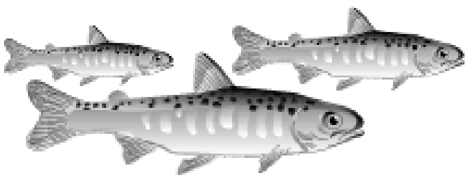
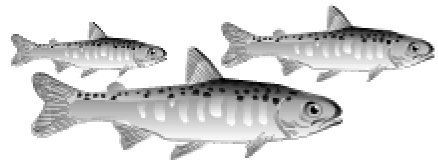


Chapter 4

Affected Environment



4. Affected Environment

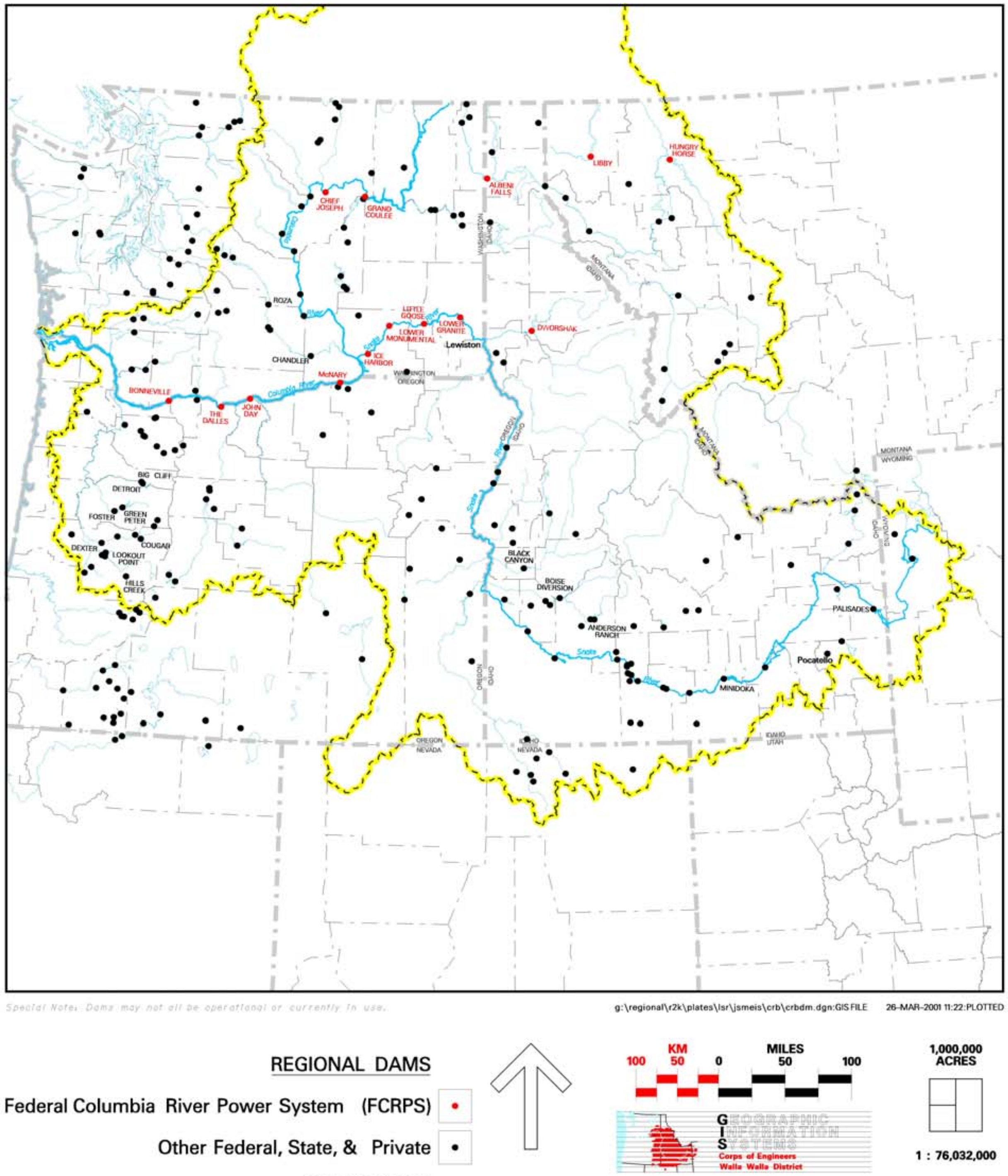
4.1 General Setting

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



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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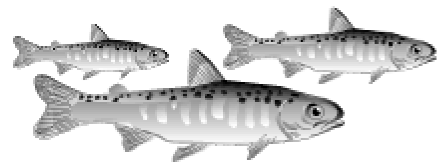

4.2 Geology and Soils

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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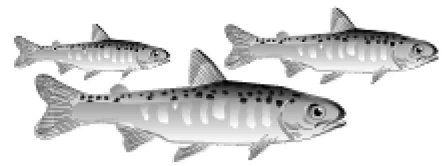


4.3 Air Quality

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.

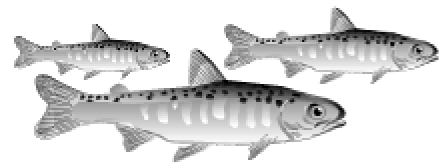
Climatic conditions in the lower Snake River area are characterized by large seasonal temperature differences, low precipitation, and relatively minimal cloud cover. Valley bottoms along the Snake River record some of the highest summer temperatures in the region, and they tend to stay slightly warmer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

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.

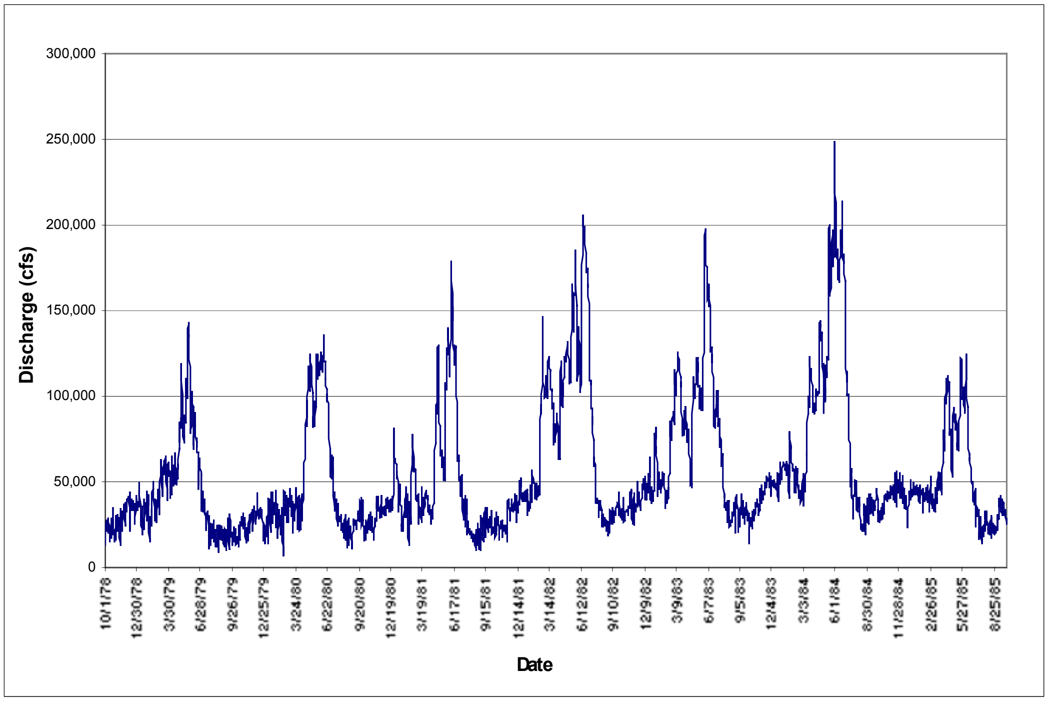


Figure 4.4-1. Average Daily Flows for Ice Harbor Dam, 10/1/78 to 10/1/85

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

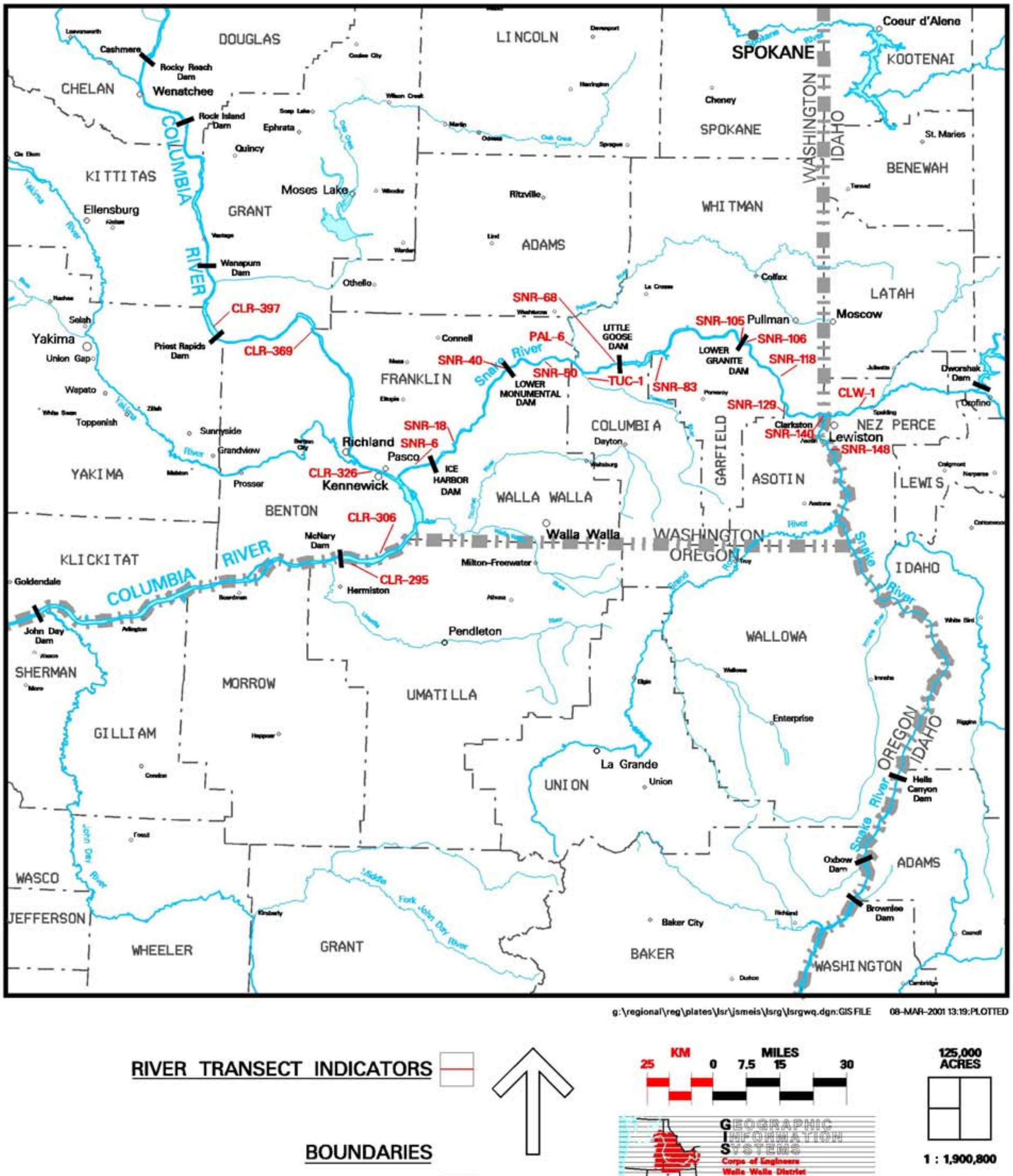
Two of the project uses of dams constructed on the lower Snake River are navigation and hydropower. The dams impound water and reduce river velocity. As a result, sediment settles on the bottom of the reservoir or remains suspended in the reservoir's water column, affecting turbidity and concentrations 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)	Acute2/: Shall not exceed instantaneous concentration of 1.1 µg/l at any time.	No
	Chronic3/: Shall not exceed concentration of 0.001 µg/l as any 24-hour average.	No
Mercury	Acute2/: Shall not exceed a 1-hour concentration of 2.1 µg/l at any time.	No
	Chronic3/: 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.

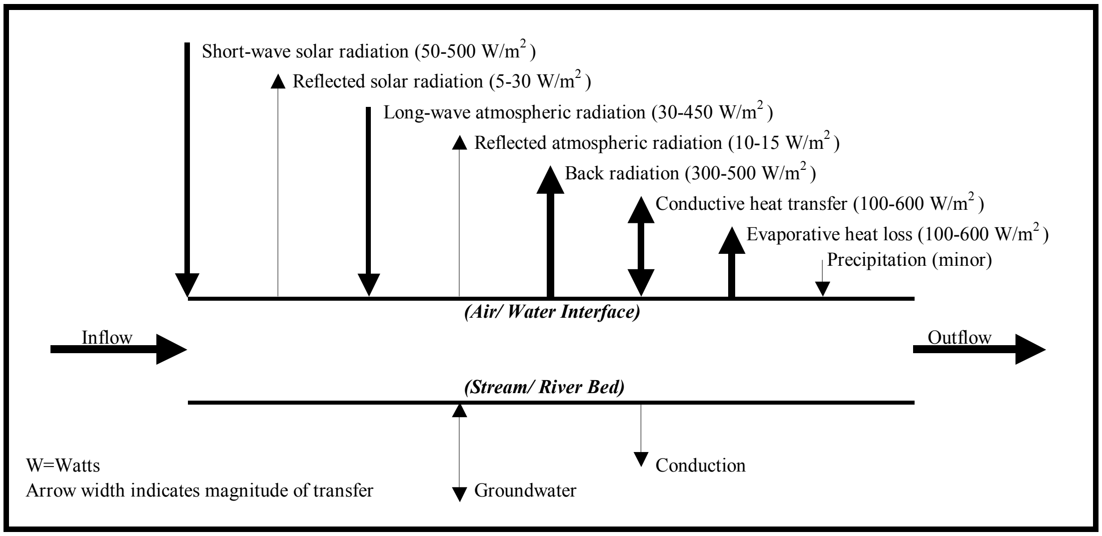
Temperature

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.

