory Bird Conservation Act

The Migratory Bird Conservation Act (16 USC 715 et seq.,) requires that lands, waters, or interests acquired or reserved for purposes established under the Act be administered under regulations promulgated by the Secretary of the Interior. This act involves conservation and protection of migratory birds in accordance with treaties entered into between the United States and Mexico, Canada, Japan, and the former Union of Soviet Socialist Republics; to protect other wildlife, including threatened or endangered species; and to restore or develop adequate wildlife habitat. The migratory birds protected under this Act are specified in the respective treaties. In regulating these areas, the Secretary of the Interior is authorized to manage timber, range, agricultural crops, and other species of animals, and to enter into agreements with public and private entities.

Section 5.6, Terrestrial Resources, addresses affected avian species as well as other terrestrial species of concern.

8.3.4 Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act)

The Northwest Power Act was passed by Congress on December 5, 1980 (16 USC 829d-1). This law created the eight-member Northwest Power Planning Council (NPPC), an interstate agency whose members are appointed by the Idaho, Montana, Oregon, and Washington governors. NPPC was entrusted with adopting a Fish and Wildlife Program for the Columbia River Basin by November 1982 and preparing a 20-year Regional Electric Power and Conservation Plan by April 1983. These plans are periodically updated and amended.

NPPC's Fish and Wildlife Program established a number of goals for restoring and protecting fish and wildlife populations in the basin. These goals led to changes in the operation of the Coordinated Columbia River System during the mid-1980s. One of the most notable changes resulted in the Water Budget, which provides for the release of specific amounts of water in the upper Columbia and Snake rivers to help juvenile salmon migrate downstream in the spring. More recently, the NPPC developed its own proposals to protect threatened and endangered salmon stocks. The NPPC has completed amendments to its Columbia River Basin Fish and Wildlife Program. The amendments adopted to date include mainstem survival, harvest,

production, habitat, flow measures that can be used to increase salmon and steelhead runs, and resident fish and wildlife measures. The Corps takes these amendments into consideration when making operating plans.

8.4 Heritage Conservation

A number of Federal laws have been promulgated to protect the nation's historical, cultural, and prehistoric resources.

8.4.1 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (16 USC 470) requires that Federal agencies evaluate the effects of Federal undertakings on historical, archeological, and cultural resources and afford the Advisory Council on Historic Preservation (ACHP) opportunities to comment on the proposed undertaking. The first step in the process is to identify cultural resources included in (or eligible for inclusion in) the National Register of Historic Places that are located in or near the project area. The second step is to identify the possible effects of proposed actions. The lead agency must examine whether feasible alternatives exist that would avoid such effects. If an effect cannot reasonably be avoided, measures must be taken to minimize or mitigate potential adverse effects.

The Corps, in coordination with other Federal agencies, the State Historic Preservation Offices (SHPOs), and Native American tribes, has identified cultural resources and sites in the project area for inclusion on the National Register. In addition, the agencies are evaluating the effects of the proposed alternatives on these sites and measures that might be implemented to mitigate the potential effects. Implementation of any of the alternatives would affect cultural sites to varying degrees. A large area of cultural sites would be exposed with dam breaching. Sites normally inundated might be exposed and subject to impacts from traffic, vandalism, and erosion from wind and waves. Those issues are addressed in Section 5.7, Cultural Resources.

8.4.2 Archeological Resources Protection Act

The Archeological Resources Protection Act (ARPA) (16 USC 470aa-470ll) provides for the protection of archeological sites located on public and Indian lands, establishes permit requirements for the excavation or removal of cultural properties from public or Indian lands, and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange, or other handling of cultural properties.

Any of the alternatives could result in continued erosion or exposure of cultural sites and subsequent damage. The drawdown included in Alternative 4—Dam Breaching could result in the new or increased exposure of sites. This in turn could lead to vandalism or an increase in ongoing vandalism at cultural sites. Appropriate monitoring/surveillance methods and awareness programs will need to be developed to prevent or minimize vandalism as part of overall monitoring and mitigation for cultural resources. The Corps will recommend prosecution of individuals caught vandalizing cultural sites.

8.4.3 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 USCA 3001) addresses the discovery, identification, treatment, and repatriation of Native American and Native Hawaiian human remains and cultural items (associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony). This Act also establishes fines and penalties for the sale, use, and transport of Native American Cultural items. Consistent with procedures set forth in applicable Federal laws, regulations, and policies, the Corps will proactively work to preserve and protect natural and cultural resources, establish NAGPRA protocols and procedures, and allow reasonable access to sacred sites.

8.4.4 American Indian Religious Freedom Act

The American Indian Religious Freedom Act (AIRFA) of 1978 (42 USCA 1996) established protection and preservation of Native American's rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that public officials must consider Native American's interests before undertaking actions that might harm those interests. The Corps will continue to coordinate with affected Native American Tribes on this study and future implementation plans.

8.5 State, Area-Wide, and Local Plan and Program Consistency

The Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR § 1506.2) require agencies to consider the consistency of a proposed action with approved state and local plans and laws. State and local government agencies operate a variety of recreational, infrastructure, and related resources along the river system. Impacts to these resources that could result from the various alternatives are identified in Section 5.0, Environmental Effects of Alternatives.

In accordance with Executive Order 12372, this FR/EIS will continue to be circulated to the appropriate state agencies for review and consultation requirements, as it has been at each stage in the process.

8.6 Coastal Zone Management Consistency

The Coastal Zone Management Act of 1972 (16 USC 1451-1564) requires that Federal actions be consistent, to the maximum extent practicable, with approved state coastal zone management programs. A state coastal zone management program (developed under state law and guided by the Act) sets forth objectives, policies, and standards to guide public and private uses of lands and waters in the coastal zone. The coastal zone as defined in the Act extends inland as far as necessary to account for factors that influence coastal shorelines. Washington and Oregon have approved coastal zone management programs, both of which list seven types of Federal activities directly affecting the coastal zone. The upper boundary of the coastal zone is downstream of Bonneville Dam.

The Feasibility Study alternatives would have little effect on water levels or river uses downstream of Bonneville Dam and therefore all alternatives are in compliance with the Act.

8.7 Environmental Justice

Environmental justice refers to executing a policy of the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws. Increasing concern with environmental equity or justice evolved from a series of studies, conducted in the late 1980s and early 1990s, that suggested that certain types of government and corporate environmental decisions may adversely affect low-income and minority populations to a greater extent than the general population. This finding was particularly the case with locally unpopular land uses, such as landfills and toxic waste sites. Recent guidelines addressing environmental justice include President Clinton's 1994 Executive Order 12898 and accompanying memorandum, the 1996 draft guidelines for addressing environmental justice under NEPA issued by the CEQ, and the 1997 interim guidelines issued by EPA.

EPA's Office of Environmental Justice defines environmental justice as:

> "*The fair and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies*" (EPA, 1998b).

Potential effects to low income and/or minority populations are discussed in Section 5.14.3.

8.8 Flood Plain Management

If a Federal agency program will affect a flood plain, the agency must consider alternatives to avoid adverse effects in the flood plain or to minimize potential harm. Executive Order 11988 requires Federal agencies to evaluate the potential effects of any actions they might take in a flood plain and to ensure that planning, programs, and budget requests reflect consideration of flood hazards and flood plain management.

The impacts of the alternatives on flood control capability are considered minor or negligible.

8.9 Wetlands Protection

Executive Order 11990 encourages Federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when undertaking Federal activities and programs. Any agency considering a proposal that might affect wetlands must evaluate factors

affecting wetland quality and survival. These factors should include the proposal's effects on the public health, safety, and welfare due to modifications in water supply and water quality; maintenance of natural ecosystems and conservation of flora and fauna; and other recreational, scientific, and cultural uses.

Emergent wetlands communities are prevalent in several areas along the lower Snake River. For wetlands that depend on full pool levels for water supply through subirrigation or shallow inundation, the wetlands might be lost or species composition would be altered with Alternative 4—Dam Breaching.

8.10 Farmland Protection

8.10.1 Farmland Protection Policy Act

The Farmland Protection Policy Act (7 USC 4201 et seq.) requires Federal agencies to identify and take into account the adverse effects of their programs on the preservation of farmlands. Each alternative in this study has been evaluated to determine whether it would cause physical deterioration and/or reduction in productivity of farmlands (see Section 8.10.2).

8.10.2 CEQ Memorandum, August 11, 1990, on Analysis of Impacts on Prime or Unique Agricultural Lands

The CEQ Memorandum establishes criteria to identify and consider the adverse effects of Federal programs on the preservation of prime and unique farmland; to consider alternative actions, as appropriate, that could lessen adverse effects; and to ensure Federal programs are consistent with all state and local programs for protection of farmland. The alternatives in this study were determined not to have a direct impact on prime or unique agricultural lands; direct impacts would be confined to the reservoirs. The Corps actions could, however, diminish the productive capacity of prime or unique agricultural lands that are adversely affected by changes in transportation or irrigation as a result of the project.

8.11 Recreation Resources

8.11.1 Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act (16 USC 1278 et seq.) designates qualifying free-flowing river segments as wild, scenic, or recreational. The Act establishes requirements applicable to water resource projects affecting wild, scenic, or recreational rivers within the National Wild and Scenic Rivers System, as well as rivers designated on the National Rivers Inventory. Under the Act, a Federal agency may not assist the construction of a water resources project that would have a direct and adverse effect on the free-flowing, scenic, and natural values of a Federally designated wild or scenic river. If the project would affect the free-flowing characteristics of a designated river or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area, such activities should be undertaken in a manner that would minimize adverse impacts and should be developed in consultation with the National Park Service (NPS).

Several reaches of the Snake River have been designated under the Wild and Scenic Rivers System, however, none are within the lower Snake River. The Hells Canyon reach, which is downstream of Brownlee Reservoir, is of primary interest.

The Hanford Reach of the Columbia River was studied by the NPS and an interagency team as a potential Federal Wild and Scenic River. The preferred alternative in a Final EIS on the Hanford Reach study was distributed in June 1994. It recommended the reach be designated as a combination National Wildlife Refuge and National Wild and Scenic River.

8.11.2 Columbia River Gorge National Scenic Area Act

On November 17, 1986, Congress established the Columbia River Gorge National Scenic Area (Scenic Area) as a Federally recognized and protected area (PL 99-663). The National Scenic Area Act (16 USCA 444 a-p) also created the bi-state Columbia River Gorge Commission and directed the Commission and the USDA Forest Service to jointly develop a management plan for the Scenic Area. The management plan is to reflect legislatively established purposes, which include a mandate to protect and provide for the enhancement of the scenic, cultural, recreational, and natural resources of the Scenic Area.

The Commission adopted a management plan on October 15, 1991. Counties affected by the plan have been encouraged to adopt ordinances consistent with this plan. The plan establishes land use designations for lands within the Scenic Area and specifies broad policies that provide for the protection of resources within the Scenic Area. Feasibility Study alternatives do not include any specific actions at the dams located within the Scenic Area (Bonneville and The Dalles).

8.11.3 Wilderness Act

The Wilderness Act of 1964 (16 USCA 1131 et seq.) established the National Wilderness Preservation System. Areas designated as wilderness under the original Act and subsequent wilderness legislation are to be administered for the use and enjoyment of the public in such a manner as to leave them unimpaired as wilderness. Development activities are generally prohibited within wilderness areas, and Federal agencies proposing actions must consider whether the effects of those actions would impair wilderness values. Although there are Wilderness Areas in this basin, none are located on the lower Snake River.

8.11.4 Water Resources Development Act

Congress generally authorizes water resources projects through biennial legislation, such as the Water Resources Development Act (WRDA) of 1990 (33 USC 2201). Section 310(b) of WRDA 1990 requires public participation in changes to reservoir operation criteria. Section 415(b) specifically requires public notification (hearings) of actions associated with drawdown of Dworshak Reservoir. No new drawdowns at Dworshak are contemplated in this FR/EIS.

8.11.5 Federal Water Project Recreation Act

In planning any Federal navigation, flood control, reclamation, or water resource project, the Federal Water Project Recreation Act (16 USCA 4612 et seq.) requires that full consideration be given to the opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. The Act requires planning with respect to the development of recreation potential. Projects must be constructed, maintained, and operated to provide recreational opportunities, consistent with the purpose of the project. The FR/EIS considers recreation opportunities of each alternative.

8.11.6 Land and Water Conservation Fund Act

The Land and Water Conservation Fund Act (LWCFA) (16 USCA 4601-11) assists in preserving, developing, and ensuring accessibility of outdoor recreation resources. The LWCFA establishes specific Federal funding for acquisition, development, and preservation of lands, water, or other interests authorized under the ESA and National Wildlife Refuge Areas Act. Funds appropriated under the Act are allocated to Federal agencies or as grants to states and localities. Recreation facilities on the lower Snake River as evaluated in the FR/EIS are not LWCFA funded facilities.

8.12 Navigable Waters

The Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. 1344) prohibits constructing bridges, dams, dikes, or causeways over harbors or navigable waters of the United States in the absence of Congressional consent and approval of plans by the Chief of Engineers and Secretary of the Army (33 U.S.C. 401). The Act prohibits any obstruction or alteration of any navigable water of the United States (33 U.S.C. 403). The purpose of the Act was to place the navigable waters of the United States under the exclusive control of the United States to prevent any interference with their navigability, whether bridges or other obstructions, except by express permission of the United States Government. It preserves the public right of navigation and prevents the interference with interstate and foreign commerce.