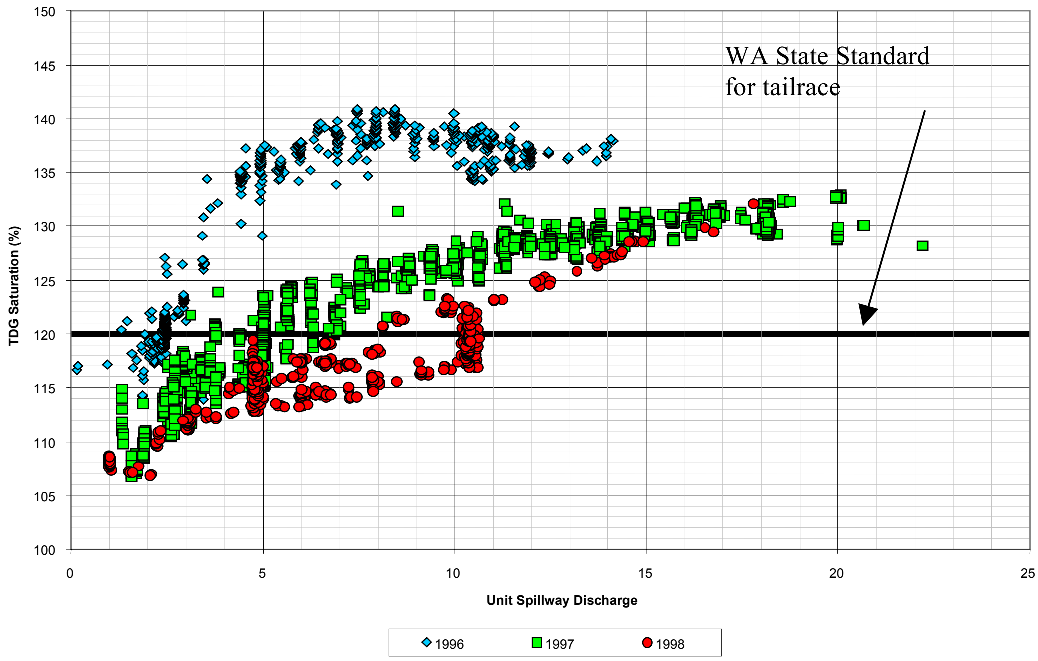
The NMFS 1998 Biological Opinion also recommends spring spill at all three Snake River collector facilities (Lower Monumental, Little Goose, and Lower Granite) outside of the time windows mentioned above, “when seasonal average flows are projected to meet or exceed 85 kcfs." In addition, the NMFS 1998 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).

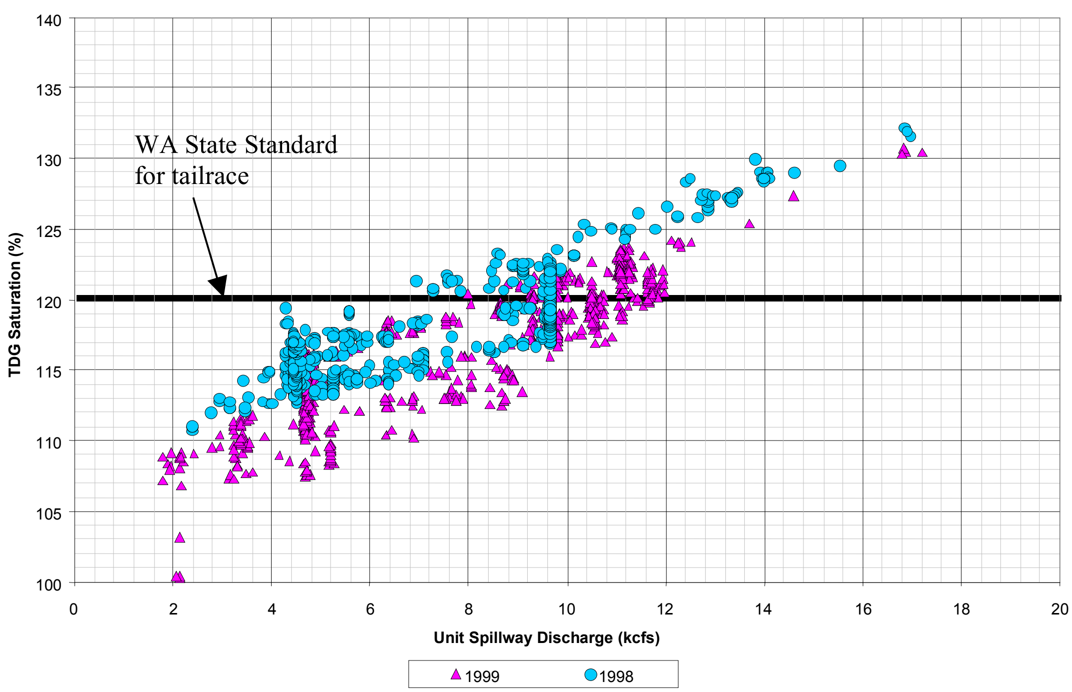
Spillway Deflector Modifications. Modifications to spillway deflectors have been implemented as a means of further reducing TDG concentrations in the lower Snake River. Among the modifications used are pier extensions, which were added to the flow deflectors at Ice Harbor Lock and Dam. These pier extensions 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

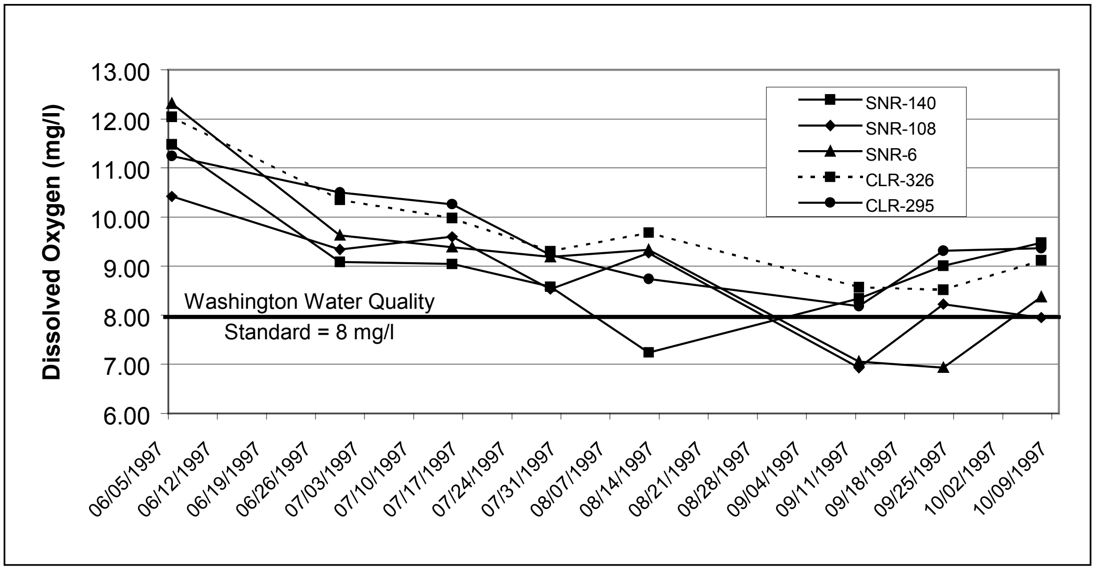
Figure 4.4-5. Total Dissolved Gas Measured Below Ice Harbor Dam, 1998 to 1999

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

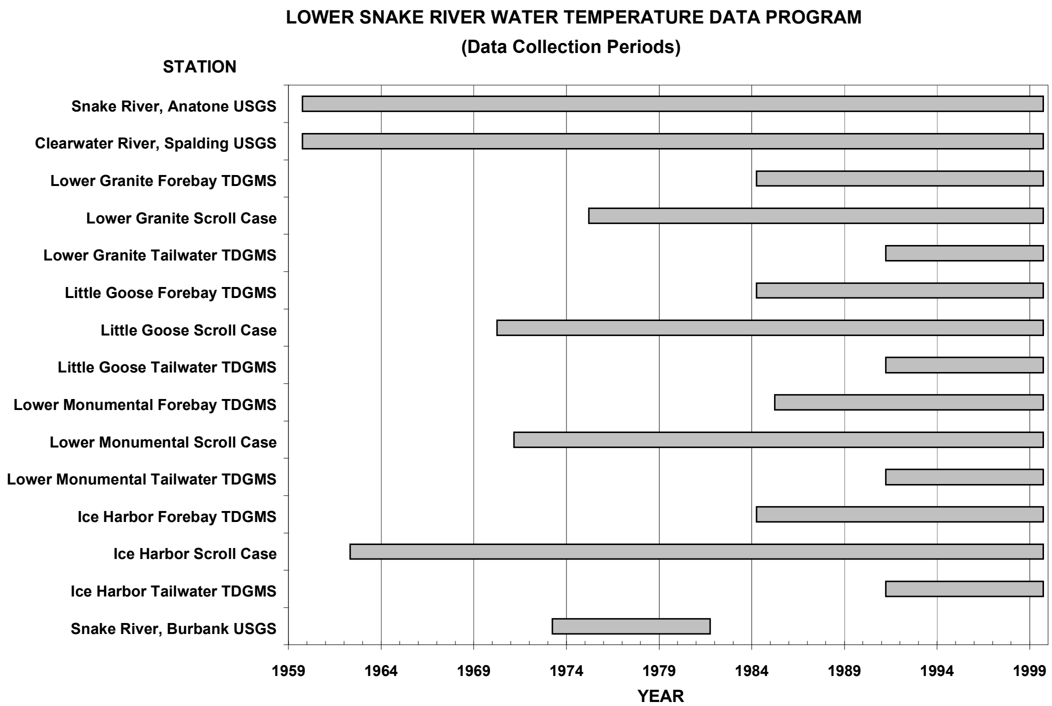
Figure 4.4-6. Dissolved Oxygen for Select Stations in 1997

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

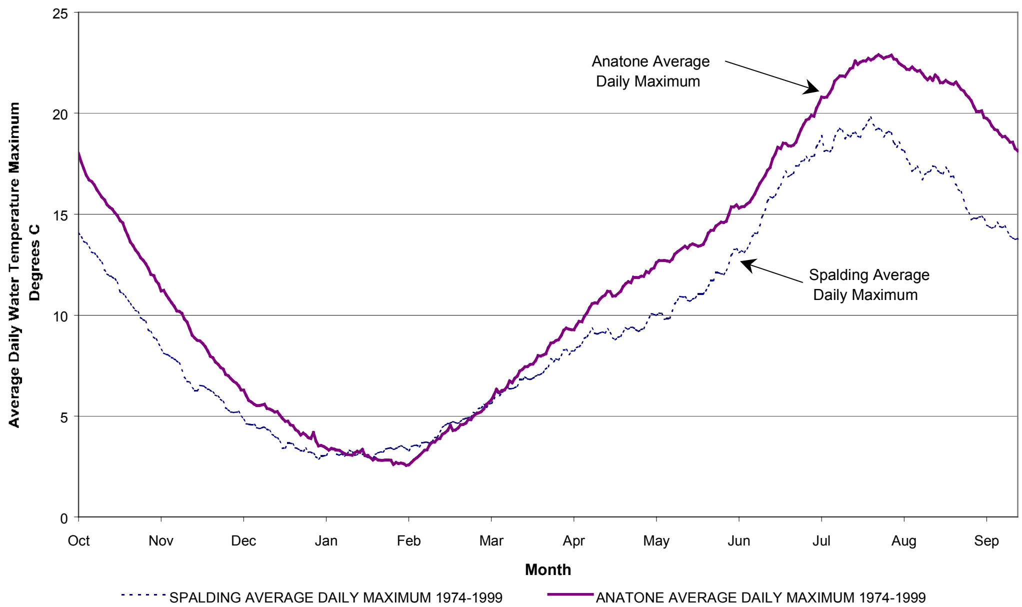
Water Temperatures Above the Lower Snake Reservoir System

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^{o}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^{o}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

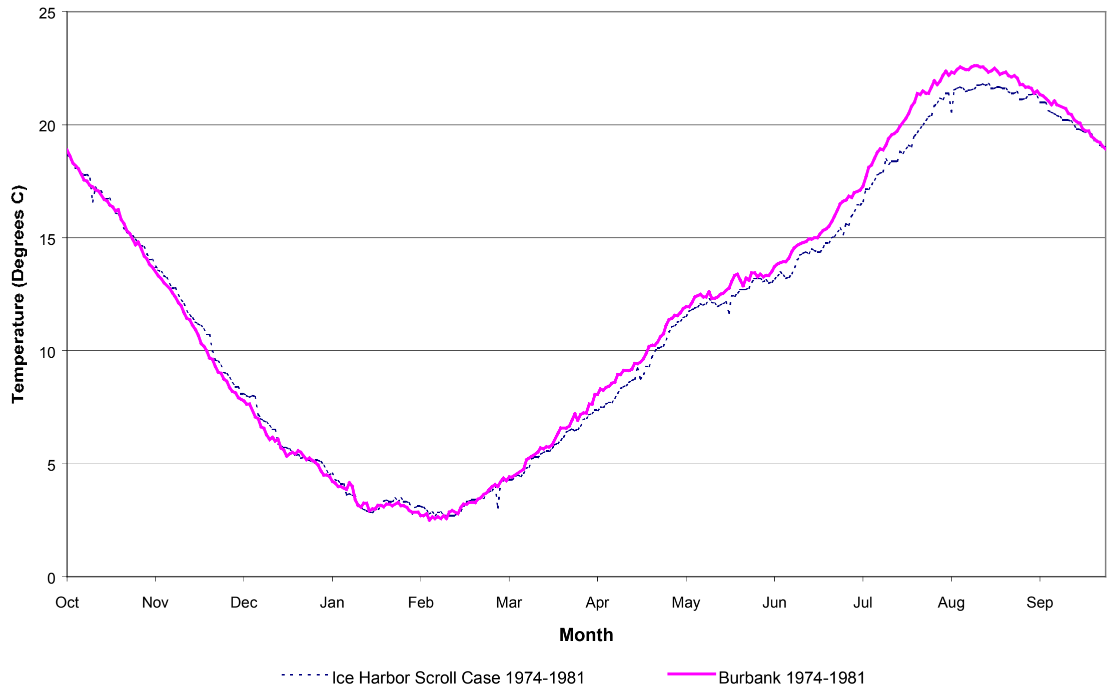
Water Temperatures Below the Lower Snake Reservoir System

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.

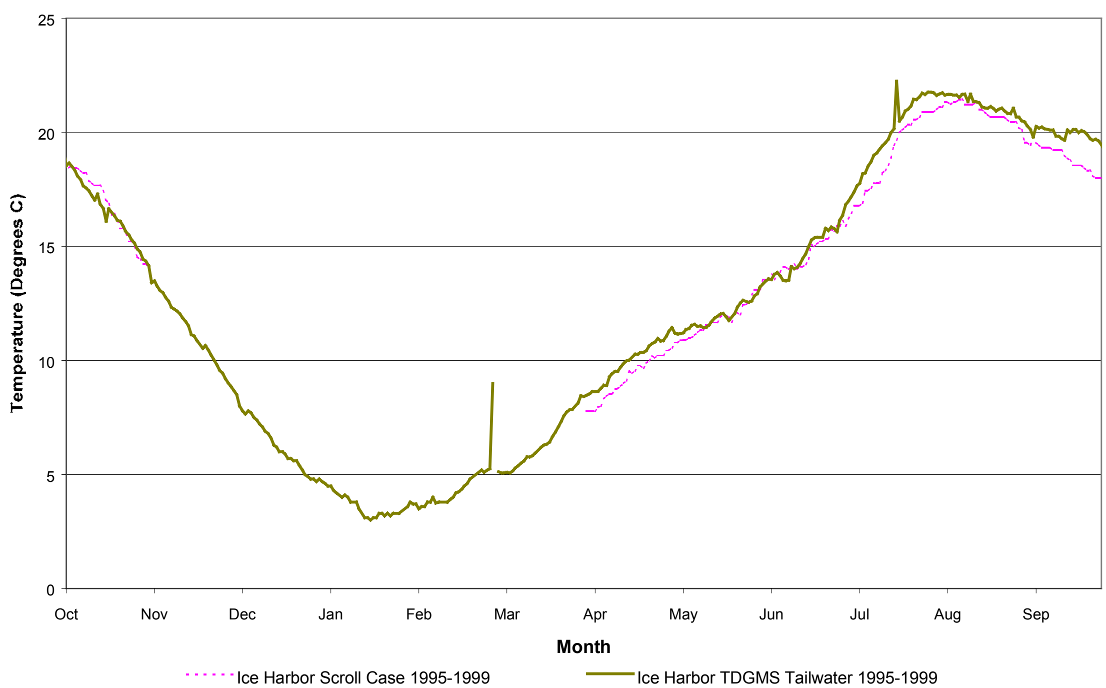
After reviewing the data and the record lengths for these stations, the Burbank site data and Ice Harbor Dam scroll case data from 1973 through 1981 (water years 1974 through 1981) were used to evaluate water temperature conditions below the Snake River reservoir system before the use of the current 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.



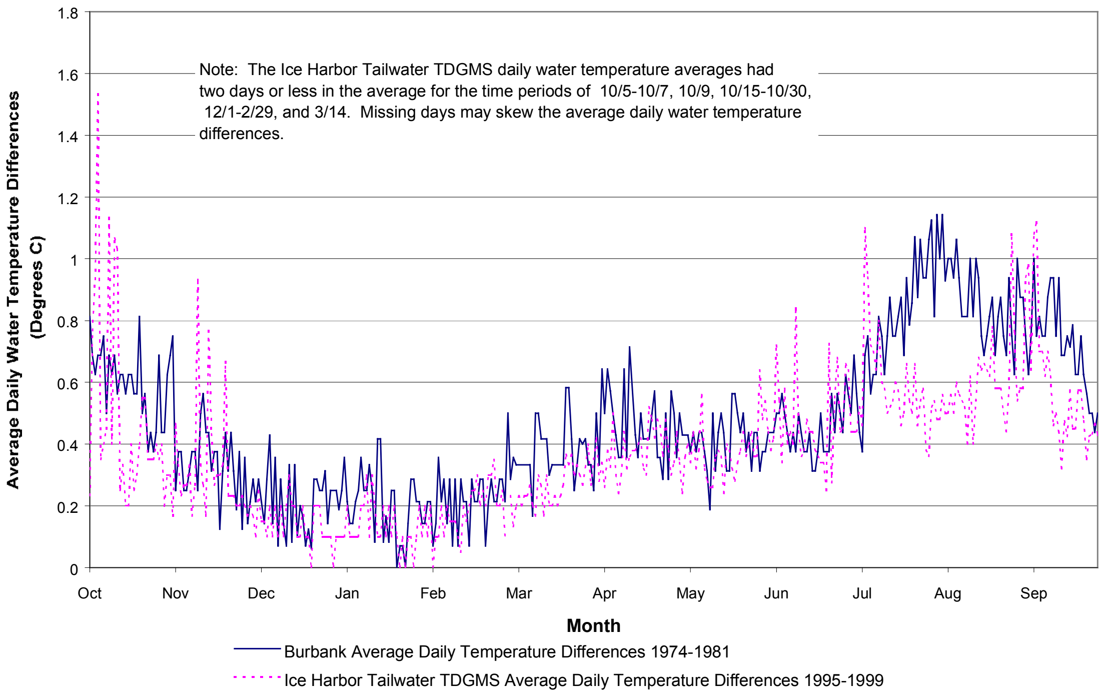
Source: Appendix C, Water Quality

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				
		TDGMS					TDGMS					TDGMS					TDGMS			
	Scroll Case	Tailwater	Days Missing	Forebay	Days Missing	Scroll Case	Tailwater	Days Missing	Forebay	Days Missing	Scroll Case	Tailwater	Days Missing	Forebay	Days Missing	Scroll Case	Tailwater	Days Missing	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

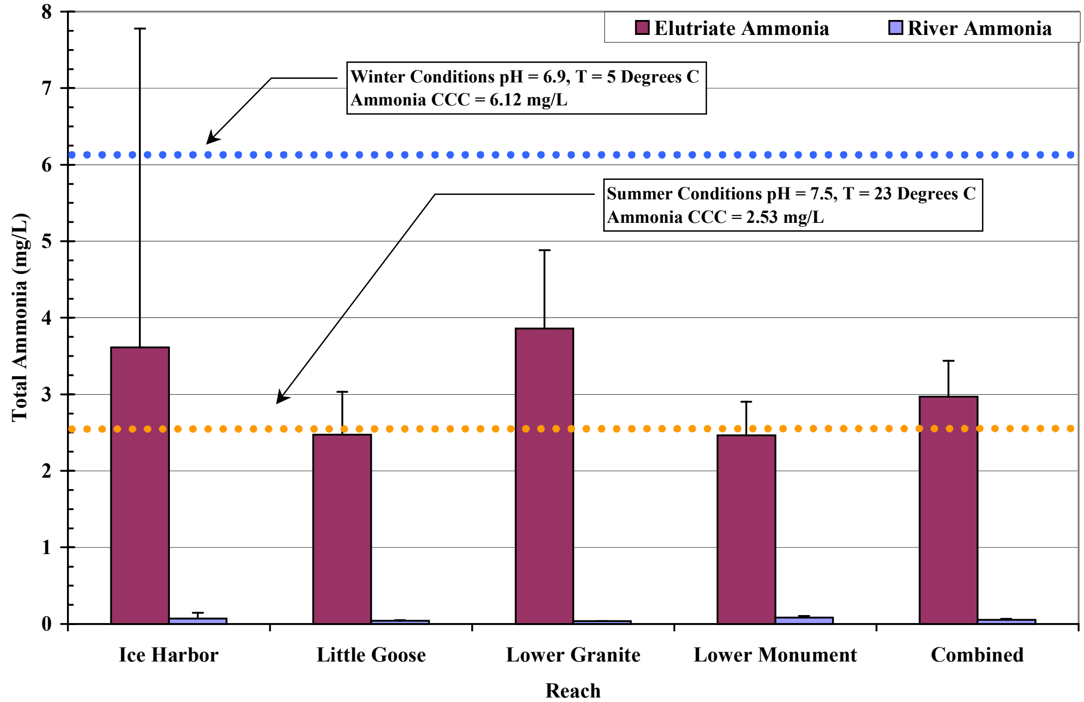
Notes: Ice Harbor Dam - Lake Sacajawea
Lower Monumental Dam - Lake West
Little Goose Dam - Lake Bryan
Lower Granite Dam - Lower Granite Lake

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

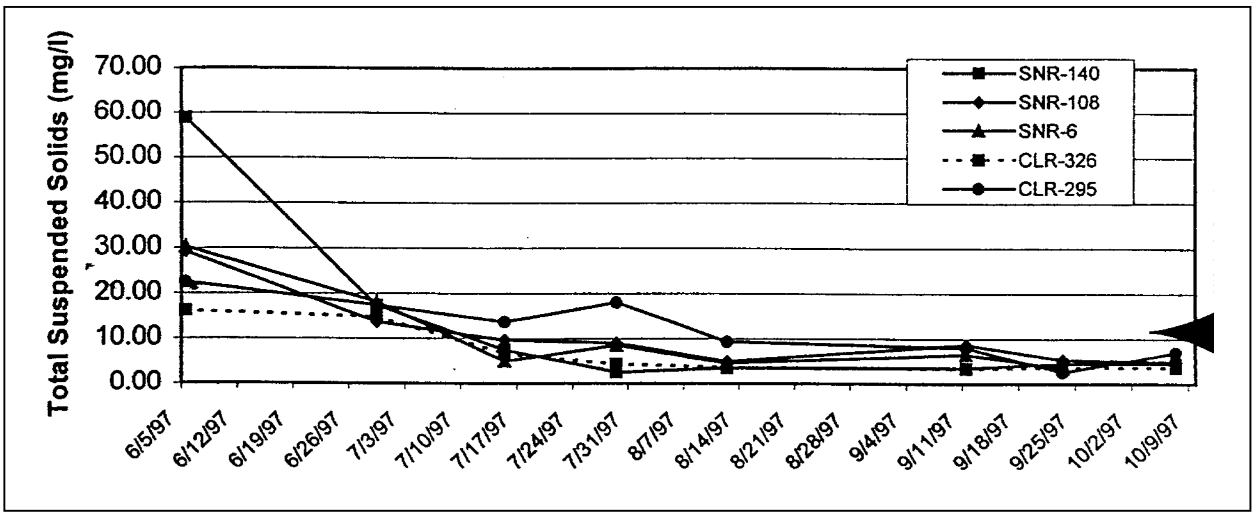
	pH										
Temperature (°C)	**6.5**	**6.6**	**6.7**	**6.8**	**6.9**	**7**	**7.1**	**7.2**	**7.3**	**7.4**	**7.5**
1	6.67	6.57	6.44	6.29	6.12	5.91	5.67	5.39	5.08	4.73	4.36
14[4]	6.67	6.57	6.44	6.29	6.12	5.91	5.67	5.39	5.08	4.73	4.36
15	6.46	6.36	6.25	6.10	5.93	5.73	5.49	5.22	4.92	4.59	4.23
16	6.06	5.97	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

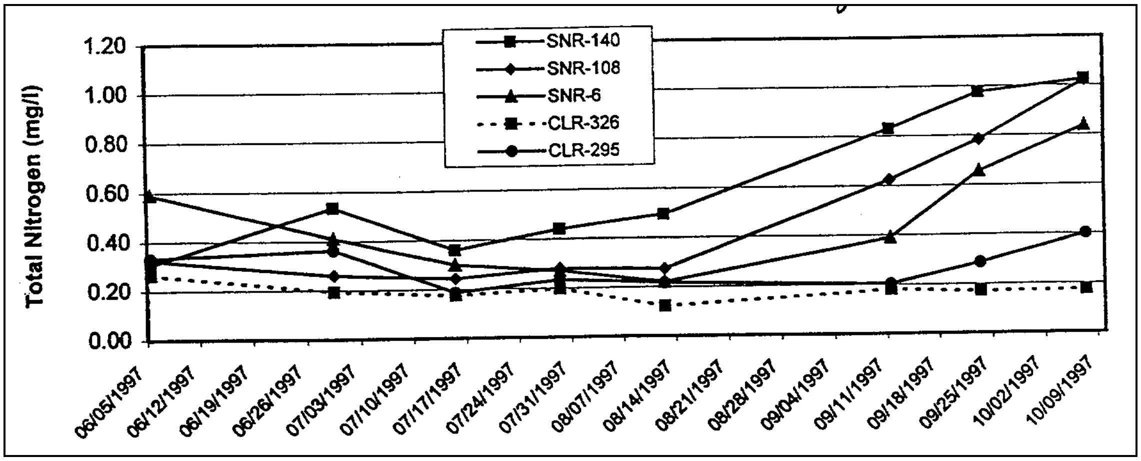
pH

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

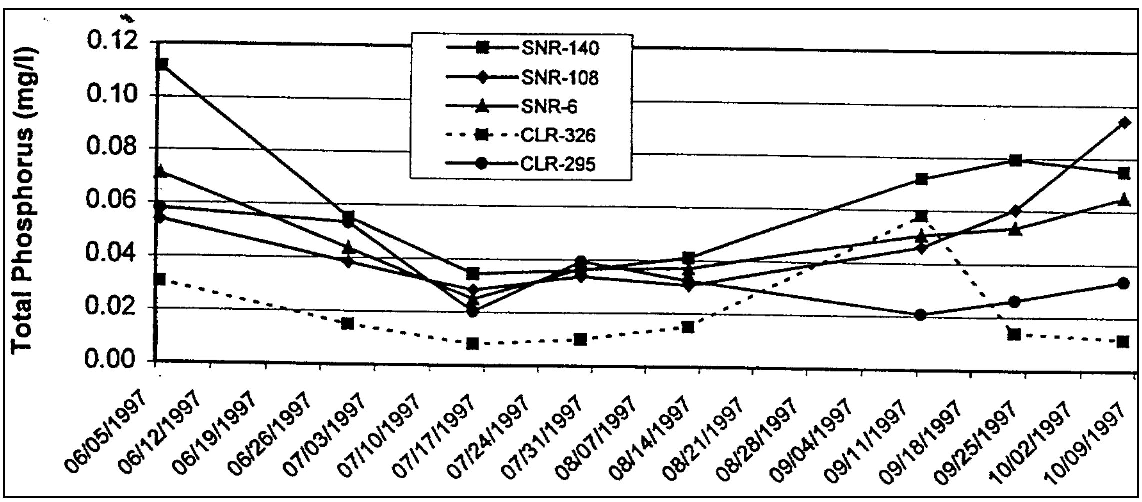
The total nitrogen concentrations for the Clearwater and Snake Rivers show a slight decline for the onset of the spring runoff to a minimum level in July, rising to maximum values in early autumn. The late season increase may be due to a reduction in plant uptake associated with aquatic plants and algae 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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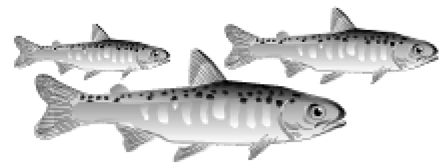