Alternative 4—Dam Breaching of the Feasibility Study is the only alternative course of action that would dramatically change the navigability of the lower Snake River. Under the other alternatives, the impacts to navigation would be minimal or nonexistent. Under Alternative 4—Dam Breaching, commercial navigation would change dramatically due to the permanent drawdown of reservoirs to near-natural river levels. This alternative would eliminate traditional barge transportation and would cause shifts in regional commodity transportation, as discussed in Section 5.9.

The Feasibility Study addresses the potential changes in navigation as one of many resources potentially affected by the actions considered within the study. If dam removal was the selected alternative, the Corps would require Congressional approval of such an action and that would involve Congressional consideration of effects to navigation in relation to the Rivers and Harbors Appropriation Act.

8.13 Pollution Control at Federal Facilities

In addition to their responsibilities under NEPA, Federal agencies are required to carry out the provisions of other Federal environmental laws. The alternatives discussed in this FR/EIS do not require any particular response with regard to Federal pollution control laws, which are more concerned with site-specific proposals and alternatives, rather than the broad decisions analyzed in this FR/EIS. Other areas will be addressed as appropriate in any site-specific document tiered to this FR/EIS.

To the extent applicable to an alternative presented in this FR/EIS, compliance with the standards contained in the following legislation will be included in this report:

- Title 42 USC 300 F, et seq., The Safe Drinking Water Act, as amended.
- Title 42 USC 6901, et seq., The Solid Waste Disposal Act.
- Title 33 USC 2701, et seq., Oil Pollution Act.
- Title 42 USC 9601 [9615] et seq., The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA).
- Title 7 USC 136, et seq., The Federal Insecticide, Fungicide, and Rodenticide Act, as amended (FIFRA)
- Title 42 USC 6901, et seq., The Resource Conservation and Recovery Act of 1976, as amended (RCRA).
- Title 15 USC, et seq., Toxic Substances Control Act (TSCA), as amended; Title 40 CFR Part 761, “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.”
- Title 42 USC 4901, et seq., The Noise Control Act of 1972, as amended.
- Title 29 USC 651, et seq., Occupational Health and Safety Act.

Short summaries of two of these acts are provided for additional information:

8.13.1 Federal Water Pollution Control Act (Clean Water Act)

The Federal Water Pollution Control Act (33 USC 1251 et. seq.) is more commonly referred to as the Clean Water Act (CWA). This act is the primary legislative vehicle for Federal water pollution control programs and the basic structure for regulating discharges of pollutants into waters of the United States. The CWA was established to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." The CWA sets goals to eliminate discharges of pollutants into navigable water, protect fish and wildlife, and prohibit the discharge of toxic pollutants in quantities that could adversely affect the environment. The Act has been amended numerous times and given a number of titles and codifications.

Further discussions on the CWA are found in Sections 4.4, 5.4, and 6.4 of the Final FR/EIS, as well as in Appendices C and T.

8.13.2 Clean Air Act

The Clean Air Act (CAA) (42 USC 7401 et. seq.), amended in 1977 and 1990, was established "to protect and enhance the quality of the nation's air resources so as to

promote public health and welfare and the productive capacity of its population." CAA authorizes the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. The CAA establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources. The CAA also requires the states to develop implementation plans applicable to particular industrial sources.

Additional discussions on the CAA are found in Sections 4.3, 5.3, and 6.4 of the Final FR/EIS, as well as in Appendix P.

8.14 Relevant Agreements

Implementation of the various proposed alternatives may affect or be affected by other specific relevant agreements. These agreements are not statutes or regulations but are important to consider with Columbia and Snake River actions. This section analyzes and presents the possible implications of implementing the alternatives with respect to the following selected relevant treaties and agreements:

- Canadian Entitlement Allocation Agreement (CEAA)
- Pacific Northwest Coordination Agreement (PNCA)
- Memorandum of Agreement (MOA) on the Bonneville Power Administration's (BPA's) financial commitment for fish and wildlife costs
- MOA on direct funding by BPA of power operation and maintenance costs at Corps projects
- United States Canada Salmon Agreement
- Tribal Treaties
- Specific Water Agreements in Idaho.

These agreements and their relationships to the proposed alternatives are summarized in the following sections.

8.14.1 Canadian Entitlement Allocation Agreement

8.14.1.1 Description

The Columbia River Treaty between the United States and Canada was signed in 1961 and ratified by the Governments in 1964. The Treaty required Canada to construct and operate 15.5 million-acre feet (MAF) of storage on the Columbia River and a tributary in Canada for optimum power generation and flood control downstream in Canada and the United States. Construction of reservoirs in Canada was undertaken at Duncan, Keenleyside (Arrow Lakes), and Mica.

The Treaty established United States and Canadian Entities as the implementing agencies for each Government. The Canadian Government designated British Columbia Hydro and Power Authority as the Canadian Entity. The United States Government designated the Administrator of BPA and the Division Engineer of the Corps, North Pacific Division as the United States Entity. The Entities are charged with carrying out most of the functions agreed to under the Treaty. Either

Government has the option to terminate the Treaty (except for certain provisions) after September 2024 with 10 years written notice.

Regulation of streamflows by the three Canadian Treaty reservoirs enables dams downstream in the United States to generate more usable electricity. This increase in usable electricity is referred to as the "downstream power benefits." The Treaty specifies that the downstream power benefits be shared equally between the two countries. Canada's portion of the downstream power benefits is known as the Canadian Entitlement. The downstream power benefits are derived under a formula prescribed by the Treaty and are determined by computing the difference in the hydroelectric power capable of being produced in the United States base system with and without the use of Canadian storage. The United States base system, defined in Annex B of the Treaty, is essentially the hydroelectric system that existed in the Columbia River Basin in 1961. The Treaty specifies a point on the United States/ Canadian border near Oliver, B.C. for the delivery of the Canadian Entitlement power unless a different point of delivery is mutually agreed upon by the United States and Canadian Entities.

The Canadian entitlement has both an energy and capacity component, defined by the Treaty as average annual usable energy and dependable capacity. The energy component may be characterized as the total number of megawatt-hours delivered over a specified time—usually one year. More typically, it is characterized as the average rate of delivery over such a time period, or average megawatts (aMW). The capacity component may be characterized as the maximum rate of delivery allowed in megawatts. Defining a capacity component in excess of the average megawatt energy figure allows the flexibility to shape the returned energy into time periods that more closely reflect the use of the energy, or its marketability.

The Treaty provided that if Canada and the United States agreed, Canada could sell its share of the downstream power benefits in the United States. Canada did not need the additional power at the time the Treaty was signed. Therefore, the Canadian entitlement was initially sold to the Columbia Storage Power Exchange (CSPE), a nonprofit corporation representing a group of 41 Pacific Northwest utilities in the United States, for a period of 30 years from the completion of each dam. These 30-year periods expire in 1998, 1999, and 2003.

8.14.1.2 Discussion of Impacts

The Canadian entitlement is guaranteed by law through at least 2024 and will continue to be provided, regardless of the power system in place. The CEAA is calculated based on theoretical water flows, not by actual water flows. However, there is a clause in the CEAA, which decreases the Canadian entitlement if the region buys more thermal power. As a result, the current level of entitlement will not be impacted by alternatives that leave the dams in place.

Under Alternative 4—Dam Breaching, the Canadian entitlement could decrease at a more rapid rate than under the dam retention alternatives, because the reliance on thermal power resources would occur more rapidly. The rule of thumb for the magnitude of these impacts is a decrease of approximately 3 megawatts (MW) benefit to the Canadians for each additional 100 MW of thermal power.

The expected range of the contribution of Federal and non-Federal sources during the life of the contract is approximately 70 to 75 percent Federal and 25 to 30 percent non-Federal. This range will continue under all alternatives. However, factors that cannot be predicted at this time could cause the percentage allocations to be outside the expected range.

8.14.2 Pacific Northwest Coordination Agreement (PNCA)

8.14.2.1 Description

The PNCA was developed to coordinate Pacific Northwest hydroelectric resources owned or operated by the signatory parties and also allows incidental coordination of other resources (thermal and miscellaneous) at the option of the parties. The parties to the current PNCA are: Montana Power Company, PacifiCorp, Portland General Electric Company, Puget Sound Power and Light Company, Washington Water Power Company, Colockum Transmission Company, Inc., Chelan County Public Utility District (PUD) #1, Cowlitz County PUD #1, Grant County PUD #2, Douglas County PUD #1, Pend Oreille County PUD #1, Snohomish County PUD #1, Seattle City Light, Tacoma City Light, Eugene Water and Electric Board, and the United States through the BOR, Corps, and BPA. The parties annually coordinate planning to estimate the firm load that can reliably be served by the coordinated resources and participate in energy exchanges throughout the contract year to achieve planned firm energy load carrying capacity (FELCC).

The overall purposes of coordination include:

- Optimizing generation through diversities and efficiencies
- Providing certainty in meeting firm load by coordinated resources
- Providing a mechanism to develop benefits from Canadian Storage.

The Columbia River Treaty between the United States and Canada also calls for the two countries to share the power benefits produced downstream in the United States as a result of the development of reservoir storage in Canada. The treaty assumes that the benefits are maximized if this storage is operated as part of a structure coordinated between the major power producers in the Pacific Northwest. In accordance with a set of principles developed by the Secretary of the Interior in 1961, the Pacific Northwest region's non-Federal utilities committed to provide a portion of the share of Treaty benefits the United States was required to deliver to Canada. In return, the U.S. Government agreed to participate in coordinated operation under the same set of principles. The CEAA and PNCA, both signed in 1964, implement those commitments. The CEAA and the PNCA will expire in 2003, but the earliest date possible for expiration of the Treaty is 2024. The parties recently agreed to a new PNCA, that, pending regulatory approval, will likely become effective in the near future.

8.14.2.2 Discussion of Impacts

The PNCA has as its primary goal the coordination of resources to maximize the efficiency and flexibility of operations to meet unusual or severe conditions (such as

may occur in severe cold weather conditions). If the power resource remains substantially unchanged, there will typically be little impact on the PNCA. However, flow augmentation occurrences in previous years (e.g., at 427,000 acre feet) have occasionally impacted the PNCA by reducing the flexibility of response. This is the case with Alternatives 1 through 3.

If an alternative under consideration further reduces the flexibility of the resources to meet the unusual or severe conditions, it could negatively impact the PNCA.

Under Alternative 4—Dam Breaching, the hydro-power resource base is reduced and is assumed to be replaced by combined turbine gas generators. The DREW Hydropower Impact Team (DREW HIT), which evaluated the potential impact of the study alternatives on the power system, concluded that 900 MW of production would be the economical level of power replacement. However, in order to develop a system that would meet the demand in severe weather (e.g., meeting the probable load factor required in a 1 in 20 winter), up to 1,550 MW of production would be required. If 1,550 megawatts of power are developed and included in the PNCA, there may be no significant affect on the PNCA. If this level of power is not developed, then the effectiveness of the PNCA could be negatively impacted.

8.14.3 Memorandum of Agreement on the Bonneville Power Administration's (BPA) Financial Commitment for Fish and Wildlife Costs

8.14.3.1 Description

A MOA was entered into by the Department of Energy (on behalf of BPA), the Department of the Army (on behalf of the Corps), the Department of the Interior (on behalf of BOR and the USFWS), and the Department of Commerce (on behalf of the National Oceanic and Atmospheric Administration [NOAA] through the NMFS) to "set forth the expectations of the Parties for the Fiscal Years 1996 through 2001 with regard to the budget commitment of Bonneville's ratepayers for the fish and wildlife costs covered under this Agreement, including a description of the procedures to be used to account for the spending of this budget commitment." The MOA placed a cap on BPA's expenditures for these programs at $252 million per year plus an estimated impact due to operational changes (e.g., lost revenue and/or power purchases).

The BPA fish and wildlife budget commitment and the MOA implementing that commitment are intended to reflect three working principles:

1. Provide greater financial certainty to BPA through a stable, multi-year budget for its fish and wildlife obligations
2. Identify a budget to meet BPA's fish and wildlife funding obligations, barring unforeseen events
3. Ensure that the funds expended for the survival, protection, mitigation, and recovery of dwindling runs of salmon and other fish and wildlife are expended soundly and efficiently."

The MOA recognizes:

1. Decisions on the part of BPA to fund the implementation of the 1995 and 1998 Biological Opinions on the operation of the Federal Columbia River Power System (FCRPS) in the manner and at the funding levels described in this Agreement.
2. Decisions on the part of the Corps and BOR to operate and modify the FCRPS in a manner consistent with the Biological Opinions and reflected in their records of decision on the Biological Opinions
3. The funding commitments in the MOA are adequate to implement the requirements of the Biological Opinions
4. A commitment on the part of BPA to fund the implementation of the Council's Fish and Wildlife Program
5. The Corps and BOR will take the Council's program into account to the fullest extent practicable when deciding on the operations of the FCRPS and other actions that affect fish and wildlife in the Columbia Basin
6. The Parties have also committed to fish and wildlife actions carried out by Columbia River Basin Indian Tribes, the states, and others that are funded by moneys subject to this budget.