4.5 Aquatic Resources

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

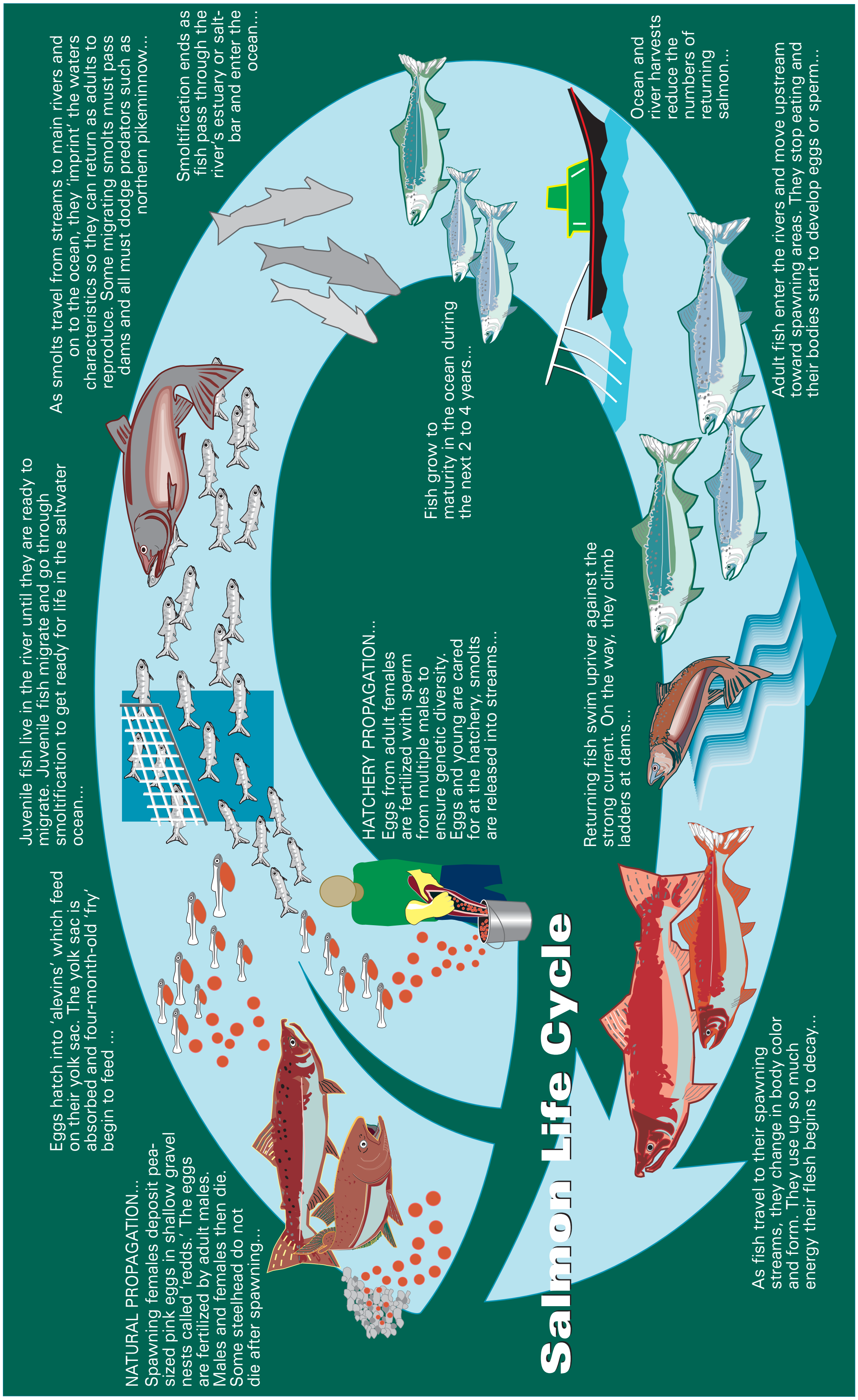
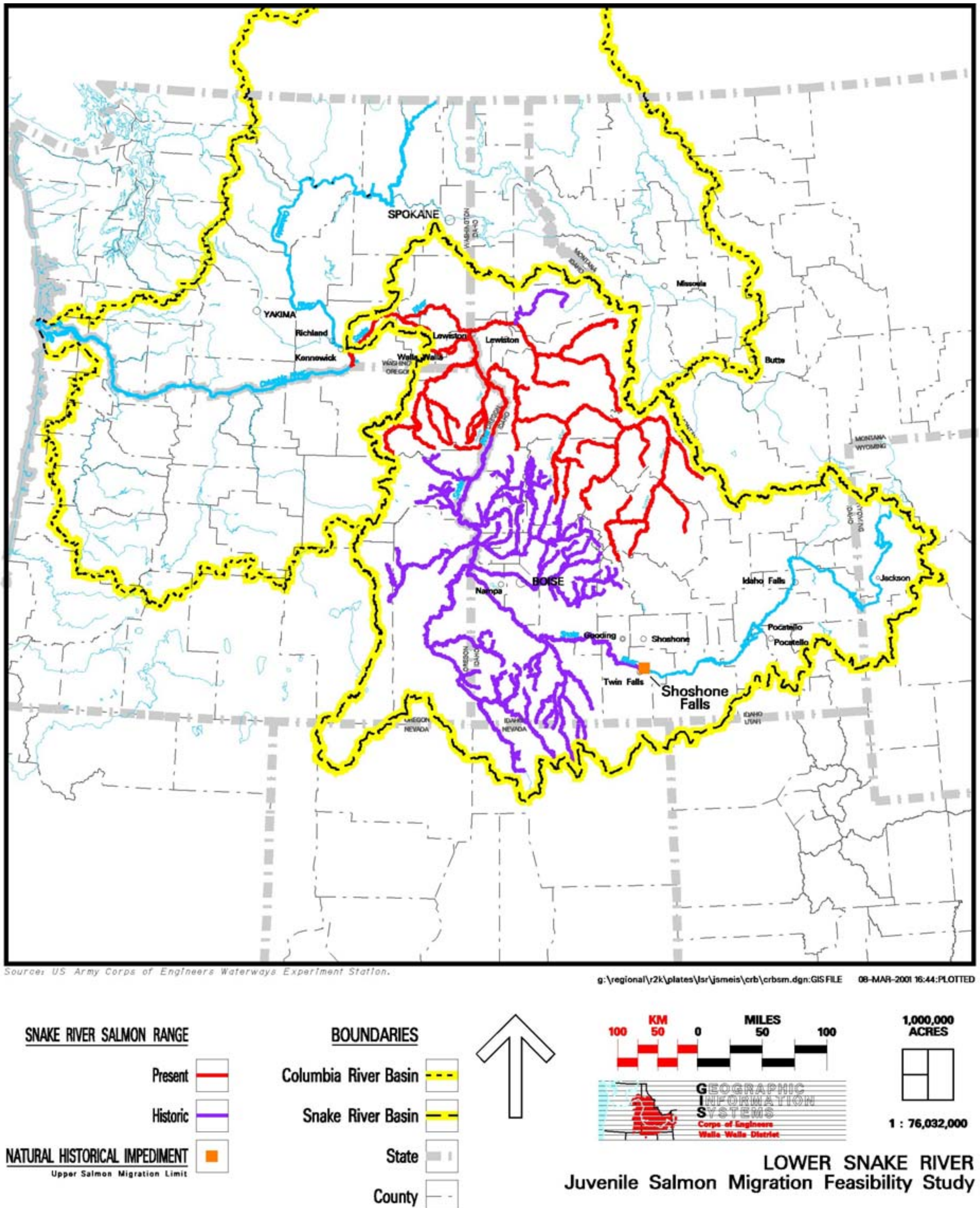


Figure 4.5-1. Salmon Life Cycle



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

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.

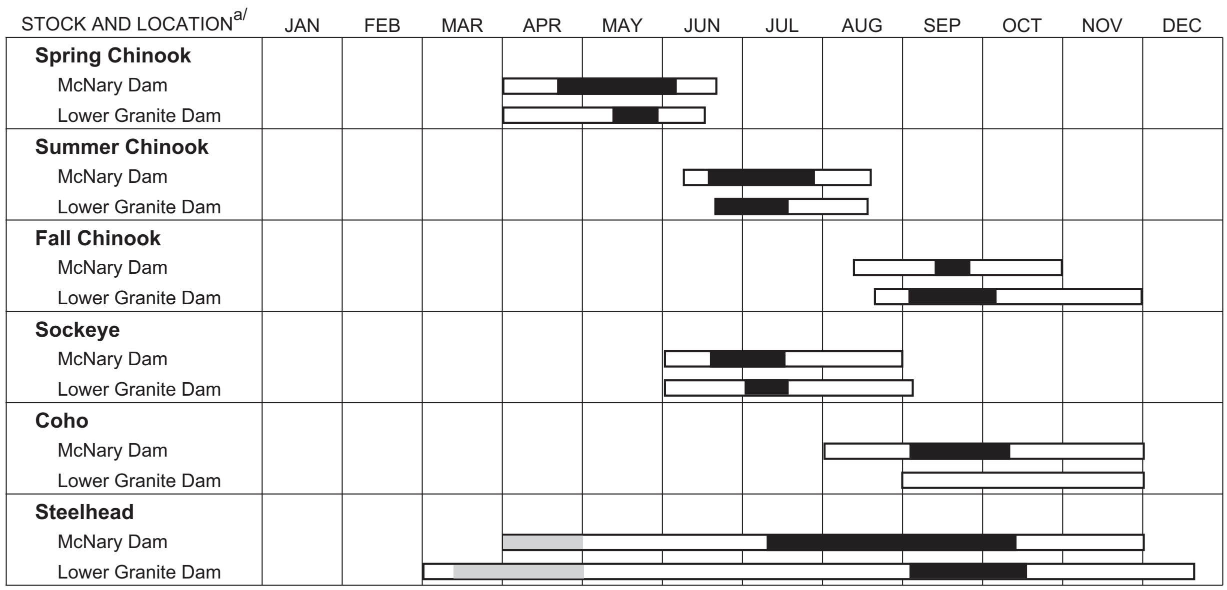
Spring Chinook Salmon

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).

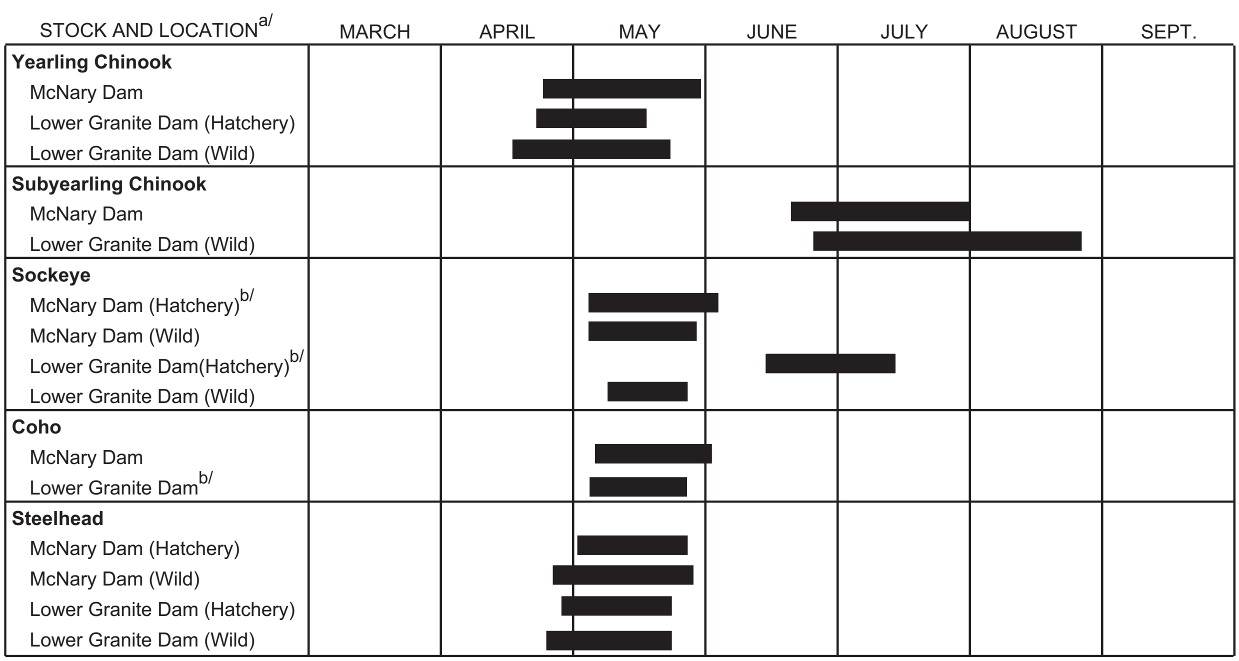
Summer Chinook Salmon

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

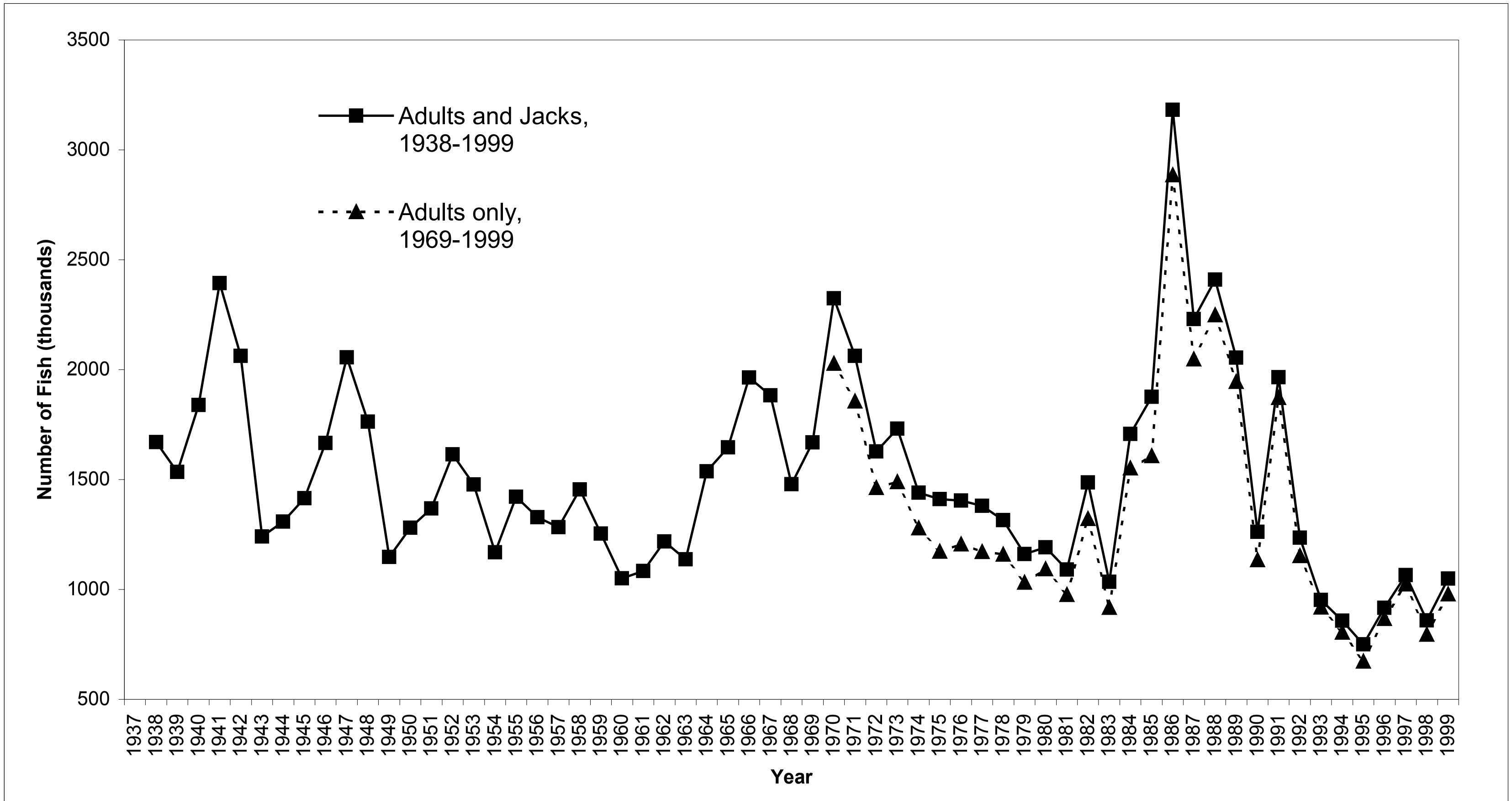
	Race							
	Spring Chinook	Summer Chinook	Fall Chinook	Coho	Sockeye	Chum	Winter Steelhead (B Run)	Summer Steelhead (A Run)
Lower Columbia River (Below Bonneville Dam)[1/]								
Lower Columbia River (Mainstem)			X	X		X	X	X
Grays River			X	X		X	X	
Elochoman River			X	X		X	X	X
Cowlitz River	X		X	X			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



(Source: ODFW and WDFW, 2000)

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).

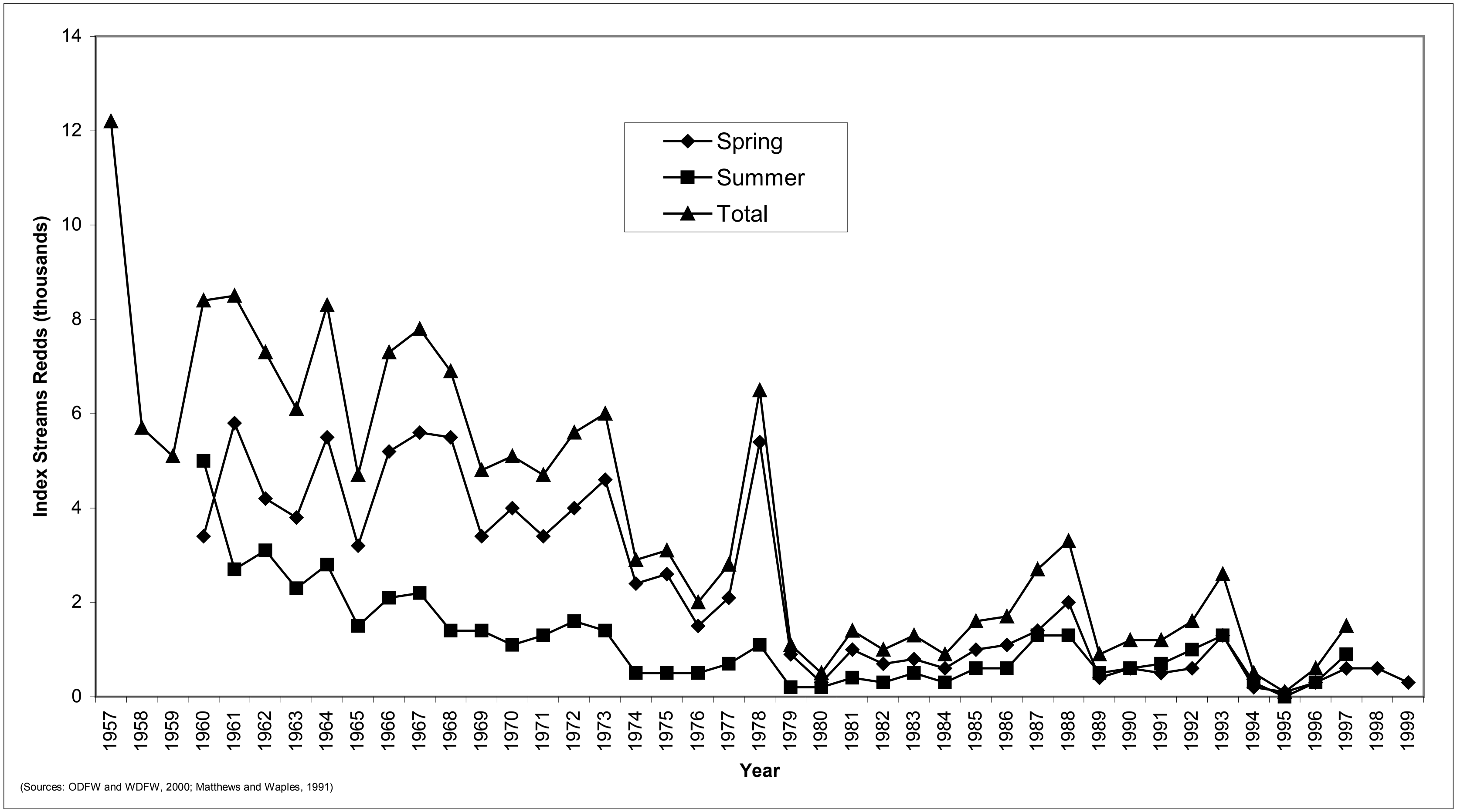
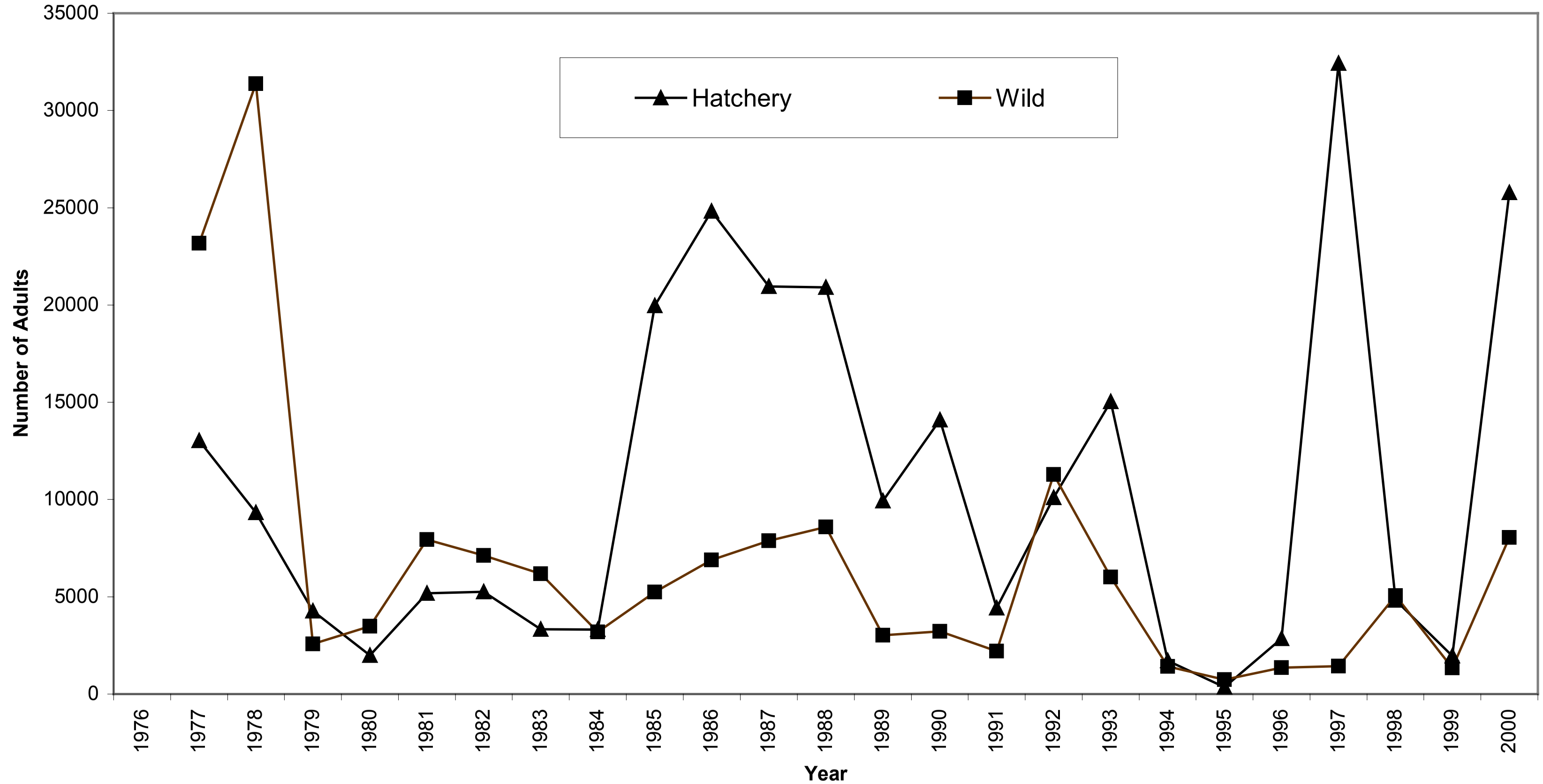
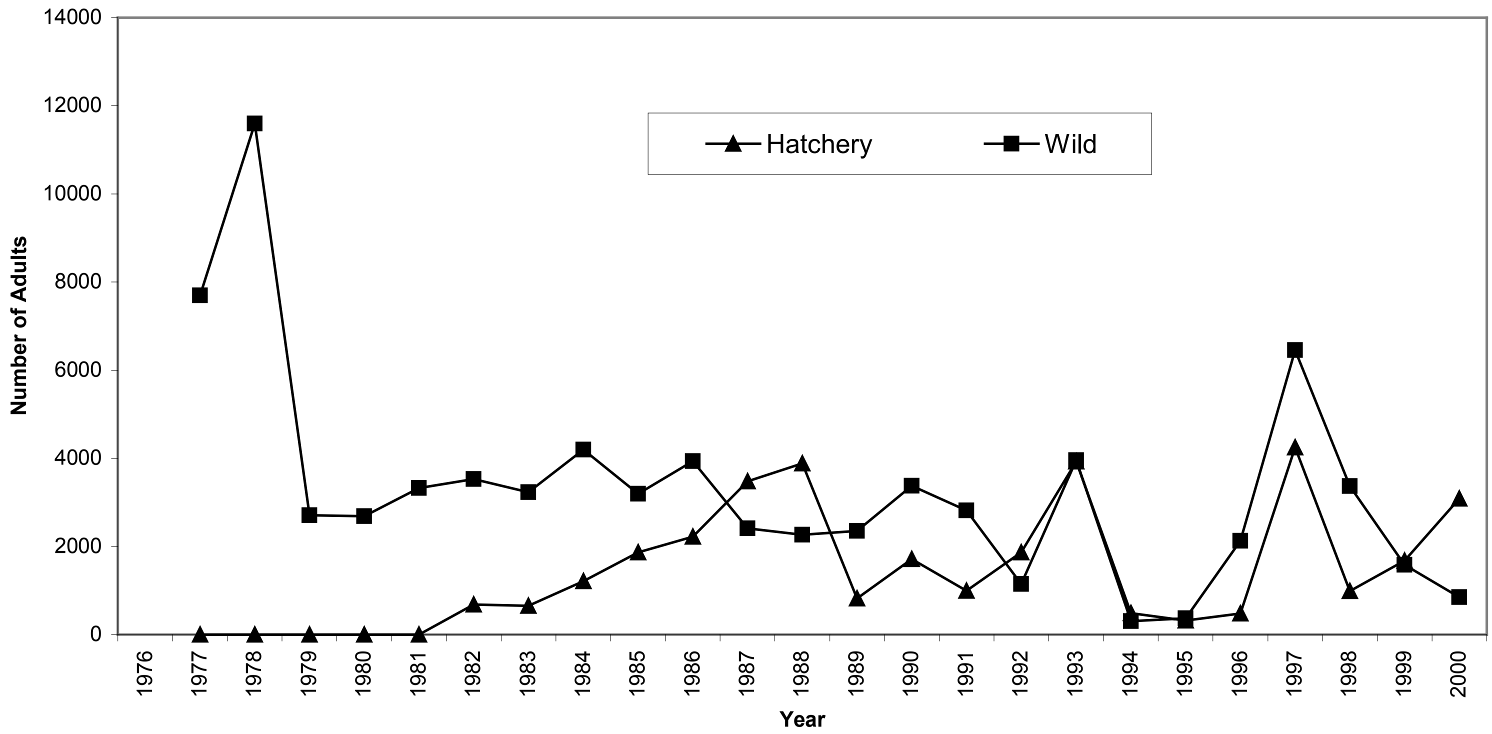


Figure 4.5-6. Index Streams Spring and Summer Chinook Redd Counts in Northeast Oregon and Idaho, 1957 to 1999



(Sources: PSC, 1991; CRFMP TAC, 1997; ODFW & WDFW, 1998; Personal Communication, Cindy LeFleur, WDFW, Vancouver, WA, 2001)

Figure 4.5-7. Estimated Wild and Hatchery Adult Spring Chinook Passing Lower Granite Dam, 1977 to 2000



(Sources: PSC, 1991; CRFMP TAC, 1997; ODFW & WDFW, 1998; Corps, 1998; Personal Communication, Cindy LeFleur, WDFW, Vancouver, WA, 2001)

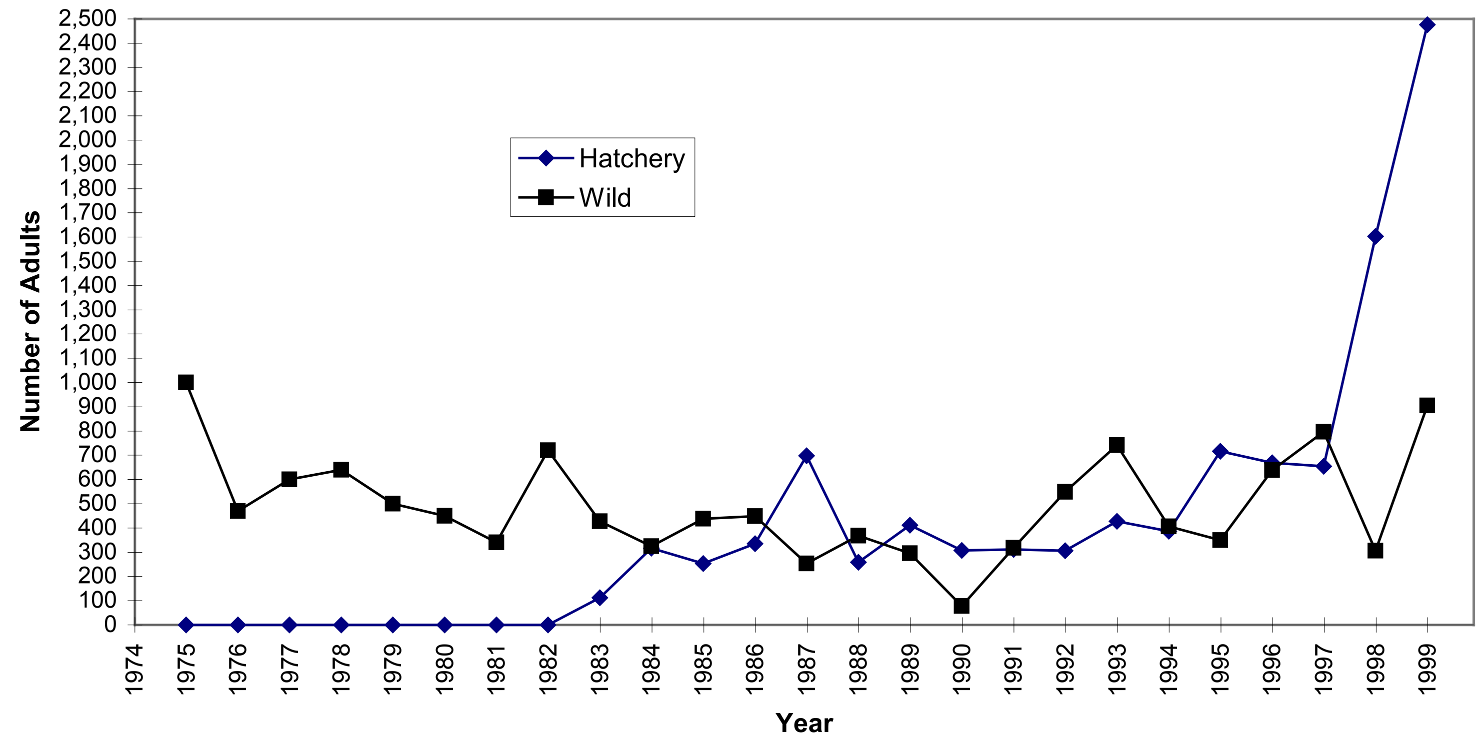
Figure 4.5-8. Estimated Wild and Hatchery Adult Summer Chinook Passing Lower Granite Dam, 1977 to 2000