The Parties agree that BPA's financial commitment under the MOA for Columbia River Basin fish and wildlife costs for Fiscal Years 1996 through 2001 is as follows:

7. BPA shall absorb the financial consequences of the System operations called for in the 1995 Biological Opinions, supplemented by certain other specific operations
8. With regard to expenditures for fish and wildlife in areas other than system operations, BPA's financial commitment shall average $252 million per year plus interest through these fiscal years for direct program costs (non-capital expenditures for fish and wildlife activities funded directly by BPA), reimbursable expenditures costs (the hydroelectric share of operation and maintenance and other non-capital expenditures for fish and wildlife related activities by the Corps, BOR and USFWS that are funded by Congressional appropriations and then reimbursed to the U.S. Treasury by BPA), and capital investment costs (the projected amortization, depreciation and interest payments for past fish and wildlife-related borrowing by BPA, the portion of past fish and wildlife capital investments by the Corps and BOR for which BPA is already obligated to repay the U.S. Treasury, the hydroelectric share of future fish and wildlife-related capital investments by the Corps and BOR that will be funded by appropriations and then reimbursed to the U.S. Treasury by BPA, based on activities called for in the Biological Opinions, the Council's Fish and Wildlife Program and other authorities, and other capital investments directly funded by BPA borrowing that are based on activities called for in the Biological Opinions and the Council's Fish and Wildlife Program).
9. The Corps, BOR, and USFWS are to be consistent with regional priorities. The MOA states: “When submitting budget requests for appropriations that will be reimbursed by Bonneville within this category, the regional offices of the Corps

of Engineers, Bureau of Reclamation, and USFWS will act in a manner consistent with this Agreement and with the regional priorities and recommendations of the Parties, Tribes, and Council developed under this Agreement pursuant to the procedures described in the Annex. If the President subsequently submits a proposed budget to Congress seeking appropriations for reimbursable expenses that will result in expenditures by Bonneville that differ from the expected budget allocation (as described in the previous sentence) for this category under this Agreement, it will be explained to Congress, NPPC Council and the Tribes the way in which the proposed budget differs from that developed under this Agreement, including an explanation of the reason for this difference and the impact of the difference on the ability to carry out other activities under this Agreement.

8.14.3.2 Discussion of Impacts

This MOA does not limit the fish and wildlife obligations of the various agencies involved under any of the alternatives under consideration. In addition, the MOA runs through 2001, which is likely to be before any of the action alternatives are scheduled for implementation.

If the budget for fish and wildlife programs needs to be increased (under any of the alternatives), it could be reflected in a modification of the budget. As a result, the MOA could remain in its present form with a modified budget or be eliminated.

8.14.4 MOA on Direct Funding of Power Operation and Maintenance Costs at Corps Projects

8.14.4.1 Description

The National Energy Policy Act of 1994 (PL 102-486, Section 2406) authorized BPA to direct fund generation additions, improvements, and replacements at Department of Army, North Pacific Region hydropower generation facilities.

A MOA was entered into by BPA and the Department of Army (Corps), subsequent to the Act, on December 4, 1994. This MOA established the framework and administrative details for BPA direct funding of large capital hydropower Operation and Maintenance (O&M) generation additions, improvements, repairs, replacements, or rehabilitations. The Corps headquarters guidance limited the use of this vehicle to non-routine capital items.

Another MOA between BPA and the Department of Army was signed on December 22, 1997. This MOA implements a major policy change by authorizing the funding of hydropower specific baseline and small capital O&M work, and the power portion of joint use costs, from congressional appropriations to direct funding by BPA. The non-power portion of the joint use costs continues to be fully funded by congressional appropriation.

The power share of joint costs account for approximately 90 percent of total costs and non-power share of joint costs account for approximately 10 percent of total costs (based on an average of all four Lower Snake River projects).

The agreement took effect in fiscal year 1999 and will continue in effect until 2008. However, the budget for direct funding has only been estimated through 2003.

8.14.4.2 Discussion of Impacts

The direct funding provisions of the MOA include both O&M and small construction costs. The MOA could continue to operate under any of the alternatives under consideration. However, if construction costs increase significantly, the budget would need to be modified. This would be the case under both Alternative 2—Maximum Transport of Juvenile Salmon and Alternative 4—Dam Breaching. There could also need to be a modification to the cost allocation process under Alternative 4 —Dam Breaching.

8.14.5 Tribal Treaties

8.14.5.1 Description

Two documents prepared for this study shed further light on tribal issues. The Corps prepared Appendix Q, Tribal Consultation/Coordination, which addresses issues related to 14 tribes that are resident in the study area. In addition, the Tribal Circumstances report prepared for this study by Meyer Resources, Inc. in association with the Columbia River Inter-Tribal Fisheries Commission (CRITFC) (Meyer Resources, 1999) addresses issues related to the Treaty Tribes. These documents provide additional information on issues related to the tribes and tribal treaties. The tribes included in these reports are (Treaty Tribes are denoted with an asterisk):

- Confederated Tribes of the Warm Springs Reservation of Oregon*
- Burns Paiute Tribe of the Burns Paiute Indian Colony
- Kootenai Tribe of Idaho
- Northwestern Band of Shoshoni Nation
- Shoshone-Paiute Tribes of Duck Valley Reservation
- Confederated Tribes of the Colville Indrau Reservation
- Nez Perce Tribe*
- Coeur d'Alene Tribe
- Shoshone-Bannock Tribes of the Fort Hall Reservation*
- Confederated Tribes and Bands of the Yakama Indian Nation of the Yakama Reservation*
- Spokane Tribe of Spokane Reservation
- Confederated Tribes of the Umatilla Reservation*
- Kalispel Indian Community of the Kalispel Reservation.
- Wanapum Band.

The Corps has long recognized the sovereign status of Indian tribes. Principles outlined in the Constitution and treaties, as well as those established by federal laws,

regulations, and Executive Orders, continue to guide the Corps' national policy towards Indian Nations.

The Corps operates within a government-to-government relationship with Federally recognized Indian tribes. This involves consulting, to the greatest extent practicable and permitted by law, with Indian tribal governments; assessing the impact of agency activities on tribal trust resources and assuring that tribal interests are considered before the activities are undertaken; and removing procedural impediments to working directly with tribal governments on activities that affect trust property or the governmental rights of the tribes.

The Corps recognizes that tribal governments are sovereign entities, with rights to set their own priorities, develop and manage tribal resources, and be involved in Federal decisions or activities which have the potential to affect these rights. The Corps worked to meet trust obligations, protect trust resources, and to obtain tribal views of trust and treaty responsibilities or actions related to this study, in accordance with provisions of treaties, laws, and Executive Orders as well as principles lodged in the Constitution of the United States. Several tribal chairs/leaders have met with Corps commanders/leaders with regard to the study. The Corps has also reached out, through designated points of contact, to involve tribes in collaborative processes designed to ensure information exchange and consideration of disparate viewpoints.

Appendix Q, Tribal Coordination/Consultation, address the Corps' work toward fulfilling obligations regarding preservation and protection of trust resources, comply with the Native American Graves Protection and Repatriation Act, and ensure reasonable access to sacred sites in accordance with published guidance.

8.14.5.2 Discussion of Impacts

The tribal impacts of the alternatives under consideration are being evaluated using many resources. These include the Tribal Circumstances and Perspectives report; Cultural Resources; Appendix Q, Tribal Coordination/Consultation; Consultation efforts; and other comments received throughout the study process. The Corps is committed to carrying out their activities in a manner that fulfills their Treaty and Trust obligations. For a more detailed discussion on alternative impacts see Sections 5.7, Cultural Resources and Section 5.8, Native American Indians.

8.14.6 Water Rights Agreements

8.14.6.1 Description

The current flow augmentation program provides approximately 427,000 acre-feet of water. The current program follows the principle of acquiring water only from willing sellers and, after 4 years, there has been permanent acquisition of approximately 78,000 acre-feet of storage space and natural flow rights. Rental pools and other sources provide the remaining volume under current conditions.

The Western States obtained ownership of streams and control of the water within each state upon admission to the United States. Section 8 of the Reclamation Act of 1902 recognizes this principle by requiring that the acquisition and use of water for

BOR projects be governed by state law, unless preempted by Federal law. Section 8 (32 Statute 390; 43 U.S.C. SS 372, 383) states:

> "Nothing in this act shall be construed as affecting or intended to affect or to in any way interfere with the laws of any State or Territory relating to the control, appropriation, use, or distribution of water used in irrigation, or any vested right acquired thereunder, and the Secretary of the Interior, in carrying out the provisions of this act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any State or of the Federal government or any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof: Provided, that the right to the use of water acquired under the provisions of this act shall be appurtenant to the land irrigated and beneficial use shall be the basis, the measure, and the limit of the right."

Reclamation storage and release of water for project purposes has complied with state water law. State laws regulate the acquisition and the use of water and limit the use of water to beneficial purposes as determined by the state. Water rights are secured in accordance with state water law, and water rights granted by the state are defined in terms of the type of water use, the period of use, the source of water, the location of the point of diversion and place of use, and the rate and total volume that may be diverted, if applicable (some rights do not involve a diversion). Any changes in water use from those described in the water right definition must generally be authorized by the state through an approval of a transfer of water right. The BOR has secured changes in purpose of use of Oregon natural flow rights and secured interim Idaho legislation approving the use of stored water for flow augmentation.

Watermasters in Idaho and Oregon oversee the local diversion and use of water to assure compliance with water rights of record. These activities tend to be more intense for those stream segments or basins where there is insufficient water to meet all valid water rights. In these cases, the watermasters regulate the diversion of water to assure that the available water supply is distributed to valid rights of record in accord with the prior appropriation doctrine.

8.14.6.2 Discussion of Impacts

Under Alternative 1—Existing Conditions, Alternative 2—Maximum Transport of Juvenile Salmon, and Alternative 3—Major System Improvements, there are no major impacts to water rights agreements. Under Alternative 4—Dam Breaching, there would be impacts to irrigators on the Ice Harbor reservoir.

8.14.7 Pacific Salmon Treaty

8.14.7.1 Description

The 1985 Canada-United States Pacific Salmon Treaty was negotiated to ensure conservation and an equitable harvest of salmon stocks. Representatives from the two countries meet annually to review the past year's fishery and to negotiate fishing regimes for future years. The main implementing body for the Treaty is the Pacific Salmon Commission. The Commission is divided into two national sections, with

commissioners appointed by each nation. Enabling legislation in the United States prescribes that the U.S. section have one member from Alaska, one from Oregon or Washington, one representing treaty tribes, and one non-voting Federal official. The Canadian section is led by the Federal Department of Fisheries and Oceans and includes representatives from First Nations, recreational and commercial fisheries, as well as the provincial government of British Columbia. The Treaty also established several scientific and technical committees, which provide the Commission with essential data on the stocks and fisheries.

The two principles on which the Treaty rests are conservation and equity.

- The conservation principle obliges the two parties to prevent overfishing and provide for optimum production.
- The equity principle provides for each country to receive fishery benefits equivalent to the production of salmon from its own rivers.

In 1985, when the Treaty was signed, Canada and the United States agreed on fishing arrangements to address chinook conservation problems and limit major interception fisheries in both countries. It was acknowledged, in a Memorandum of Understanding (MOU) attached to the Treaty, that the equity principle was not implemented in 1985. The MOU also provided limited guidance on how the equity principle should be implemented when the necessary data on salmon interceptions were developed.

Although the parties have made substantial improvements in the estimates of stock contributions to intercepting fisheries, agreement on how the equity principle should be implemented has not been reached. The Commission has not been able to agree on key policy issues affecting equity implementation.

8.14.7.2 Discussion of Impacts

NMFS estimates that "nearly two-thirds of the ocean harvest impacts on Snake River fall chinook occurred in Canadian fisheries during the base period, although this is a very small fraction of the harvest. As a result, substantial ocean impact reductions, which are necessary to protect the listed salmon, can only be achieved with the cooperative involvement of Canada. Canada's cooperation can best be achieved by focusing on the general coast-wide status of wild chinook stocks that have been the concern of the bilateral chinook rebuilding program (and a key element of the Pacific Salmon Treaty) since 1985."

The alternatives under consideration that meet the NMFS jeopardy standards are considered the best options to enhance United States obligations with respect to the Pacific Salmon Treaty.

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Chapter 9

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9. Literature Cited

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Chapter 10

Glossary

10. Glossary

A-race/B-race—Terms related to timing and distribution of adult steelhead in the Columbia River System. A-race refers to those summer steelhead that enter the Columbia River in early August and are destined for tributaries throughout the Columbia. B-race refers to those that enter in late August through October and are destined primarily for tributaries of the Snake River.

Adaptive migration strategy—An approach that balances the passage of fish between in-river and transport methods. This strategy addresses concerns about risks and effectiveness associated with bypass-only and transport-only approaches. It allows flexibility for implementing operational changes within a migration season, if necessary.

Aesthetics—Of or pertaining to the sense of beautiful.

Agricultural land tenure—Land owned, used, or held for agricultural purposes.

Algae—Photosynthetic organisms lacking multicellular sex organs.

Alternative 1—Existing Conditions—The existing hydrosystem operations under the National Marine Fisheries Service's 1995 and 1998 Biological Opinions. The Corps would continue to increase spill and manipulate spring and summer river flows as much as possible to assist juvenile salmon and steelhead migration. Juvenile salmon and steelhead would continue to pass the dams through the turbines, over spillways, or through the fish bypass systems. Transportation of juvenile fish via barge or truck would continue at its current level.

Alternative 2—Maximum Transport of Juvenile Salmon—The existing hydrosystem operations plus maximum transport of juvenile salmon, without surface bypass collectors. The number of juvenile fish transported via barge or truck would be increased to the maximum extent possible.