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)

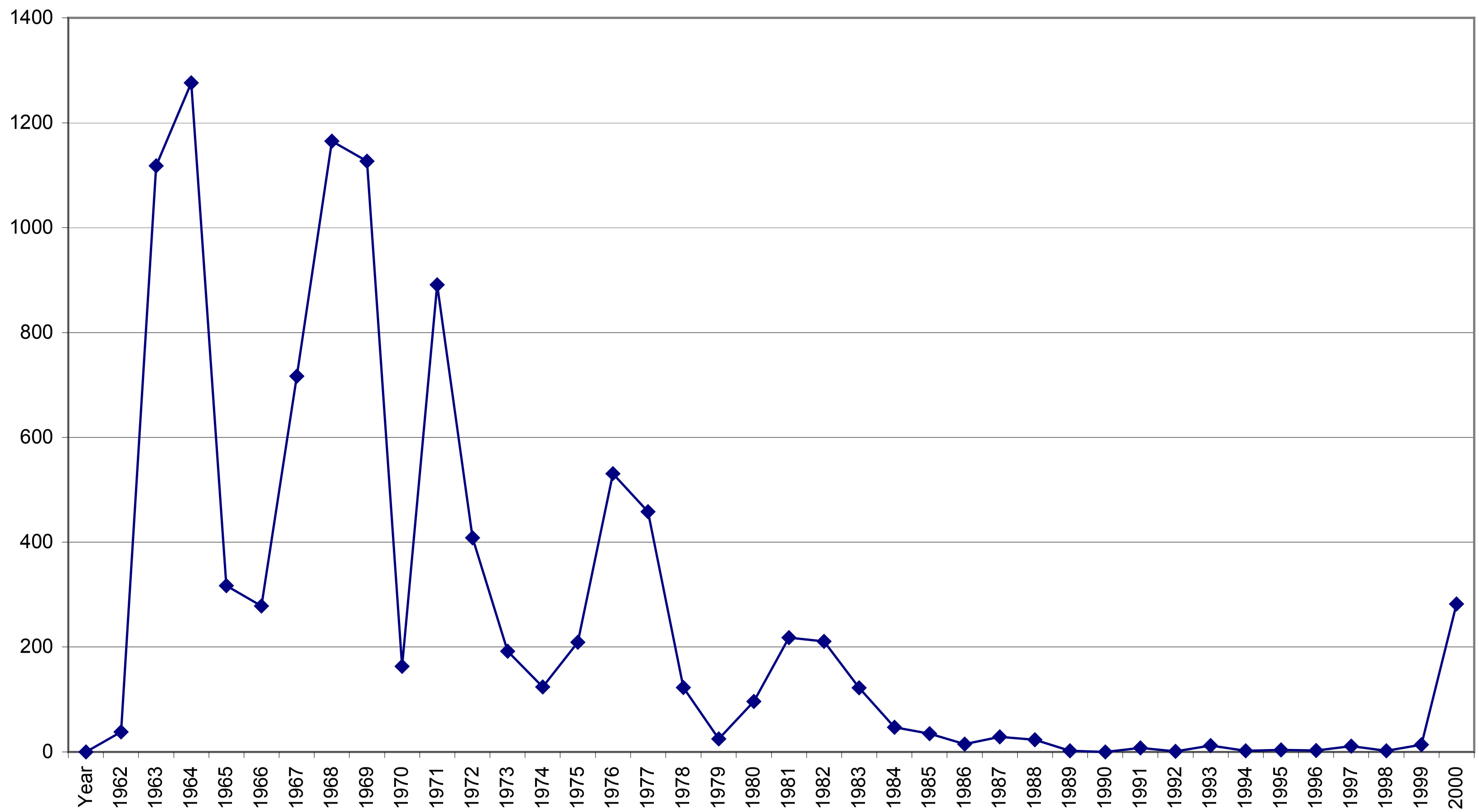
Figure 4.5-9. Estimated Wild and Hatchery Adult Fall Chinook Passing Lower Granite Dam, 1977 to 1999 and in 2000, 282 sockeye were counted (Figure 4.5-10). Returns in 2001 were lower again, at 36 over Lower Granite Dam. All but one of the fish passing in 1999 were small jack-sized fish originating from 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

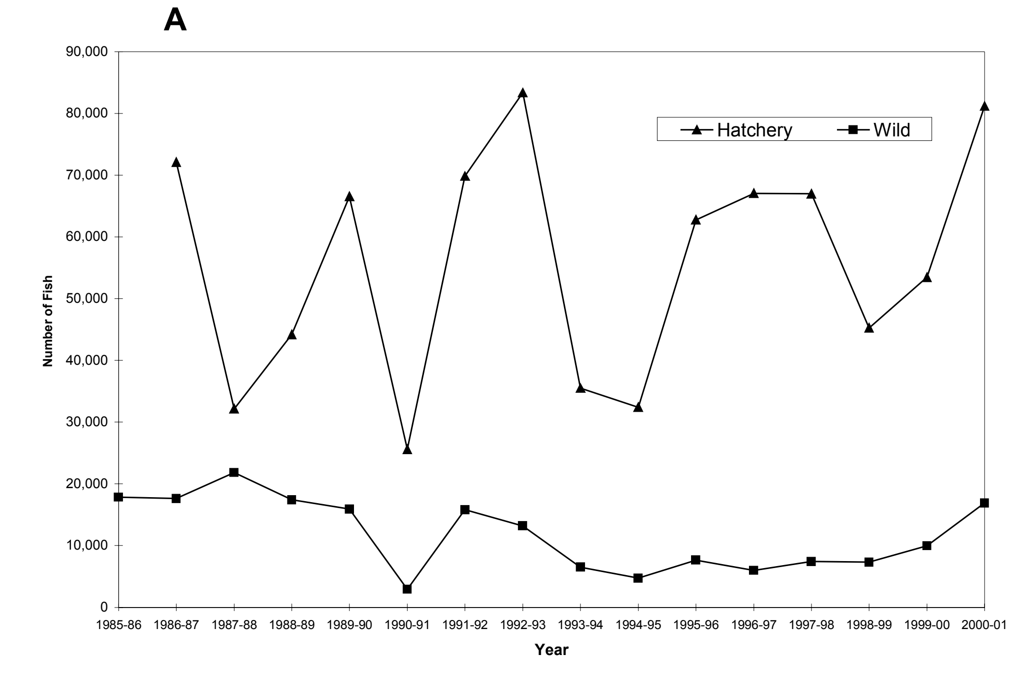
The numbers of other anadromous stocks on the Columbia River show varying trends. Shad populations have been very high in the last decade. Eight of the 10 highest recorded runs occurred in the last 10 years, all over 2 million fish. A peak of 4 million shad entered the Columbia River and 3 million passed 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).

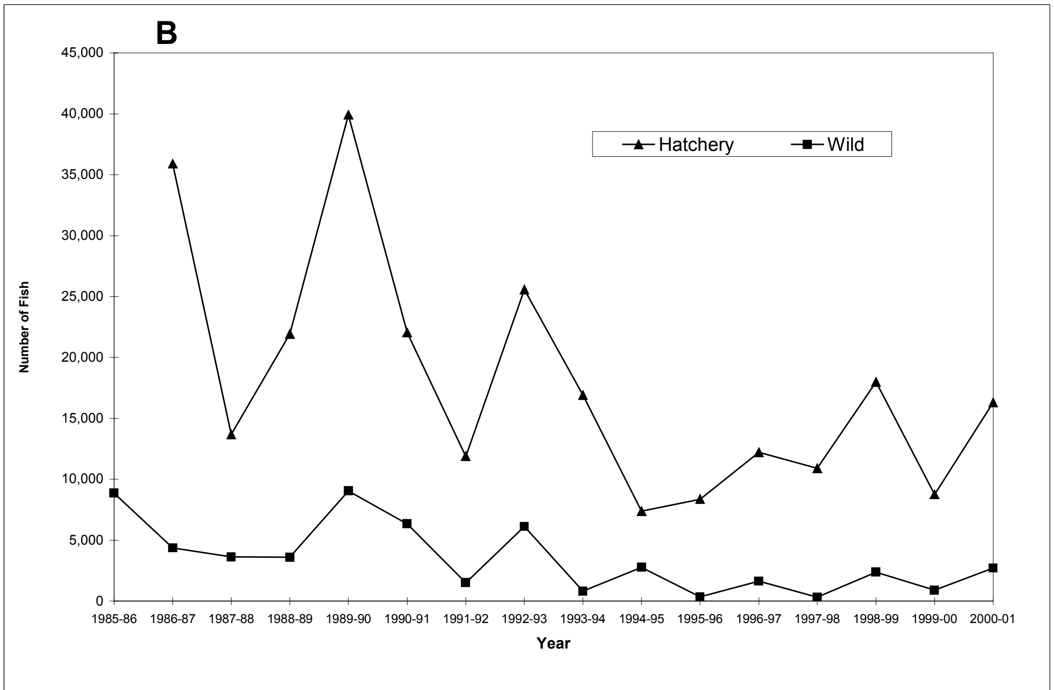
Columbia River Chinook Salmon

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



(Source: CRFMP TAC, 1997; Personal Communication, Sharon Kiefer, IDFG, 1999; 1998-99 data projected)



(Source: CRFMP TAC, 1997; Personal Communication, Sharon Kiefer, IDFG, 1999; 1998-99 data projected)

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).

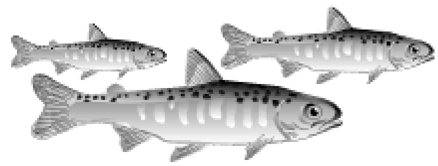
Bull Trout (*Salvelinus confluentus*)—Bull trout within the lower Snake River were listed as threatened on July 10, 1998. Bull trout are piscivorous and require an abundant supply of forage fish. They exhibit four distinct life history forms: resident, fluvial, adfluvial, and anadromous. Resident bull 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

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).

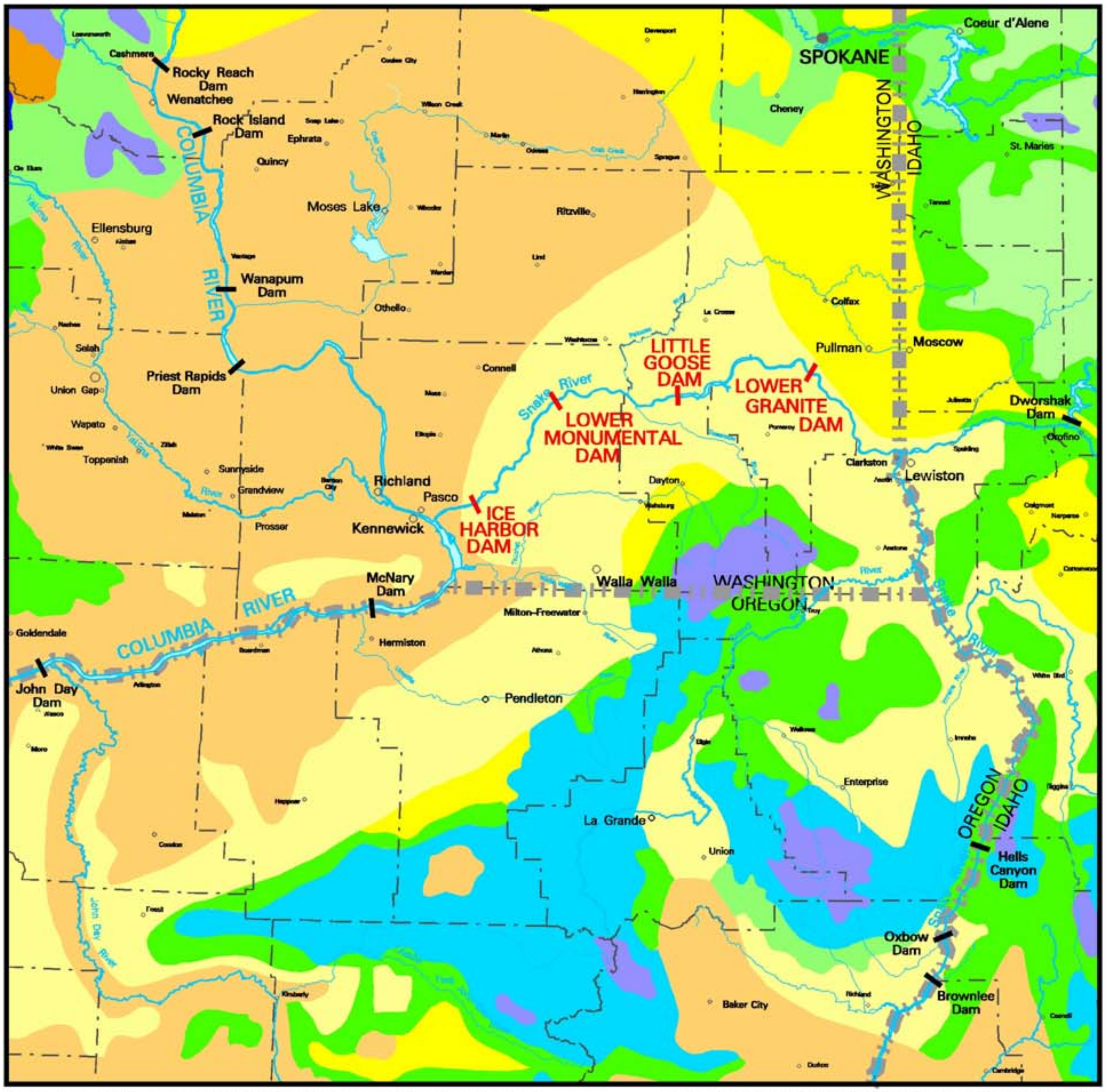
Many wetlands have been modified, degraded, or destroyed over the last 100 years by land use practices and manipulation of hydrology. Human activities such as railroad construction, road construction, livestock grazing, and agricultural have adversely impacted vegetation in the study area. Regional vegetation 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

125,000 ACRES

1 : 1,900,800

GEOGRAPHIC INFORMATION SYSTEMS
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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).

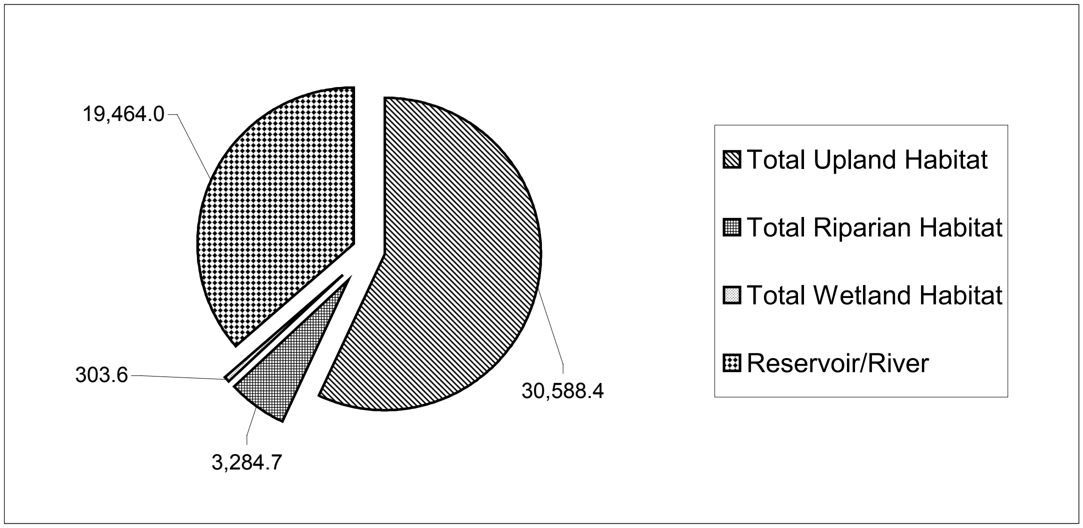


Figure 4.6-2. Pre-project (1958) Acreage of Vegetation Types in the Study Area

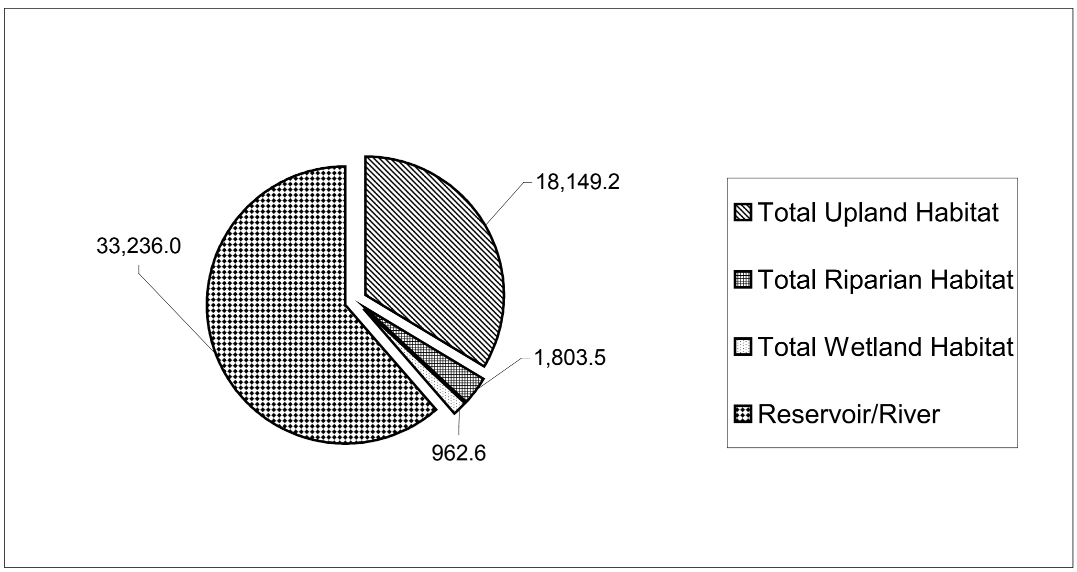


Figure 4.6-3. Current (1995) Acreage of Vegetation Types within the Study Area

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.

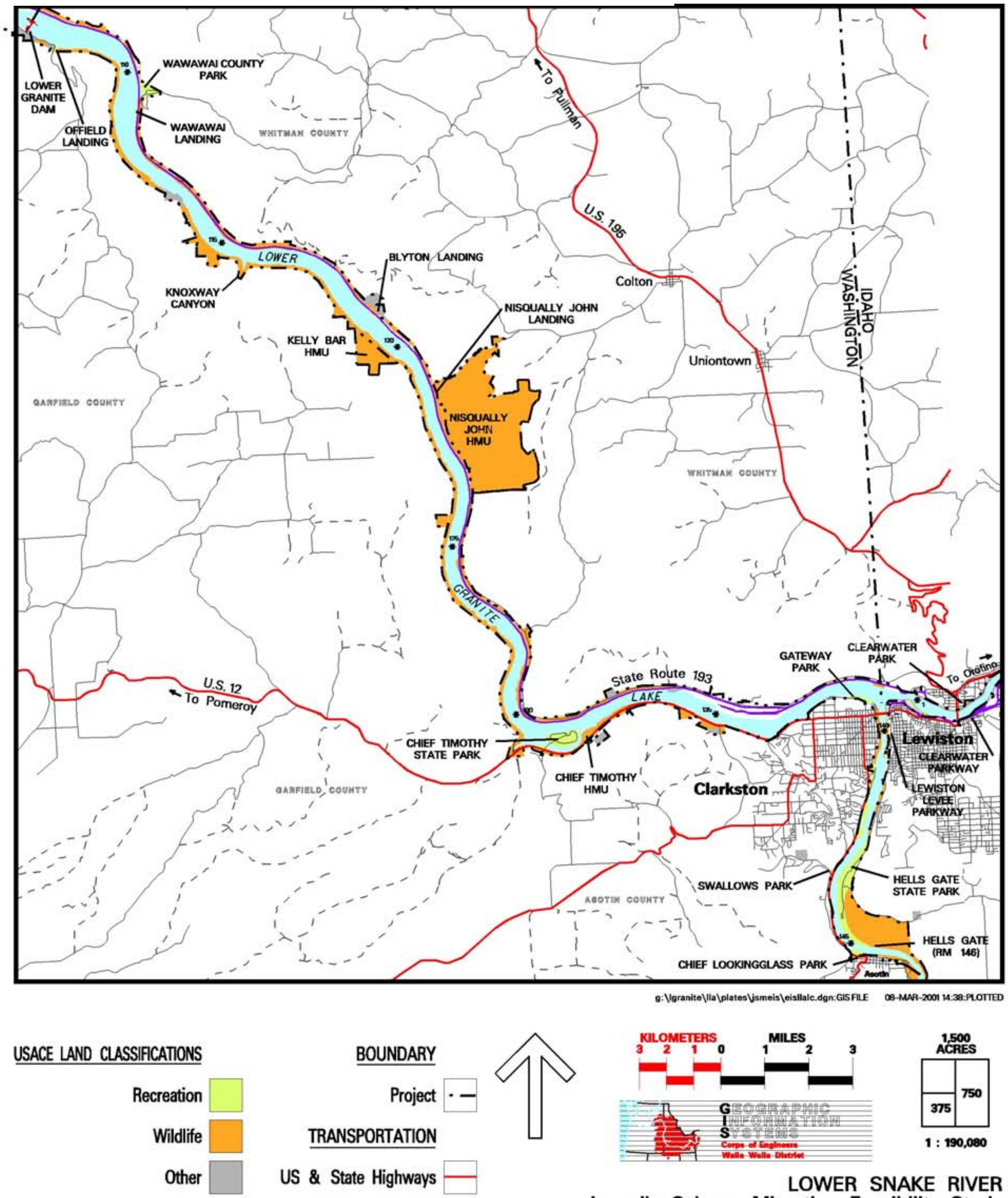
Inundation of the lower Snake River following dam construction between 1962 and 1975 eliminated approximately 45 percent of the woody riparian habitat present along the pre-impoundment river (Asherin and Claar, 1976; Appendix L, Lower Snake River Mitigation and History and Status). The remaining riparian 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.

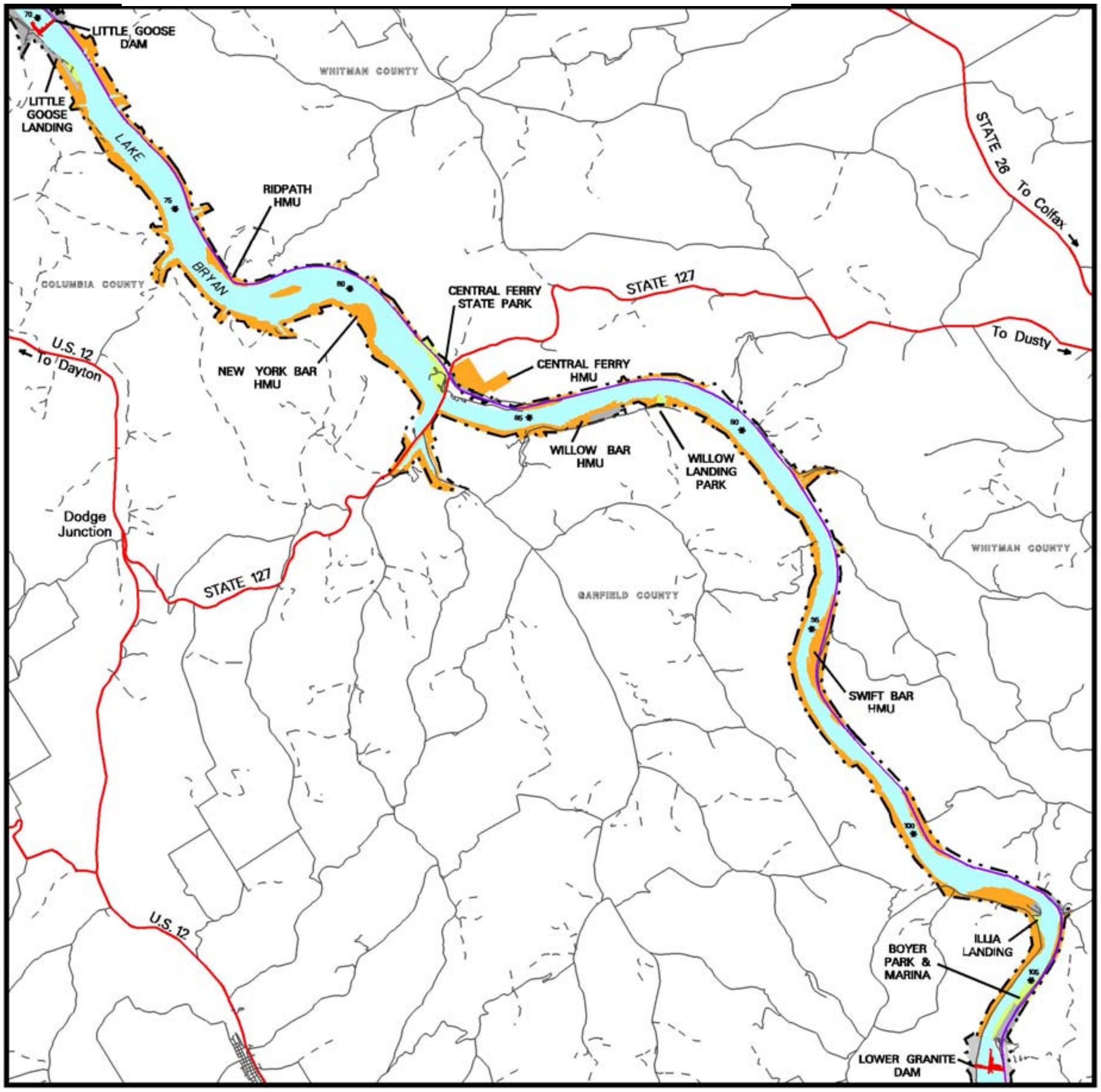
4.6.2.1 Current Terrestrial Mitigation and Habitat Evaluation Procedures

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



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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

1,500 ACRES — 750 — 375

1 : 190,080

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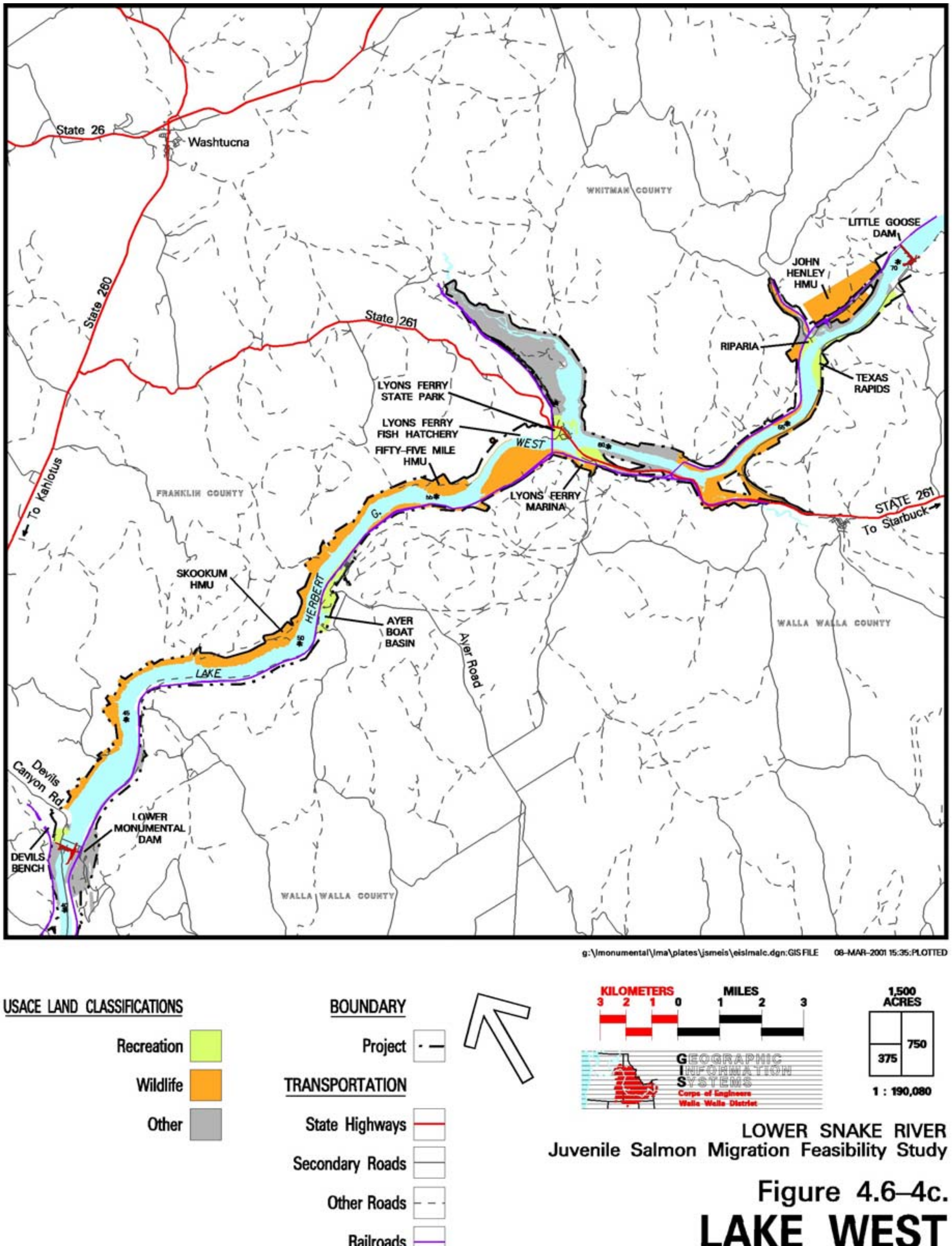
Walla Walla District