Alternative 3—Major System Improvements—The existing hydrosystem operations and adaptive migration measures for juvenile salmon and steelhead, but with additional major system improvements (such as surface bypass collectors) that could be accomplished without dam breaching.

Alternative 4—Dam Breaching—Near-natural river drawdown of the four lower Snake River reservoirs.

Ambient air quality standards (AAQSs)—Standards required by the Federal Clean Air Act and enforced by the U.S. Environmental Protection Agency that protect public health, provide for the most sensitive individuals, and allow a margin of safety by setting an acceptable level for measured pollutant concentrations. AAQSs cannot take into account the cost of achieving the standards.

Anadromous fish—Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Assumption sets—When running the lifecycle model to generate future salmon population levels, several choices must be made regarding the magnitude of particular sources of mortality, routes of fish passage, flow rates, and so on. A complete set of these assumptions, used to generate 4,000 replicate Monte Carlo simulations of the effect of an alternative hydrosystem management action, is called an assumption set.

Average megawatt (aMW)—The average amount of energy (in megawatts) supplied or demanded over a specified period of time; equivalent to the energy produced by the continuous operation of one megawatt of capacity over the specified period.

Bacterial Kidney Disease (BKD)—A disease of salmonids caused by the bacterium *Renibacterium salmoninarum*. The bacterium can be passed between juvenile fish where they are concentrated in hatcheries and in transportation systems and can be passed to the next generation by an infected female.

Behavioral guidance structure (BGS)—A long, steel, floating structure designed to simulate the natural shoreline and guide fish toward the surface bypass collection system by taking advantage of their natural tendency to follow the shore.

Benthic community—Aquatic organisms and plants that live on the bottom of lakes or rivers, such as algae, insects, worms, snails, and crayfish. Benthic plants and organisms contribute significantly to the diets of many reservoir fish species.

Bulkhead channel—Channel through which fish are carried upward through the turbines via a bulkhead slot if they are not diverted by turbine intake screens.

Bypass channel—Fish diverted from turbine passage are directed through a bypass channel to a holding area for release or loading onto juvenile fish transportation barges or trucks.

Class 1 River—The largest rivers of the state (e.g., Skagit, Columbia, Snake, Nooksack, Chehalis, or Willamette).

Collection channel—Holding area within the powerhouse that fish enter after exiting the bulkhead slot.

Columbia-Snake Inland Waterway—456-mile long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake Rivers.

Commodity—A transportable article of trade or commerce, especially an agricultural or mining product.

Community resiliency—A town's ability to successfully deal with multiple social and economic changes; a primary indicator of a community's health and vitality.

Comp Plan—Refers to the Lower Snake River Fish and Wildlife Compensation Plan, a plan to fulfill the Corps' mitigation obligations under the Fish and Wildlife Coordination Act (1958). The plan was authorized under the Water Resources Development Act of 1976.

Conversion rates—The estimated survival of adults during upstream migration is expressed as a "conversion rate." Conversion rates are calculated by dividing the count of a particular group of adult fish at the uppermost dam by the count of that group at the lowest dam, subtracting out estimates of harvest and tributary harvest between the dams.

CRI—Acronym for Cumulative Risk Initiative, which is a network of NMFS scientists working to synthesize information and provide a clear, consistent, and scientifically rigorous decision support for salmonid conservation. The CRI has used matrix modeling of salmonid population dynamics to evaluate extinction risks and the sensitivity of population growth for each ESU to changes in survival as a result of management actions.

CRiSP—Acronym for Columbia River Salmon Passage, the passage model developed by the Center for Quantitative Studies at the University of Washington under contract to the Bonneville Power Administration.

CRITFC Tribes—Members of the Columbia River Inter-tribal Fish Commission include the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Tribes, the Yakama Indian Nation, and the Confederated Tribes of the Warm Springs of Oregon.

Cultural resources—Archaeological and historical sites, historic architecture and engineering, and traditional cultural properties.

Dam breaching—In the context of this FR/EIS, dam breaching involves removal of the earthen embankment section at Lower Granite and Little Goose, and formation of a channel around Lower Monumental and Ice Harbor.

Decommission—To take the dams and associated facilities out of service such that they are not in use or working condition.

Deflation—The removal of the archaeological soils by water, leaving heavier items and artifacts in place, but dispersing lighter artifacts.

Differential delayed transportation mortality—Additional mortality suffered by transported fish after their release from the transport vehicle into the Columbia River below Bonneville Dam—hypothesized to be caused by stresses associated with the transportation system. Differential mortality is measured as the ratio of the post-Bonneville-Dam survival of transported fish to that of nontransported fish. Delayed transportation mortality is differentiated from any direct mortality of fish that occurs during transportation.

Direct service industries (DSIs)—Some of the region's largest industries (e.g., aluminum companies) who buy their power directly from the Bonneville Power Administration.

Dissolved gas supersaturation—Caused when water passing through a dam's spillway carries trapped air deep into the waters of the plunge pool, increasing pressure and causing the air to dissolve into the water. Deep in the pool, the water is "supersaturated" with dissolved gas compared to the conditions at the water's surface.

Drawdown—In the context of this FR/EIS, drawdown means returning the lower Snake River to its near-natural condition via dam breaching.

Drawdown Regional Economic Workgroup (DREW)—A group of regional economists studying the economic issues associated with alternative actions on the lower Snake River.

D-values—Measure used to quantify differential delayed transportation mortality. A D-value of 1.0 would mean that there was no differential delayed transportation mortality (there could be mortality; it is just no different between transported and non-transported fish). The lower the value of D (relative to 1.0), the larger the differential delayed transportation mortality. It is possible for D to be greater than 1 (in which case transported fish would have survived at a higher rate than non-transported fish).

Economic diversity index—Provides a relative indication of the economic opportunities present in a community.

Endangered species—A native species found by the Secretary of the Interior to be threatened with extinction.

Endemic—A term used to describe a species whose population is limited to one area.

Environmental justice—The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income within the development, implementation, and enforcement of environmental laws.

Evapotranspiration—Discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces and by transpiration from plants. Also know as total evaporation, water loss.

Evolutionary Significant Unit (ESU)—A population that 1) is substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species.

Extra mortality—Any mortality occurring outside the migration corridor (i.e., below Bonneville Dam) that is not accounted for by in-common climate effects or by differential delayed transportation mortality.

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.

Fauna—A general term for animal life.

Federal Columbia River Power System (FCRPS)—Official term for the 14 Federal dams on the Columbia and Snake Rivers.

Firm energy—The amount of energy that can be generated given the region's worst historical water conditions. It is energy produced on a guaranteed basis.

Firm energy load-carrying capability (FELCC)—The amount of energy the region's generating system, or an individual utility or project, can be called on to produce on a firm basis during actual operations. FELCC is made up of both hydro and non-hydro resources, including power purchases.

Fish collection/handling facility—Holding area where juvenile salmon and steelhead are separated from adult fish and debris by a separator and then passed to holding ponds or raceways until they are loaded onto juvenile fish transportation barges or trucks.

Fish guidance efficiency (FGE)—Percent of juvenile salmon and steelhead diverted away from the turbines by submersed screens or other structures.

Fish passage efficiency (FPE)—Portion of all juvenile salmon and steelhead passing a facility that do not pass through the turbines.

Flow augmentation—Increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs upstream.

FLUSH—Acronym for Fish Leaving Under Several Hypotheses, the passage model developed by the states of Oregon, Washington, and Idaho and the Columbia River Intertribal Fish Commission.

Foraging habitat—Areas where wildlife search for food.

Fugitive emissions—Material released into the air from sources other than industrial vents and stacks (e.g., windblown dust).

Gas bubble disease (GBD) or trauma (GBT)—Condition caused when dissolved gas in supersaturated water comes out of solution and equilibrates with atmospheric conditions, forming bubbles within the tissues of aquatic organisms. This condition can kill or harm fish.

Habitat—An area that provides some portion of the requirements for the life history of a given species.

Habitat management units (HMUs)—62 parcels of land scattered along the river and reservoirs that the Corps purchased and manages as mitigation for the land that was inundated as a result of the dams and reservoirs. These HMUs are managed to replace hunting, fishing, and recreation opportunities lost as a result of inundation as well as to benefit and provide for wildlife that lost habitat to inundation.

Habitat units (HUs)—A numerical value used to quantify wildlife habitat. HUs are developed using the U.S. Fish and Wildlife Services Habitat Evaluation Procedures (HEP).

Headburn—A condition where open wounds are found on heads of adult fish.

Hunter use-day—Unit of measurement used in recreation section that refers to one day of hunting by one person.

Hydrographs—A graphic representation of stage, flow, velocity, or other characteristics of water at a given point and time.

Hydrology—The science dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Inundation—The covering of pre-existing land and structures by water.

Irrigation—Artificial application of water to usually dry land for agricultural use.

Jack salmon—A precocious or early maturing salmonid fish; most are males.

Juvenile fish transportation system (JFT)—System of barges and trucks used to transport juvenile salmon and steelhead from the lower Snake River or McNary Dam to below Bonneville Dam for release back into the river; alternative to in-river migration.

Kilowatt—1 kilowatt is 1,000 watts of energy.

Littoral zone—The shore area along a body of water, usually a lake, down to the depth of 10 meters.

Lock—A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Lower Snake River Hydropower Project (Lower Snake River Project)—The four hydropower facilities operated by the Corps on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor.

Macroinvertebrates—A broad term used to refer to invertebrates large enough to be seen with the naked eye.

Macrophytes—large, vascular aquatic plants that grow in shallow water along the shorelines of lakes or in the slow-moving reaches of rivers.

Megawatt (MW)—One million watts, a measure of electrical power or generating capacity. A megawatt will typically serve about 1,000 people. The Dalles Dam produces an average of about 1,000 megawatts.

Mesic shrubland—Wetlands usually found in side canyons and seasonal springs and seeps, characterized by species such as netleaf hackberry, Douglas hawthorn, smooth sumac, blackberry, and rose.

Mils—One tenth of a penny.

Minimum operating pool (MOP)—The bottom one foot of the operating range for each reservoir. The reservoirs normally have a 3-foot to 5-foot operating range.

Mitigation—To moderate or compensate for an impact or effect.

Natal stream—Stream of origin.

Navigation—Method of transporting commodities via waterways; usually refers to transportation on regulated waterways via a system of dams and locks.

Nonattainment areas—Geographic areas with measured pollutant concentrations greater than the AAQSs.

Ocean regime shift—Cycle of oceanographic conditions that alters patterns of circulation, the distribution of predators and prey, and productivity. Cycles have been observed on the timescale of years (El Niño), decades (Pacific interdecadal oscillations), and thousands of years (ice ages). The current ocean regime, and a shift on the timescale of years or decades, may affect the likelihood of recovery under any hydrosystem management alternative.

Palustrine emergent—Wetland type characterized by cattail, bulrushes, and sedges.

Palustrine forest—Wetlands found adjacent to the reservoirs and major tributaries characterized by cottonwood, alder, and black locust.

Palustrine open water—Wetland type characterized by open water such as ponds.

Palustrine scrub-shrub—Wetlands found adjacent to river and on islands characterized by shrubs such as willow.

Passage model—Mathematical simulation of the effect of downstream passage (through eight Federal mainstem hydro projects) on the survival of juvenile salmonids. PATH used two passage models, CRiSP and FLUSH (see above). The models differ both in their mathematical structure and in assumptions about survival through various parts of the hydrosystem (see page 25 in Marmorek and Peters [1998] *[March 1998 report]* for a brief comparison).

Pelagic food sources—Food sources for aquatic organisms that live in the water column.

Per capita income—Average income per person.

pH—An index of the hydrogen ion concentration in water, measured on a scale of 0 to 14. A value of 7 indicates a neutral condition, values less than 7 indicate acidic conditions, and values greater than 7 indicate alkaline conditions.

Photic—Relating to light.

Photoperiod—Length of the period of daylight each day.

Photosynthesis—Biochemical process by which plants use the energy of sunlight to combine carbon dioxide and water into sugars.

Phytoplankton—Drifting plants such as microscopic algae that nourish themselves from the energy of the sun; they are at the base of the food chain and provide a food source for bacteria, water molds, and zooplankton. Plankton that demonstrate characteristics of the plant kingdom (i.e., they derive energy from inorganic substances).

Piping—Soil erosion process in which the pore pressure increases cause a vertical type fracture in the soil; this process can be a precursor to larger mass wasting failures.

Plan for Analyzing and Testing Hypotheses (PATH)—A work group of regional fisheries biologists that measure projected salmon and steelhead survival rates associated with alternative actions.

Plankton—The passively floating animal and plant life of a body of water.

Pumping stations—Facilities that draw water through intake screens in the reservoir and pump the water uphill to corresponding distribution systems for irrigation and other purposes.

Reasonable and Prudent Alternatives (RPA)—Alternatives to a proposed or continuing action when that action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat.

Recovery—The process by which the ecosystem is restored so it can support self-sustaining and self-regulating populations of listed species as persistent members of the native biotic community. This process results in improvement in the status of a species to the point at which listing is no longer appropriate under the ESA.

Redd—A salmon or steelhead spawning nest in gravel in which eggs are deposited.

Removable spillway weir (RSW)—A removable steel structure that is attached to the forebay of an existing spill bay, creating a raised overflow weir above and upstream of the existing spillway crest.

Reservoir fluctuation area—Area between the minimum and maximum pool levels of a reservoir which includes the littoral, wave-action, and inundation zones.

Resident fish—Fish species that reside in fresh water throughout their lifecycle.

Riparian—Ecosystem that lies adjacent to streams or rivers and is influenced by the stream and its associated groundwater.

Riparian area—Area including a stream channel, a lake, a pond, or wetland, and the adjacent land where the vegetation complex and microclimate conditions are products of the combined presence and influence of perennial and/or intermittent water, associated high water tables, and soils that exhibit some wetness characteristics.

Risk averse—In the context of PATH analyses, "risk averse" corresponds to a management action that minimizes the risk of not meeting recovery and survival criteria, an action that succeeds in satisfying performance criteria over the widest range of assumptions.

Rookery—A concentration of nesting birds, usually herons or pelicans.

Rule curves—Water levels, represented graphically as curves, that guide reservoir operations. See critical rule curves, energy content curves, and flood control rule curves.

Run-of-river—This describes hydropower facilities that do not have storage or the associated flood control capacity; run-of-river facilities essentially pass through as much water as they have coming in, either through the turbines or over the spillways.

Scouring—Concentrated erosive action, especially by stream or river water, as on the outside curve of a bend.

Simulated Wells Intake (SWI)—Modified turbine intake that draws water from below the surface so that the surface is calmer and juvenile fish are less influenced by turbine flows. This allows juvenile fish more opportunity to discover and enter the surface bypass collection system.

Slumping—A landslide; the separation of a land or soil mass from a land surface and its movement downslope.

Spawning—The reproductive process for aquatic organisms which involves producing or depositing eggs or discharging sperm.

Spill—Water released through the dam spillways, rather than through the turbines. Involuntary spill occurs when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs. Voluntary spill is one method used to pass juvenile fish without danger of turbine passage.

Spillway flow deflectors (flip lips)—Structures that limit the plunge depth of water over the dam spillway, producing a less forceful, more horizontal spill. These structures reduce the amount of dissolved gas trapped in the spilled water.

Surface bypass collection (SBC) system—System designed to divert fish at the surface before they have to dive and encounter the existing turbine intake screens. SBCs direct the juvenile fish into the forebay, where they are passed downstream either through the dam spillway or via the juvenile fish transportation system of barges and trucks.

Surface erosion—Movement of soil particles down or across a slope, as a result to gravity and a moving medium such as rain or wind. The transport of sediment depends on the steepness of the slope, the texture and cohesion of the soil particles, the activity of rainsplash, sheetwash, gullying, dry ravel processes, and the presence of buffers.

Surficial deposits—Unconsolidated alluvial, residual, or glacial deposits overlying bedrock or occurring on or near the surface of the earth.

Survival—The species' persistence beyond the conditions leading to its endangerment, with sufficient resilience to allow for potential recovery from endangerment. The condition in which a species continues to exist into the future while retaining the potential for recovery.

Terracing—Creation of a relatively level bench or step-like surface, breaking the continuity of a slope.

Threatened species—A native species likely to become endangered within the foreseeable future.

Total suspended solids (TSS)—The portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one millimeter in diameter (clays and silts). High TSS concentrations can adversely affect primary food production and fish feeding efficiency. Extremely high TSS concentrations can impair other biological functions such as respiration and reproduction.

Transponder—A transmitter-receiver used to track fish passage.

Transport to In-river Ratio (TIR)—The ratio of the number of adults returning to a given location from a transport group of marked juveniles to the number of adults returning to the same location from the "in-river" group of marked juveniles released to migrate downsteam in-river.

Trophic level—Position in the food chain determined by the number of energy-transfer steps to that level.

Tules—Fall chinook salmon that are confined mainly to the lower Columbia River tributaries (below Bonneville pool).

Turbidity—An indicator of the amount of sediment suspended in water. It refers to the amount of light scattered or absorbed by a fluid. In streams or rivers, turbidity is affected by suspended particles of silts and clays, and also by organic compounds like plankton and microorganisms. Turbidity is measured in nephelometric turbidity units.

Turbine intake screens—Standard-length traveling fish screens or extended-length submerged bar screens that are lowered into the turbine bulkhead slots to divert fish from the turbine intake.

Turbine intakes—Water intakes for each generating unit at a hydropower facility.

Upriver brights—Fall chinook salmon that mainly spawn in the mainstem Columbia River in the Hanford Reach (downstream of Priest Rapids Dam) and in the Snake River System.

Wetland—An ecosystem in which groundwater saturates the surface layer of soil during a portion of the growing season, often in the absence of surface water. This water remains at or near the surface of the soil layer long enough to induce the development of characteristic vegetative, physical, and chemical conditions. Lands where saturation with water is the major factor in determining soil development and the types of plants that grow there.

Zooplankton—Tiny, floating animals that provide a food source for larger aquatic organisms such as snails and small fish. Plankton that demonstrate characteristics of the animal kingdom (i.e., they derive energy from organic matter).

Chapter 11

List of Preparers

11. List of Preparers

U.S. Army Corps of Engineers, Walla Walla District

Greg Graham, Civil Engineer—B.S. Civil Engineering; 20 years of experience
Experience/Expertise: Civil Engineering Water Resource Planning, Water Resource Project Management
Role in FR/EIS Process: Project Manager

Lonnie Mettler, Environmental Resource Planner—M.S. Wildlife Resources, B.S. Zoology; 25 years of experience
Experience/Expertise: ESA Coordination, FWCA Coordination, Wildlife Ecology, and NEPA Document Preparation, Plan Formulation
Role in FR/EIS Process: Lead Planner, Contracting Officers Representative, Project Manager

David Dankel, Environmental Resource Specialist—M.S. Natural Resource Communications, B.S. Forest Resources; 30 years of experience
Experience/Expertise: Public Involvement, Natural Resource Management, and Environmental Interpretation
Role in FR/EIS Process: Public Involvement Coordinator, Environmental Planner

Jeff Sedgwick, Environmental Engineer—B.S. Materials Science and Engineering, A.A.S. Environmental Technology; 7 years of experience
Experience/Expertise: NEPA Document Preparation
Role in FR/EIS Process: Assistant Planner

Anneli Aston, Environmental Resource Specialist—B.S. Environmental Policy; 9 years of experience
Experience/Expertise: Environmental Resource Coordination and NEPA Compliance
Role in FR/EIS Process: EIS Coordination and Contract Administration

Mary Keith, Archaeologist—B.A. Anthropology; 20 years of experience
Experience/Expertise: Plateau Cultural Area, Ethno-Archeology
Role in FR/EIS Process: Cultural Resource Appendix, Tribal Coordination Appendix

Scott Ackerman, Wildlife Biologist—M.S. Geography, B.S. Wildlife Management; 19 years of experience
Experience/Expertise: Terrestrial Resources, ESA Coordination, Mitigation Coordination, and FWCA Coordination
Role in FR/EIS Process: Wildlife, Non Anadromous Fish ESA and CAR Manager

Rick Jones, General Biologist—M.S. Environmental Biology, B.S. Fish and Wildlife Management; 27 years of experience
Experience/Expertise: Fisheries and Aquatic Ecology
Role in FR/EIS Process: Anadromous Fish Appendix, Resident Fish Appendix, Water Quality Appendix, and Fluvial Geomorphology Appendix

Chris Pinney, Fishery Biologist—M.S. Aquatic Ecology, B.S. Zoology; 20 years of experience
Experience/Expertise: Aquatic Ecology, Anadromous Fish Modeling, and Anadromous Fish ESA Coordination
Role in FR/EIS Process: Anadromous Fish Modeling, Anadromous Fish ESA Coordination

Tim Wik, Biologist—B.S. Aquatic Biology; 16 years of experience
Experience/Expertise: Fish Bypass at Mainstream Dams and Fish Culture
Role in FR/EIS Process: Surface Bypass Collection

Steve Tatro, Civil Engineer, Technical Specialist—M.S. Civil Engineering, B.S. Civil Engineering; 23 years of experience
Experience/Expertise: Concrete and Construction Materials Design, Concrete Construction, Project Engineering, and Technical Management
Role in FR/EIS Process: Natural River Drawdown Engineering Appendix

Bruce Collison, Civil Engineer—B.S. Civil Engineering; 22 years of experience
Experience/Expertise: Structural Design, Construction Contract Administration, and Engineering Technical Management
Role in FR/EIS Process: Existing Systems and Major System Improvements Engineering Appendix

Dave Reese, Chief, Hydrology Branch—M.S. Civil Engineering, B.S. Civil Engineering; 28 years of experience
Experience/Expertise: Hydrology, Hydraulics, Reservoir Regulation and Water Resources
Role in FR/EIS Process: Hydrology/Hydraulics and Sedimentation Appendix

Nola Conway, Public Affairs Specialist—B.A. Journalism, B.S. Mass and Organizational Communication; 20 years of experience
Experience/Expertise: Local, National, and Foreign Public Affairs and Media Outlets. Development and Coordination of Products for both Public and Media Audiences that Inform and Educate.
Role in FR/EIS Process: Development of Media Communication Strategy

Clayton Garland, Realty Specialist—Certified Engineering Technician; 36 years of experience
Experience/Expertise: Engineering, Contracting, and Real Estate
Role in FR/EIS Process: Real Estate Appendix

Gary Ellis, Economics—M.B.A., B.S. Agricultural Economics; 19 years of experience
Experience/Expertise: Incremental Cost Analysis/Environmental Projects, Flood Projects-Cost Benefits Analysis, Powerhouse Rehabilitation Projects, Cost Estimation, Navigation Reports, Flood Damage Reports to Congress, and Regional Input/Out Analysis
Role in FR/EIS Process: Regional and Social Analysis

Gina Trafton, Regional Economist—B.S. Economics; 14 years of experience
Experience/Expertise: Economic Analysis of Environmental Restoration (endangered species and habitat mitigation), Flood Control, Agricultural Projects, and Inland Navigation.
Role in FR/EIS Process: Economic Appendix

John McKern, Chief, Fisheries Management Unit (Retired)—M.S. Fisheries Science, B.S. Wildlife Science; 29 years of experience
Experience/Expertise: Fish Passage at Dams, Fish and Wildlife Mitigation
Role in FR/EIS Process: Review and Input to Anadromous Fish Appendix, Review of all Appendices and Documents for Operations

Blaise Grden, Landscape Architect—Master Landscape Architecture, B.A. Geography; 28 years of experience
Experience/Expertise: Landscape Architecture, Environmental Planning, and Geographic Information Systems
Role in FR/EIS Process: Main Report: Oversight of GIS Plate Production and Snake River Maps Appendix, Conversion of 1934 Historical Data into Digital Form

Phil Benge, Outdoor Recreation Planner—B.S. Natural Resources Management; 26 years of experience
Experience/Expertise: Outdoor Recreation, Park Management, and Rural Tourism
Role in FR/EIS Process: Recreation and Tourism Analysis

Karen Kelly, Programmer/Analyst (Anteon)—Bachelor of Music in Vocal Performance; 23 years of experience
Experience/Expertise: Programming, GIS Analysis, Internet Preparation/ Maintenance/Coding, Technical Writing/Editing, Software Development and Configuration, Database Development, Graphics
Role in FR/EIS Process: Feasibility Study Web Site Development and Management; Document Preparation, Coding, and Formatting for the District Web Site

Bridgett Read, Programmer/Analyst (Anteon)—B.A. Physics, B.A. Environmental Studies; 6 years of experience
Experience/Expertise: GIS Analysis, Database Development/Design, Graphic Analysis/Design, and Spatial Data Conversion
Role in FR/EIS Process: Graphic Assembly of Main Report GIS Plates and Snake River Maps Appendix, Conversion of 1934 Historical Data into Digital Form

Robert Herres, GIS Specialist—B.S. Technology, AAAS Civil Engineering Technology; 7 years of experience
Experience/Expertise: CADD and GIS Applications
Role in FR/EIS Process: Graphic Assembly for Snake River Maps Appendix and FR/EIS GIS Plates, Conversion of 1934 Historical Data into Digital Form

George Hardin, Civil Engineering Technician—A.A. Mechanical Design and Drafting; 12 years of experience
Experience/Expertise: GIS; Database Design, Development, and Management; Data Research; and Data Development
Role in FR/EIS Process: Snake River Maps Appendix, Conversion of 1934 Historical Data into Digital Form

Gene R. Spangrude, Hydraulic Engineer—M.S. Civil Engineering, B.S. Civil Engineering; 23 years of experience
Experience/Expertise: Hydrology, Hydraulics, Sedimentation
Role in FR/EIS Process: Hydrology/Hydrolics and Sedimentation Appendix

Mona Wright, Archaeologist—M.A. Anthropology, B.A. Anthropology; 23 years of experience
Experience/Expertise: Cultural Resource Management/Archaeology
Role in FR/EIS Process: Cultural Resource Analysis and Appendix

James "Red" Smith, Environmental Resources Specialist—B.S. Park and Recreation Administration; 21 years of experience
Experience/Expertise: Environmental Compliance
Role in FR/EIS Process: Clean Water Act, Section 404(b)(1) Evaluation

Russell D. Heaton III, Limnologist—B.S. Zoology, M.S. Biology; 11 years of experience
Experience/Expertise: Freshwater Ecology/Ecology, Dredge Material Analysis, Wastewater and Drinking Water Treatment, Analytical Chemistry, Scientific Instrumentation & Data Analysis, Dissolved Gas/Temperature Modeling.
Role in FR/EIS Process: Water Quality Appendix, Clean Water Act, Section 404(b)(1) Evaluation

Mark D. Perkins, Programmer/Analyst (Anteon)—B.A. Criminal Justice; 18 years of experience

Experience/Expertise: Programming, GIS Analysis, Internet Preparation/ Maintenance/Coding, Editing, Software development and Configuration, Graphics

Role in FR/EIS Process: Feasibility Study Web Site Development and Management; Document Preparation, Coding, and Formatting for the District Web Site.

Cindy Boen, Landscape Architect—B.L.A. Landscape Architecture and Environmental Planning, B.S. History; 2 years of experience

Experience/Expertise: Master Planning, Environmental Planning, Recreation Planning, GIS

Role in FR/EIS Process: Conversion of 1934 historical data into digital form.

Craig Newcomb, Regional Economist—B.A. Economics; 15 years of experience

Experience/Expertise: Economic analysis of projects for flood control projects. Analysis and application of residential/commercial, agriculture, municipal, industrial, recreation, and environmental benefits to projects. Analysis of energy projects and rate impact studies. Utility financial analysis and load forecast.

Role in FR/EIS Process: Decision Process Team member. Review Economic appendix.

U.S. Army Corps of Engineers, North Pacific Division

Dennis Wagner, Chief, Planning and Policy Division—B.A. Economics; 29 years of experience

Experience/Expertise: Planning, Economics, Policy, Project Formulation for Legislative/Congressional Authorization

Role in FR/EIS Process: Chairman, Drawdown Regional Economic Workgroup

Joe Johnson, Hydraulic Engineer—B.S. Civil Engineering; 25 years of experience

Experience/Expertise: Hydroelectric System Operation Studies

Role in FR/EIS Process: Hydroregulations Appendix

David Ponganis, Civil Engineer—M.S. Civil Engineering; 24 years of experience

Experience/Expertise: Water Resource Planning, Endangered Species Act Section 7 Consultation

Role in FR/EIS Process: Review of Main Report, Assist in Preparing and Coordinating Biological Assessments, and Regional Coordination

Witt Anderson, Fishery Program Manager—M.S. Resource Management; 24 years of experience
Experience/Expertise: Fishery Program and Project Management; Water Resources Planning Studies Management; Environmental Studies; NEPA Document Preparation
Role in FR/EIS Process: Program Management, Regional Interface, Policy Review

Jim Fredericks, Economist—M.S. Applied Economics, B.S. Economics; 13 years of experience
Experience/Expertise: Economics Evaluation of Civil Works Projects
Role in FR/EIS Process: Assisted in the Study Management and Review of Economic Studies

U.S. Army Corps of Engineers, Portland District

Tim Kuhn, Regional Economist—M.A. Resource Economics, B.S. Resource Economics; 15 years of experience
Experience/Expertise: Economic Evaluation of Water Resources Projects
Role in FR/EIS Process: Water Supply Economic Analysis and Implementation Cost Analysis

Joe Hise, Regional Economics (Retired)—M.A. Economics, B.S. Economics; 28 years of experience
Experience/Expertise: Economics and Planning
Role in FR/EIS Process: Transportation Analysis

Edwin Woodruff, Chief, Economics Section—B.A. Economics, B.A. Mathematics; 28 years of experience
Experience/Expertise: Economics and Hydropower Analyst
Role in FR/EIS Process: Hydropower Analysis and Economics Review

U.S. Environmental Protection Agency

Mary Lou Soscia, Columbia River Coordinator—M.A. Geography/Water Resources, B.A. Geography/Water Resources; 22 years of experience
Role in FR/EIS Process: Agency Representative for Water Quality

John Bregar, Regional Hydropower Coordinator—B.A. International Environmental Studies; 6 years of experience
Role in FR/EIS Process: Agency Representative for Water Quality and NEPA

Bill Ryan, Environmental Engineer
Role in FR/EIS Process: Agency Representative for Air Quality

U.S. Bureau of Reclamation

Susan Black, Social Science Analyst—B.A. Economics
Experience/Expertise: Social Analysis and Public Involvement for NEPA Compliance
Role in FR/EIS Process: Social Analysis

Robert Christensen, Regional Environmental Officer—M.S. Wildlife Science, B.S. Biology; 26 years of experience
Role in FR/EIS Process: Biological Analysis Reviewer

Allen Reiners, Agricultural Economist—M.S. Agricultural Economics, B.S. Agriculture; 31 years of experience
Role in FR/EIS Process: Economic Analysis

Richard Rigby, Program Manager, Water Rights and Acquisition—B.S. Economics; 27 years of experience
Experience/Expertise: Water Contracting, Water Acquisition, and Water Rights
Role in FR/EIS Process: Agency Impact Analysis

Richard Prange, Environmental Specialist—B.S. Natural Resources Management; 29 years of experience
Experience/Expertise: ESA Section 7 Consultation, Water Project and Land Management Planning Activities
Role in FR/EIS Process: Agency Representative

David Zimmer, Regional Water Quality Coordinator—Ph.D. Limnology, M.S. Limnology, B.S. Fish and Wildlife Biology; 27 years of experience
Experience/Expertise: Water Quality and Limnology
Role in FR/EIS Process: Water Quality Analysis

Bonneville Power Administration

Philip Thor, Mechanical Engineer—B.S. Mechanical Engineering; 24 years of experience
Experience/Expertise: Operations and Power Systems Analysis, Hydroregulation Review and Alternative Identification and Analysis Review, Transmissions Impacts, River Operations, and System Costs
Role in FR/EIS Process: Agency Coordinator, Hydropower Analysis, and Hydroregulation Appendix

Audrey Perino, Industry Economist—M.A. Economics; 20 years of experience
Experience/Expertise: Economic Analysis of Power Systems
Role in FR/EIS Process: Hydropower Analysis – Power System Impacts

Marvin Laudauer, Electrical Engineer—B.S. Electrical Engineering; 23 years of experience
Experience/Expertise: BPA Transmission Business Line, Network Planning, Transmission Impacts of Breaching the Lower Snake and John Day Dams
Role in FR/EIS Process: Hydropower Analysis – Transmission Impacts

Kyle Kohne, Electrical Engineer—B.S. Electrical Engineering; 8 years of experience
Experience/Expertise: BPA Transmission Business Line, Network Planning, Transmission Impacts of Breaching the Lower Snake and John Day Dams
Role in FR/EIS Process: Hydropower Analysis – Transmission Impacts

Roger Schiewe, Hydraulic Engineer—B.S. Civil Engineering (Hydraulics); 29 years of experience
Experience/Expertise: Operations and Power Systems Analysis, Hydroregulation Review and Alternative Identification and Analysis Review, Transmissions Impacts, River Operations, and System Costs
Role in FR/EIS Process: Hydropower Analysis and Hydroregulation Appendix

Foster Wheeler Environmental Corporation

Kirby Gilbert, Environmental Program Manager—M.S. Resource Geography, B.S. Environmental Science; 19 years of experience
Experience/Expertise: NEPA Analysis, Environmental Policy and Compliance, Water and Natural Resource Allocation Studies
Role in FR/EIS Process: Foster Wheeler Project Manager

Alan Olson, Fisheries Biologist—M.S. Fisheries Science, B.S. Aquatic Biology; 11 years of experience
Experience/Expertise: Fish Biology; Pacific Salmon and Trout Habitat Requirements, Population Dynamics, and Behavior; Database Management
Role in FR/EIS Process: Resident Fish Sections of FR/EIS

Brian Landau, Watershed Specialist—M.A. Geological Sciences, B.S. Geological Engineering; 6 years of experience
Experience/Expertise: Hydrology, Water Quality, and Fish Habitat Data; Riparian and Stream Habitat Mapping; Geologic Mapping, Slope Stability Surveys, Surface-Groundwater Hydrologic Modeling
Role in FR/EIS Process: Geology and Soils Sections and Water Quality Sections of FR/EIS

Tom Martin, Consulting Engineer—B.S. Civil Engineering, C.A.S. Electronics; 19 years of experience
Experience/Expertise: Water Resources, Civil Engineering, Software Development, GIS/CADD
Role in FR/EIS Process: Water Quality and Hydrology Sections

Don Beyer, Fisheries Biologist—Ph.D. Fisheries Science, B.S. Fisheries Science; 29 years of experience
Experience/Expertise: Interdisciplinary Watershed Analysis and Planning, Salmon Biology, Biological Evaluation of River Systems Operation
Role in FR/EIS Process: Fisheries and Sections 1, 2, and 3 of the FR/EIS

John Knutzen, Fisheries Biologist—M.S. Fisheries, B.A. Biology; 23 years of experience
Experience/Expertise: Evaluation of Development Project Effects, including Hydroelectric, Forestry, Urban Land Development, and Mining on Aquatic Resources, Primarily Salmon and Trout
Role in FR/EIS Process: Anadromous Fish Section of FR/EIS

Elizabeth Roy, Water Quality Specialist—B.S. Environmental Engineering, Massachusetts Institute of Technology, 1996; 5 years of experience
Experience/Expertise: Hydrology, Water Quality, Dissolved Oxygen, Numerical Modeling, Flood Studies
Role in FR/EIS Process: Water Quality Sections

Gray Rand, Wildlife Biologist—Post-baccalaureate Studies, B.S. Biology; 9 years of experience
Experience/Expertise: Terrestrial Mammal, Amphibian, and Bird Habitat, Ecology, Distribution and Demography Studies. Rare, Threatened, and Endangered Species Habitat Evaluation Procedures
Role in FR/EIS Process: Wildlife Section of the FR/EIS

Bill Kerschke, Botany, Vegetation—Post-baccalaureate Studies, B.S. Biology and Wildlife Management; 10 years of experience
Experience/Expertise: Habitat and Sensitive Plant Inventories, Wetlands, Riparian Areas, and Wildlife
Role in FR/EIS Process: Vegetation Section of the FR/EIS

Matt Dadswell, Planner/Economist—Ph.D. Candidate Geography, M.A. Geography, B.A. Economics and Geography; 10 years of experience
Experience/Expertise: Economics, Resource Allocation, Demand Studies, Social Analysis and Environmental Policy
Role in FR/EIS Process: Economic and Social Sections of FR/EIS, Economics Appendix

Erik Nielsen, National Resources Policy Analyst—Ph.D. Candidate, M.A. Public Policy; 6 years of experience
Experience/Expertise: Environmental Policy and Natural Resource Management
Role in FR/EIS Process: Social Analysis

Mark Greenig, AICP, ASLA Landscape Architect/Recreation Planner—MUP Urban Planning, BSLA Landscape Architecture; 20 years of experience
Experience/Expertise: Recreation Planning/Aesthetics/Land Use Planning
Role in FR/EIS Process: Recreation and Aesthetics Section of the FR/EIS

Marcy Rand, Technical Writer/Editor and/Public Involvement Specialist—B.A. Journalism and Mass Communications; 11 years of experience
Experience/Expertise: Technical Editing and Writing, Development and Publication of Public Involvement Materials
Role in FR/EIS Process: Lead Editor for FR/EIS and Associated Documents, Lead Public Involvement Specialist, Task Lead on Appendix U, Response to Comments

Elesa Field, Technical Editor—B.A. English; 8 years of experience
Experience/Expertise: Technical Writing and Editing, NEPA Document Coordination and Production
Role in FR/EIS Process: Lead Editor for Draft FR/EIS

Lindsey Amtmann, Technical Editor—M.S. Environmental Psychology and Communications, B.A. Theater and Anthropology; 8 years of experience
Experience/Expertise: Forestry and Hydropower Studies
Role in FR/EIS Process: Lead Editor of Appendices

Margaret Huffer, Technical Editor—B.A. Public Relations/Journalism; 2 years of experience
Experience/Expertise: Technical Editing and Writing, Proofing, Document Production and Coordination
Role in FR/EIS Process: Lead Editor for Appendices

Karen Cantillon, Senior Technical Writer—B.A. English Literature; 25 years of experience
Experience/Expertise: Public Involvement, Writing, Marketing, Event Planning
Role in FR/EIS Process: Technical Editor for Appendices

Clarice Keegan, Technical Writer—M.A. Philosophy; 22 years of experience
Experience/Expertise: Writing, Editing, Desktop Publishing
Role in FR/EIS Process: Technical Writer for Summary, Technical Editor for Appendices, Comment Coder for Draft FR/EIS

Tim Richards, Marketing Art Director—2 years of college courses; 22 years of experience
Experience/Expertise: Graphic Design and Art Direction
Role in FR/EIS Process: Design and Art Direction on Summary Document, Graphic Design for FR/EIS and Appendices

Judy Brown, Lead Word Processor—Certified with Microsoft Software; 22 years of experience
Experience/Expertise: Desktop Publishing, Graphics Design in PageMaker/Freehand
Role in FR/EIS Process: Lead Word Processor for Final FR/EIS

Don Bergquist, Word Processor—Certified with Microsoft Software; 7 years of experience
Experience/Expertise: Word Processing Document and Table Preparation, Scanning and Placement of Graphics
Role in FR/EIS Process: Lead Word Processor for Draft FR/EIS

Steve Flegel, Word Processor—A.A.S. Printing; 13 years of experience
Experience/Expertise: Desktop Publishing, Web Design, Various PC and Macintosh Applications
Role in FR/EIS Process: Lead Word Processor for Appendices

Dawn Carroll, Word Processor; 7 years of experience
Experience/Expertise: Word Processing Document and Table Preparation, Scanning and Placement of Graphics
Role in FR/EIS Process: Word Processor for EIS and Appendices

Other Contributors to the Study Process

National Marine Fisheries Service

Dr. Steve Freese
Lynne Krasnow
Tom Cooney
Dr. Peter Karieva
Michelle McClure

U.S. Fish and Wildlife Service

Don Haley
Marv Yosinaka
Pat Bigelow

Northwest Power Planning Council

Terry Morlan

Parametrix

Dr. John Toll

Decision Support

Walt Haerer

Agricultural Enterprises

Dr. John Loomis
Bill Spencer
John McKean

Consultants

Tom White
Linda Wear

The Research Group
Shannon Davis
Hans Radtke

Belyea, Sorenson, Trottier and Associates
Paul Sorenson

University of Idaho
Dr. Chuck Harris
Dennis Becker
Dr. William McLaughlin
Dr. John Ratti
Dr. Kirk Lohmann
Dr. Ronald Robberecht
Anne Rockledge
Susan Loper

Triangle Associates, Inc.
Dennis Clarke

Project Time and Cost, Inc.
Kate Larson
Diana Bebee

Upper Great Plains Transportation Institute
Gene Griffin
Kim Vaschal

Marshall University
Mark Burton

Institute for Water Resources
David Grier

Sverdrup
Rolf Wielick
Peter Christiansen

ENSR
Chick Sweeney
Perry Johnson

Blair, Inc.
Bruce McPherson

Odyssey Productions, Inc.
Steve Heiser
Carolyn Zelle
Donna Matrazzo

Normandeau and Associates

Terry Easton
Marcia Bowen

Battelle, Pacific Northwest National Laboratory

Tim P. Hanrahan
Marshall C. Richmond

Historical Research Associates, Inc.

Lisa Mighetto

DREW Participants

Witt Anderson	Corps—NWD
Phil Benge	Corps—NWW
Susan Black	U.S. Bureau of Reclamation (USBR)
Kenneth Boire	Northwest Power Planning Council—Independent Economic Advisory Board (NPPC-IEAB)
Randy Bostrum	Port of Whitman County
James Buchal	Ball, Janik and Novak
Ken Casavant	Northwest Power Planning Council (NPPC)—WA
Daren Coppock	Oregon Wheat Growers League
Jim Daly	Port of Portland
Adam Diamont	Environmental Defense Fund
Gary Ellis	Corps—NWW
Paula Engel	USBR
Dick Fiddler	Sierra Club
Jim Fredericks	Corps—NWP
Steve Freese	NMFS
Clayton Garland	Corps—NWW
Terry Glover	Shoshone-Bannock Tribes
Charlie Grist	NPPC - Oregon
Don Haley	USFWS
Joel Hamilton	NPPC-IEAB, Chair
Joe Hise	Corps—NWP
Daniel Huppert	NPPC-IEAB
Joe Johnson	Corps—NWD
Rebecca Kalamasz	Corps—NWW
Tim Kuhn	Corps—NWP
Phil Lansing	Save Our Salmon
Bruce Lovelin	Columbia River Alliance
Mike Mason	Corps—NWW
John McKern	Corps—NWW
Lonnie Mettler	Corps—NWW
Phil Meyer	Meyer Resources
Terry Morlan	NPPC—WA
Erik Nielsen	Foster Wheeler Environmental
Darryl Olsen	Pacific Northwest Project
Eric Ostrovsky	NMFS
Charles Pace	Spokane Tribe
Audrey M. Perino	Bonneville Power Administration (BPA)

Lon Peters	NPPC—IEAB
Allen Prouty	Potlatch Corporation
Matt Rea	Corps—NWP
Dave Reese	Corps—NWW
Al Reiners	USBR
Jack Richards	NPPC—IEAB
Bennie Rinehart	Consulting Engineer/Scientist
Elliot Rosenberg	U.S. Environmental Protection Agency (EPA)
Anthony Scott	NPPC—IEAB
Lisa Sharp	Consultant, DSIs
Ed Sheets	Consultant, NMFS
Paul Sorensen	Belyea,Sorenson, Trottier & Asso.
Phil W. Thor	BPA—PGF
John Toll	Parametrix Inc.
Ray Tracy	Corps—NWW
Gina Trafton	Corps—NWW
George Veighey	Corps—NWW
Dennis Wagner	Corps—NWD
Lynda Walker	Corps—NWD
Linda Wear	Consultant
Steve Weiss	NW Energy Coalition
Karl Weist	NPPC—OR
Steve Wise	River Network
Ed Woodruff	Corps—NWD

Chapter 12

Distribution List

12. Distribution List

AGENCIES

Alaska Department of Fish & Game

Bonneville Power Administration

Bureau of Land Management

Canada, BC Utilities Commission

Canada, Ministry of Environment

Centers For Disease Control

Columbia Basin Fish & Wildlife Authority

Department of Natural Resources

Environmental Protection Agency

Federal Energy Regulatory Commission

Federal Highway Administration

General Accounting Office

Gooding County Cooperative Extension

Idaho Department of Agriculture

Idaho Department of Commerce

Idaho Department of Environmental Quality

Idaho Department of Fish and Game

Idaho Department of Health and Welfare

Idaho Department of Parks and Recreation

Idaho Department of Water Resources

Idaho State Historic Preservation Office

Idaho Wildlife Federation

Interior Columbia Basin Ecosystem Management Project

Joint Legislative Audit and Review Committee

Montana Department of Agriculture

Montana Department of Environmental Quality

Montana Department of Fish, Wildlife, & Parks

Montana Department of Natural Resources and Conservation

Montana Environmental Quality Council

National Marine Fisheries Service

National Park Service

Natural Resources Conservation Service

NMFS/Northwest Fisheries Science Center

Northwest Power Planning Council

Oak Ridge National Lab

Oregon Agriculture Department

Oregon Department of Environmental Quality

Oregon Department of Fish and Wildlife

Oregon Department of Transportation

Oregon Economic Development Department

Oregon Emergency Services Division

Oregon State Marine Board

Oregon State Police

Oregon Water Resources Department

State Lands & Investments

U.S. Army Institute for Water Resources

U.S. Bureau of Indian Affairs

U.S. Bureau of Land Management

U.S. Bureau of Reclamation

U.S. Coast Guard

U.S. Department of Agriculture

U.S. Department of Commerce, National Oceanic and Atmospheric Administration

U.S. Department of Energy

U.S. Department of Justice- Environmental and Natural Resources Division

U.S. Department of the Army

U.S. Department of the Interior

U.S. Fish and Wildlife Service

U.S. Geological Survey

U.S. Forest Service

Washington Department of Agriculture

Washington Department of Ecology

Washington Department of Fish and Wildlife

Washington Department of Health

Washington Department of Natural Resources

Washington Department of Transportation

Washington State Parks and Recreation Commission

Wyoming Department of Environmental Quality

Wyoming Department of Transportation

Wyoming Game & Fish Department

INSTITUTIONS

Albertson College

Boise State University

Central Washington University

Colorado State University

Dartmouth College

Duke University-Nicholas School of the Environment

Eastern Washington University

Gonzaga University

Highlands Middle School

John F. Kennedy School of Government, Harvard University

Kamiakin High School

Lewis-Clark State College

Milton-Freewater School District

Northwestern School of Law

Northwestern University

Oregon State University

Portland State University

Post Middle School

St. Georges School

St. Vincent College

University of Idaho

University of Montana

University of Washington

Walla Walla College

Washington State University

Washtucna High School

Weston-McEwen High School

Whitman College

ELECTED OFFICIALS—FEDERAL AND STATE

Honorable John Anderson, U.S. House of Representatives

Honorable Max Baucus, U.S. Senate

Honorable Conrad Burns, U.S. Senate

Honorable Chuck Carpenter, Oregon House of Representatives

Honorable Gary Chandler, Washington House of Representatives

Honorable Larry Craig, U.S. Senate

Honorable Michael D. Crapo, U.S. Senate

Honorable Barbara Cubin, U.S. House of Representatives

Honorable Jerome Delvin, Washington House of Representatives

Honorable Jennifer Dunn, U.S. House of Representatives

Honorable Michael B. Enzi, U.S. Senate

Honorable Eve Franklin, Montana State Senate

Honorable Jim Geringer, Governor of Wyoming

Honorable Bill Grant, Washington House of Representatives

Honorable Shirley Hankins, Washington House of Representatives

Honorable Richard (Doc) Hastings, U.S. House of Representatives

Honorable John Hoeven, Governor of North Dakota

Honorable Cecil Ingram, Idaho State Senate

Honorable Grant Ipsen, Idaho State Senate

Honorable Douglas Jones, Idaho House of Representatives

Honorable June Judd, Idaho House of Representatives

Honorable Dirk Kempthorne, Governor of Idaho

Honorable Jim Kitzhaber, Governor of Oregon

Honorable Tony Knowles, Governor of Alaska

Honorable William Lanklow, Governor of South Dakota

Honorable Patricia Lantz, Washington House of Representatives

Honorable John Lim, Oregon State Senate

Honorable Gary Locke, Governor of Washington

Honorable Lynn Lundquist, Oregon House of Representatives

Honorable Dan Mader, Idaho State Representative

Honorable Dave Mastin, Washington House of Representatives

Honorable Jim McDermott, U.S. House of Representatives

Honorable Marquerite McLaughlin, Idaho State Senate

Honorable Cathy McMorris, Washington House of Representatives

Honorable Thomas Mielke, Washington House of Representatives

Honorable Joyce Mulliken, Washington House of Representatives

Honorable Patty Murray, U.S. Senate

Honorable David Nelson, Oregon State Senate

Honorable George Nethercutt, U.S. House of Representatives

Honorable Barbara Nickum, Washington State Senate

Honorable Laird Noh, Idaho State Senate

Honorable Val Ogden, Washington House of Representatives

Honorable C.L. "Butch" Otter, U.S. House of Representatives

Honorable Horace Pomeroy, Idaho House of Representatives

Honorable Marc Racicot, Governor of Montana

Honorable Charlie Ringo, Oregon House of Representatives

Honorable Edward Schafer, Governor of North Dakota (former)

Honorable Mark Schoesler, Washington House of Representatives

Honorable Larry Sheahan, Washington House of Representatives

Honorable Mike Simpson, U.S. House of Representatives

Honorable Gordon Smith, U.S. Senate

Honorable Sid Snyder, Washington State Senate

Honorable Ruby Stone, Idaho House of Representatives

Honorable Charles Swysgood, Montana State Senate

Honorable Craig Thomas, U.S. Senate

Honorable Greg Walden, U.S. House of Representatives

Honorable Moon Wheeler, Idaho State Senate

Honorable Ron Wyden, U.S. Senate

TRIBES AND TRIBAL ORGANIZATIONS

Burns Paiute Tribe of the Burns Paiute Indian Colony

Coeur D'Alene Tribe of Idaho

Columbia River Inter-Tribal Fish Commission

Confederated Salish and Kootenai Tribes of the Flathead Reservation, Montana

Confederated Tribe of the Warm Springs Reservation of Oregon

Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation

Confederated Tribes of the Colville Indian Reservation

Confederated Tribes of the Umatilla Indian Reservation

Kalispel Indian Community of the Kalispel Reservation

Kootenai Tribe of Idaho

Nez Perce Tribe

Northwest Indian Fisheries Commission

Shoshone-Bannock Tribes of the Fort Hall Reservation

Shshone-Paiute Tribes of the Duck Valley Reservation

The Spokane Tribe of the Spokane Reservation, Washington

Upper Columbia United Tribes

Wanapum Band

Washington Energy Division

Washington Energy Facility Site Evaluation Council

Yakama Agency

LOCAL GOVERNMENT

Asotin Chamber of Commerce

Asotin County

Bellevue Chamber of Commerce

Benton County

Benton-Franklin Council of Governments

Boundary County Board of Commissioners

City of Asotin

City of Blackfoot

City of Boardman

City of Boise

City of Burley

City of Clarkston

City of Coeur d'Alene

City of Colfax

City of Connell

City of Dayton

City of Endicott

City of Garfield

City of Grangeville

City of Hermiston

City of Idaho Falls

City of Irrigation

City of Kennewick

City of La Grande

City of LaCrosse

City of Lakewood, Canada

City of Lewiston

City of Milton-Freewater

City of Moscow

City of Moses Lake

City of Orofino

City of Othello

City of Palouse

City of Pasco

City of Peck

City of Pendleton

City of Pocatello

City of Pomeroy

City of Prescott

City of Prosser

City of Pullman

City of Richland

City of Spokane

City of Starbuck

City of Stevenson

City of The Dalles

City of Twin Falls

City of Umatilla

City of Waitsburg

City of Walla Walla

City of West Richland

City of Yakima

Clarkston Chamber of Commerce

Clatsop County Commissioner

Clearwater County Board of Commissioners

Columbia County Commissioner

Columbia Rural Electric Association

Community of Aspen Springs

Deer Park Chamber of Commerce

Franklin County

Garfield County

Grant County

Greater Pasco Area Chamber of Commerce

Kittitas County

Lewis County Board of County Commissioners

Lincoln County Commissioner

Nez Perce County Commissioner

Orofino Chamber of Commerce

Pasco Chamber of Commerce

Richland Chamber of Commerce

Seattle City Light

Spokane Chamber of Commerce

Spokane County

Tri-Cities Visitor Convention Bureau

Tri-City Area Chamber

Umatilla County Soil & Water Conservation

Umatilla Electric Cooperative

Walla Walla County Commissioners

Wallowa County Commissioner

Whitman County Commissioners

Whitman County Parks

Yakima County

ORGANIZATIONS

Alaska Troller Association

American Fisheries Society

American Rivers

American Waterways Operators

AmeriCorps/NWSA

Association of Idaho Cities

Association of Northwest Steelheaders

Association of Oregon Counties and Council of Forest Trust Land Counties

ASU

Badger Mountain Irrigation District

BC Hydro and Power Authority

Benton County PUD

Big Bend Economic Dev. Council

Bio-Analysts

Blue Mountain Audubon Society

Blue Mountain Chapter

Blue Mountain Growers

Boise-Kuna Irrigation District

Bonneville County Sportsmen

Braden Rural Electric Association

Bureau of National Affairs

Burbank Homeowners

Canyon Property Owners

Cascadians

Centers for Disease Control

Central Basin Audubon Society

Central Ferry Terminal Association

Chelan County Power

Chelan County PUD

Citizens for Better Health

Clark County Pomona Grange

Clearwater Flycasters

Clearwater Management Council

Clearwater Power

Clover Island Yacht Club

Coalition for Anadromous Salmon and Steelhead Habitat

Columbia Basin Fish and Wildlife Authority

Columbia Basin Fly Casters

Columbia County Grain Growers

Columbia Deepening Opposition Group

Columbia River Alliance

Columbia River Estuary Study Taskforce

Columbia River Fishermen's Protective Union

Columbia River Towboat Association

Columbia Valley Grange

Community of Aspen Springs

Community Network of Idaho

Conservation Biology Center

County Road Administration Board

Douglas County PUD

Earth Club

East Columbia Basin Irrigation District

Elmer's Irrigation

Environmental Distribution Network

Falls Irrigation District

Farm Bureau

Federation of Fly Fishers

Franklin County PUD

Friends of the Earth

Friends of the Wild Salmon

Gooding County Cooperative Extension

Grand Coulee Hydroelectric Authority

Grand Coulee Power Office

Grant County PUD

Hells Canyon Alliance

Henry Fork Foundation

IAMAW 364

Idaho Barley Commission

Idaho Cattleman's Association

Idaho Council on Industry & the Environment

Idaho Environmental Council

Idaho Farm Bureau

Idaho Grain Producers Association

Idaho Green Org.

Idaho-Oregon Planning & Development

Idaho Power Company

Idaho Power Council

Idaho Rivers United
Idaho State Grange
Idaho State Water Board
Idaho Water Alliance
Idaho Water Users Association
Idaho Wheat Commission
Idaho Wildlife Federation
Idaho Women in Agriculture
Inland Empire Fly Fishing Club
Interagency Committee for Outdoor Recreation
Interior Columbia Basin Ecosystem Management
Ironworkers #14
Juvenile Fish Facility
Kaotenai Environmental Alliance
Kelly Creek Flycasters
Kennewick Irrigation District
Kooskooskie Commons
Kootenai Electric
Lake Roosevelt Forum
Lamont Grain Growers, Inc.
Lewis-Clark Economic Development Association
Lewis-Clark Wildlife Club
Lower Columbia Basin Audubon Society
Lower Columbia Fish Enhancement Group
Lower Columbia River Estuary Program
Marine Environmental Support Office
Mid-Columbia Economic Development District
Middle Snake Regional Water Resource Comm.
Middleton Six Son Farms
Monograph Acquisition Service
Montana Environmental Quality Council
MonteRay Peninsula Waterway District
Monterey Penisula Water Management District
National Barley Growers Association
National Rec. Task Force
National Waterway Conference
National Wildlife Federation
Native Fish Society
North End Grange #820
North Pacific Research
North Side Canal Company--Committee of 9
Northern WASCO PUD
Northwest Council of Grain Growers
Northwest Economic Research
Northwest Environ Watch
Northwest Environmental Defense Service
Northwest Food Processors
Northwest Grain Growers
Northwest Indian Fisheries Commission
Northwest Pulp & Paper Association
Northwest River Runners & Chamber
NPPC Independent Economic Analysis Board
NW Resource Information Center, Inc.
NWCOGA
Ogden Environmental Energy Service
Oregon Farm Bureau
Oregon Natural Resources Council
Oregon Plan to Restore Salmon
Oregon Trout
Oregon Water and Environmental Coalition
Oregon Water Coalition
Oregon Water Resources Congress
Oregon Wheat Growers League
PACE - Local 712
Pacific Fishery Management Council
Pacific Northwest Waterways Association
Pacific States Marine Fisheries Commission
PEAC
Perkins Coie LLP
Pew Charitable Trust
PNGC Power
Port of Benton
Port of Clarkston
Port of Columbia
Port of Kennewick
Port of Lewiston
Port of Morrow
Port of Pasco
Port of Portland
Port of Umatilla
Port of Walla Walla
Port of Whitman County
Port of Wallupa
Public Power Council
Public Utility District No. 1 of Asotin County
Quincy-Columbia Basin Irrigation District

Richland Rod and Gun Club

Rivershore and Heritage Tourism

Riverside Water and Sewer District

Roza Irrigation District

Salmon Corps

Salmon for All

Save Our Dams

Save Our Wild Salmon

Settlers Irrigation District

Sierra Club

Sierra Club Legal Defense Fund

Snake River Irrigators Association

Snake River Preservation Council

Snohomish County Public Utility District

South Columbia Basin Irrigation District

Spokane Canoe Club

Stanfield Westland Irrigation District

Taxpayers Network Inc

The Lands Council

The Research Group

Timberworkers Resource Council

Touchet Valley Irrigation District, #16

TREC

Tri-Cities Visitor Convention Bureau

Trout Unlimited

Trout Unlimited-Idaho

Umatilla Electric Coop Association

Umatilla National Wildlife Refuge

Uniontown Coop Association

United Power Trades Organizations

Upper Columbia Resource Council

Upper Snake River Fly Fishers

Vancouver Water Resources Education Center

Walla Walla Watershed

Washington Agriculture and Rural Development

Washington Association of Wheat Growers

Washington Cattlemen's Association

Washington Conservation Commission

Washington PIRG

Washington State Grange

Washington State Potato Commission

Washington Water Power Company

Washington Wheat Commission

Washington Wildlife Federation

Washington Wool Grower's Association

Water District Number 65

Water Research Center

Western Center For Environmental Information

Western Montana Electric G & T Cooperative, Inc.

Western Center for Environmental Information

Westland Irrigation District

Whitman County Assoc of Wheat Growers

Whitman County Public Works

Wildlife Forever, Inc.

Wolf Education & Research Center

LIBRARIES

Asotin County Libraries

Boise Public Libraries

Boley Libraries

Colorado State University Libraries

Columbia Basin College Libraries

Documents Dept. University Of Oregon Libraries

Government Publications

Hatfield Libraries-Williamette University

Idaho State Libraries

Lewiston City Libraries

Meridian Libraries District

Milton-Freewater Public Libraries

Monograph Acquisitions Service

Oregon State Libraries

Oregon State University

Oregon Trail Libraries District

Pacific University Libraries

Paul L. Boley Law Library - Northwestern School of Law of Lewis and Clark College

Penrose Memorial Libraries

Preston Public Libraries

Richland Public Libraries

Salem Public Libraries

Seattle Public Libraries

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Stream Net Libraries
The Libraries of Congress
Tri-Community Libraries
University of Idaho Libraries
University of Oregon Libraries
University of Washington Libraries
US Geological Survey Libraries
Walla Walla College Libraries
Walla Walla Public Libraries
Washington State Libraries
Wenatchee Public Libraries
White Salmon Community Libraries
Woodland Public Libraries

MEDIA

Columbia Basin Bulletin
Dayton Chronicle
Hermiston Herald
KONA Radio
Media
News Tribune
NW Ag Info Net
The Daily News
The Oregonian
The Seattle Times
The Spokesman Review
The Tri-City Herald
Walla Walla Union Bulletin
Wenatchee World
Western Outdoors
Whitman County Gazette

BUSINESSES

3B's Moving & Storage
A & M Farms, Inc.
A-1 Body Shop
ABB Alstom Power
AEI Enterprises, Inc.
AgriNorthwest
Agri-Times Northwest
Almota Elevator Company
American West Steamboat Co.
Ater, Wynne, Hewitt, Dodson, et al.
Atlas Sand and Rock
Bank of Commerce
Bar Star, Inc.
Batelle Pacific Northwest Laboratories
Bear Creek Farms
Belyea, Sorensen, and Trottier
Berg Brothers Farm
Bernert Barge Lines, Inc.
Big Bend Electric Coop, Inc.
BioAnalysts, Inc.
Biological Resources Division
Blue Dog Ranch
Blue Mountain Growers
Blue Mountain Valley Physical Therapy Clinic
BNP Lentil Company
Boise Cascade
Broughton Land Company
Brown's Eden Tree Farm
BST Consultants
Bullivant Houser Bailey Pendergrass & Hoffman
Canyon Creek Realty
Cargill, Grain Division
Cascade Columbia Foods
Cegnar, Inc.
CER
CH2M HILL
Clarkston Estates
Clarkston Golf and Country Club
Clearwater Power Company
Coley/Forest Inc.
Columbia Grain
Columbia Grain International, Inc.
Columbia Rural Electric Association
Common Sensing, Inc.
Consulting Economist Inc.
Continental Grain Company
Cottonwood Fiber Farm
DeAtley Co. Inc.
Deep Sea Charters
Diamond H Construction
Direct Service Industries, Inc.
Discovery River Expeditions
Dix Corporation
Dworshak Excursions
Echo Northwest
Ecosystem Management Int. Inc.
Emerson Logging
Empire Lumber Company
Energy and Natural Resources
Environmental Distribution Network
F Bar C Ranch
Far West Fertilizer & Agrichemical Assoc.
Farm Credit Services
Fish Passage Incorporated
Flat Top Ranch

Foss Maritime Company
Foster Wheeler Environmental
Fuller Consulting Services
Geologic Analysis & Consulting Svcs
Givens, Pursley, & Huntley
Goffinet Farms
Golder Associates, Inc.
Granger Company
Guy Bennett Lumber Company
Harper Chiropractic Pain Relief Clinic
HARZA
Hawley, Troxell, Ennis & Hawley
HDR Engineering
Heli-Jet Corporation
Henry Fork Foundation
Henry M. Jackson Foundation
Horizon Project, Inc.
Huckell, Weinman Associates
Hydro Review
Idaho National Engineering and Environmental Laboratories
IGPA
INCA Engineers, Inc.
Inland Empire Jetdock
Interior Design Associates
International Water Power and Dam Construction
IRZ Consulting
J-Bar S, Inc.
JF Micro
Jones & Stokes Assoc.
Jones and Jones
K & J Enterprise
K&N Industrial Equipment
Kauerrer Brothers
Keylock Security Storage
Kimball Engineering
Kooskooskie Commons
Kootenai Electric
Kuther Ranch
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Laib Brothers
Lake Oswego LOIP
Lamb-Weston
Legrow Water Co.
LePage Farms
Liebler, Ivey, & Connor
Lillard's RV Park
Littler Farm, Inc.
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Louis Dreyfus Corporation
LSRD - BLM
Lyons Ferry Marina
Maxim Technologies
McCormack Land Design
McGregory Company
McNary Farm
Means Building Co
Mercer Ranch
Metz Marina
Model Watershed Project
Moffatt & Nichol Engineering
Morbeck and Beeler Inc PS Law Office
Morken Ranch
Monterey Peninsula Waterway District
Motyka's Fishin Post
Neace Farms
New Pioneer Log Homes, Inc.
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Norm Druffel & Sons
Normandeau Associates
Norton - Arnold - Janeway
Northwest Food Processors
NPT Fisheries
Oakesdale Farm
OFBF
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Pomeroy Grain Growers, Inc.
Portland Bureau of Environmental Services
Potlatch Corporation
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Prior West Farms
Pulp & Paperworks Resource Co.
R & A Plan-Soil Inc.
R.A. Hanson Co.
Rattlesnake Ranches, Inc.
Reese, Baffney, Schrag & Frol
Resource Writers Northwest
Richland Rod and Gun
Ritzville Warehouse Co.
River View Estates
Rivershore and Heritage Tourism
Riverview Marina
Roach Law Offices

Robert K. Bauer & Associates
S & S Farms
Saager's Shoe Shop
Sage Hill Northwest
Schlueter Ranch's, Inc.
Schwabe Williamson & Wyatt Suite 1800
SCM Consultants Inc
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Shaver Transportation
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SMR
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Styner's Feed
Sunheaven Farms
T & R Farms, Inc.
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Tidewater Barge Lines, Inc.
Tidewater Terminal
Tippett Land & Mortgage
Tremblay Associates, LLC
Troutman Sanders LLP
Union Elevator
Unocal Agriculture Products
Upper Snake River Fly Fishers, Ltd.
Valley Boat and Motor
Valley Car Sales and Rental
Valmont NW
Vandenburg Sales, Inc.
Voith Simmons Hjydro
Washington Grower's League
Weather or Not Inc.
West Rock Inc.
Western Construction & Logging
Western Outdoors
Weyerhauser
Whetstone Farms
Worden Farms

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