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

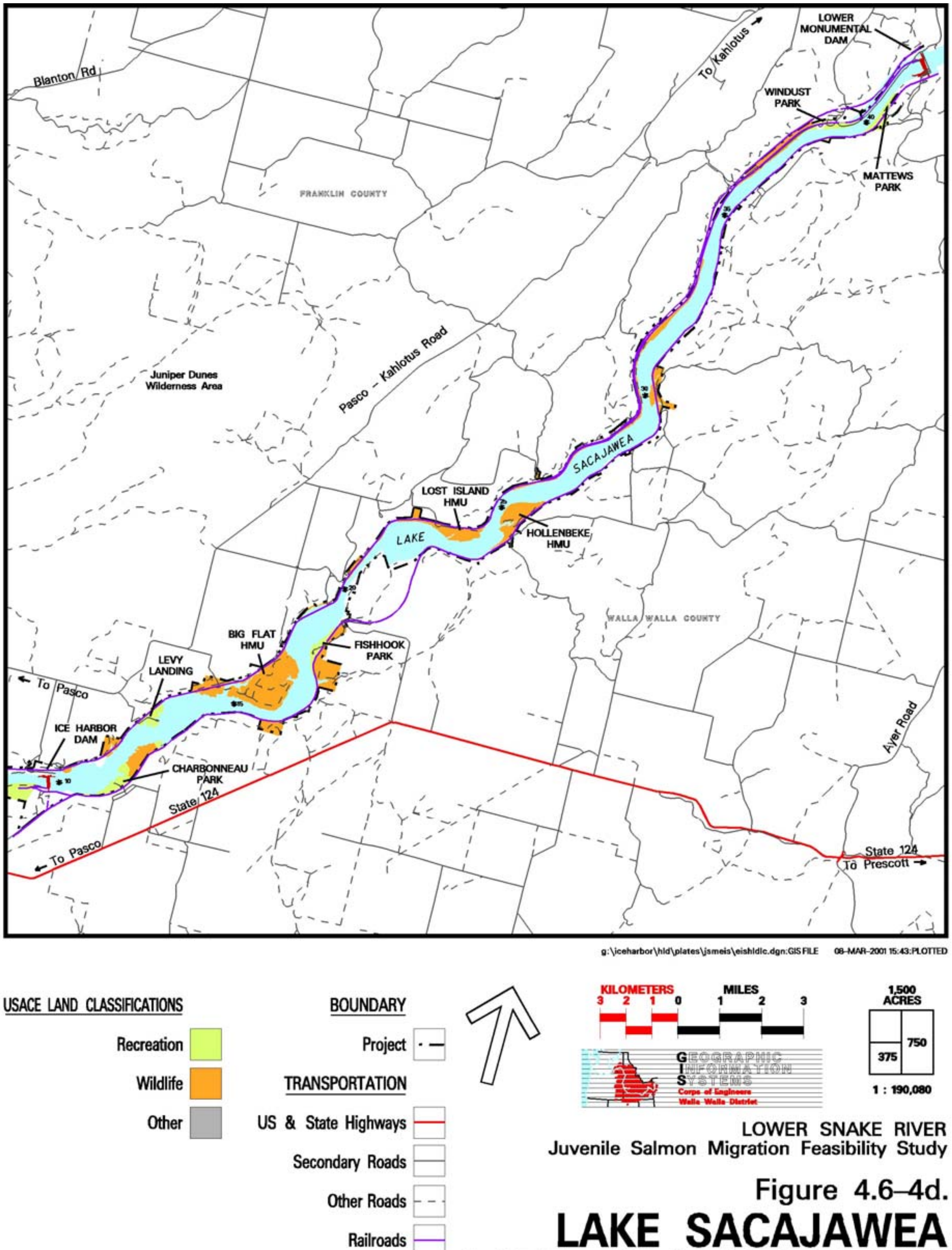
Figure 4.6–4b.

LAKE BRYAN LAND CLASSIFICATION



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.6–4c.
LAKE WEST
LAND CLASSIFICATION



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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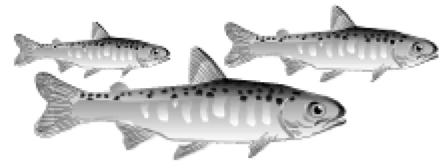


4.7 Cultural Resources

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:

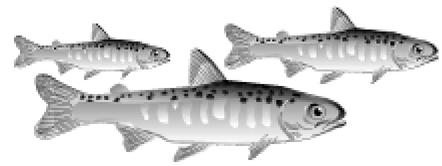
Ice Harbor Dam, Lake Sacajawea
- Windust Cave Archaeological District (listed)
- 45FR272 (listed)

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

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

[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.

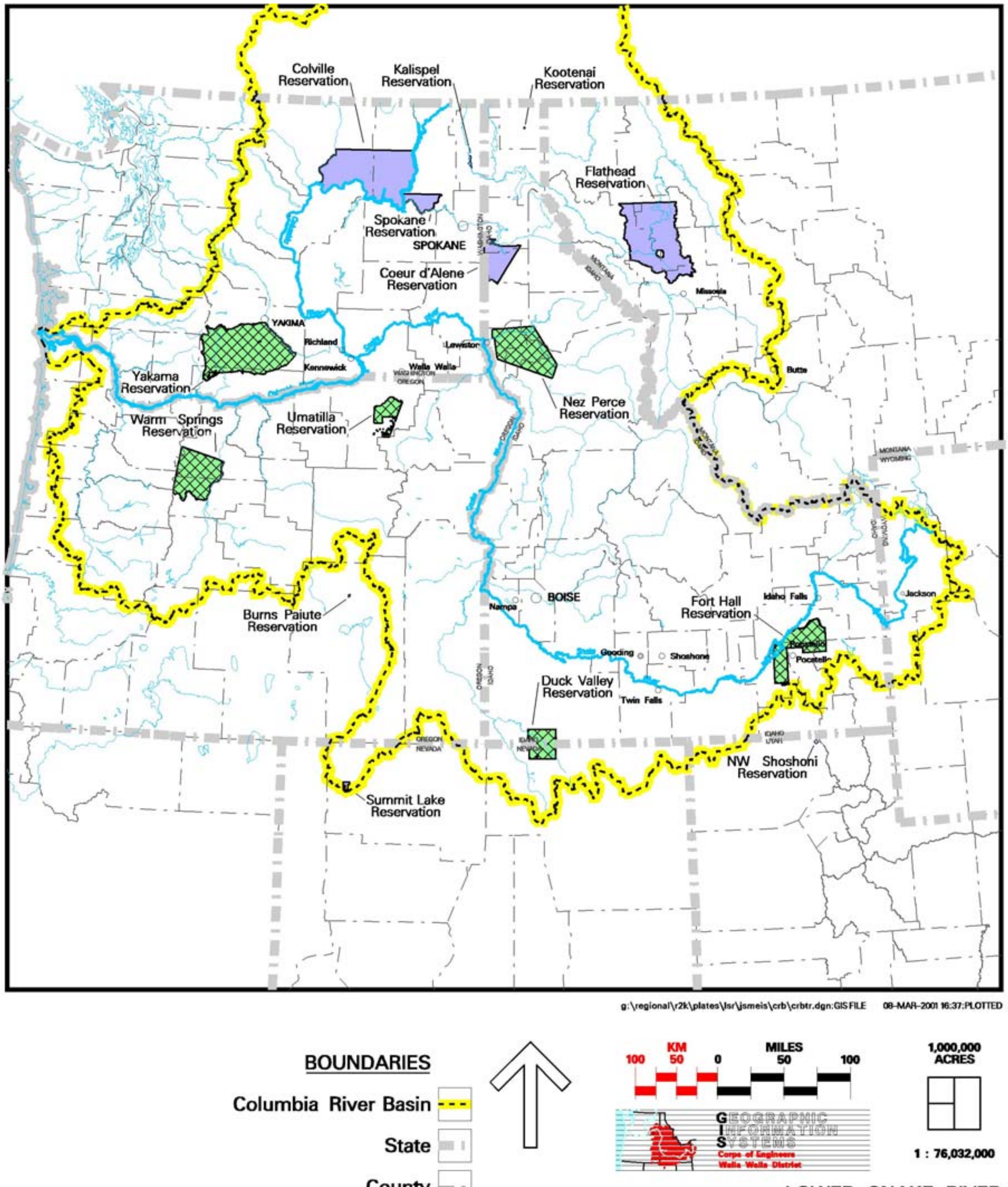


Figure 4.8–1.
TRIBAL RESERVATIONS

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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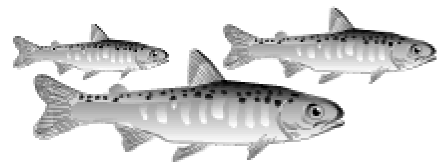


4.9 Transportation

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.

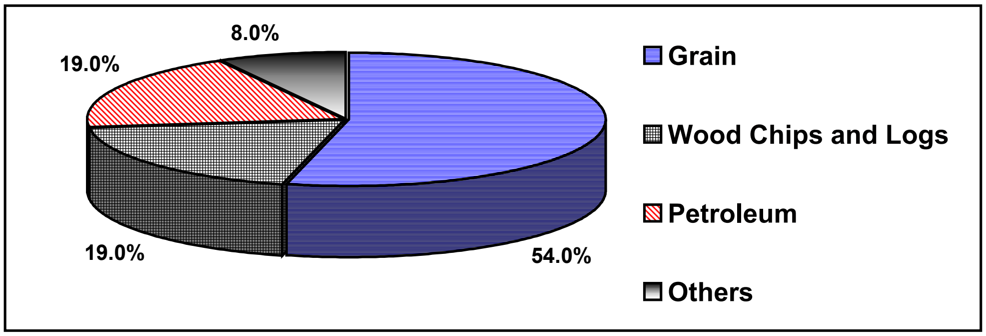
Analysis of data from the Waterborne Commerce Statistics Center (WCSC) and the Corps' Lock Performance Monitoring System (LPMS) showed that commodities from 37 commodity groups were shipped on the waterway in both 1996 and 1997. These commodity groups were aggregated into five groups for the purposes 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.

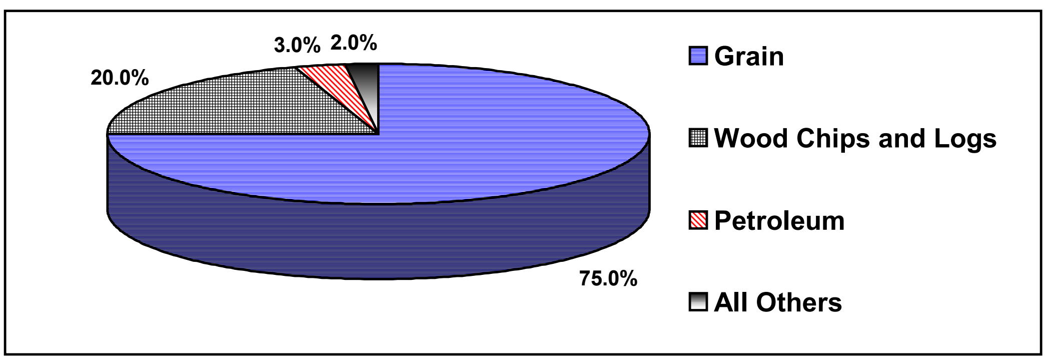


Source: DREW Transportation Workgroup, 1999, Table 4-6

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).

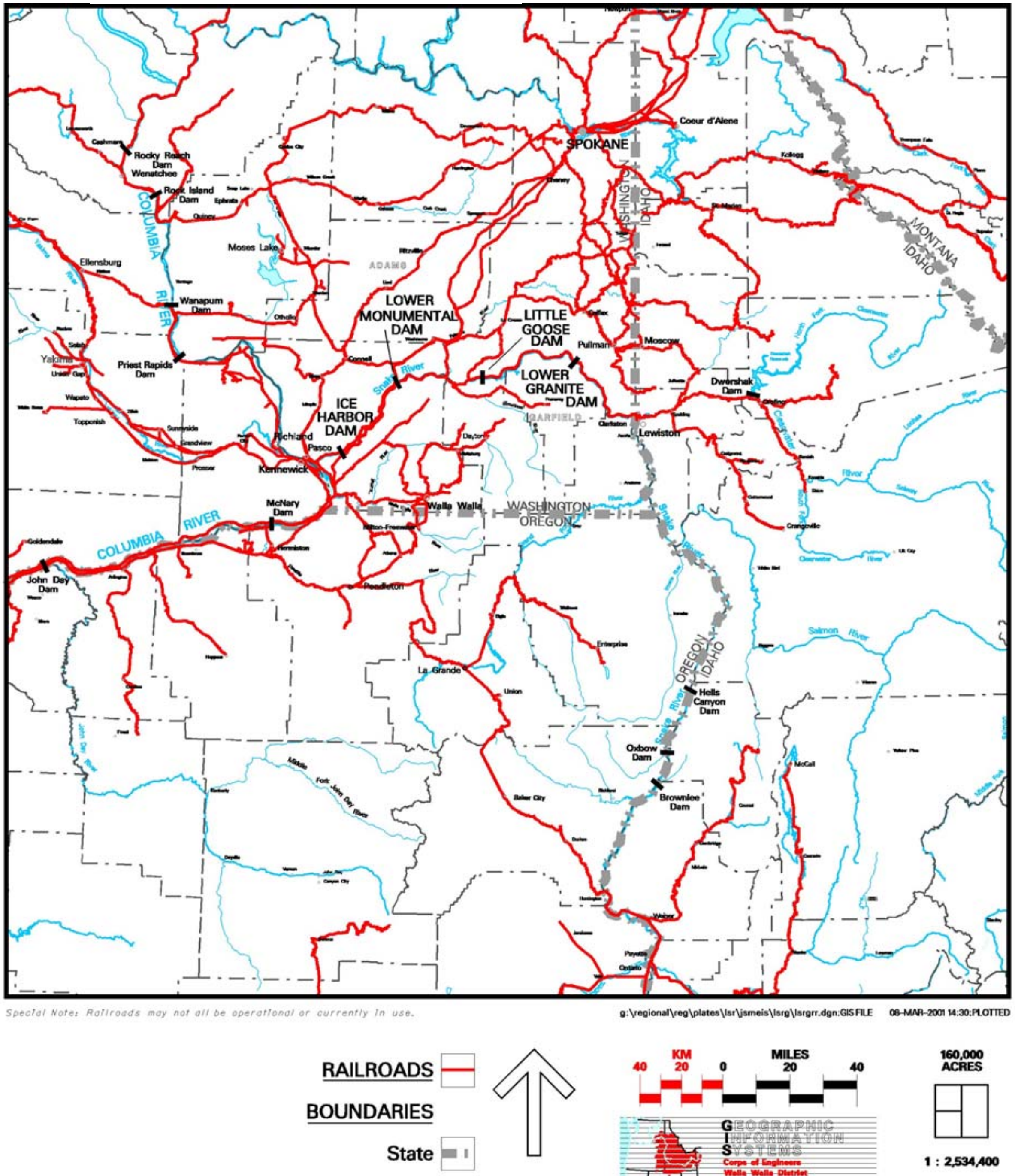
4.9.3 Highways

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.



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

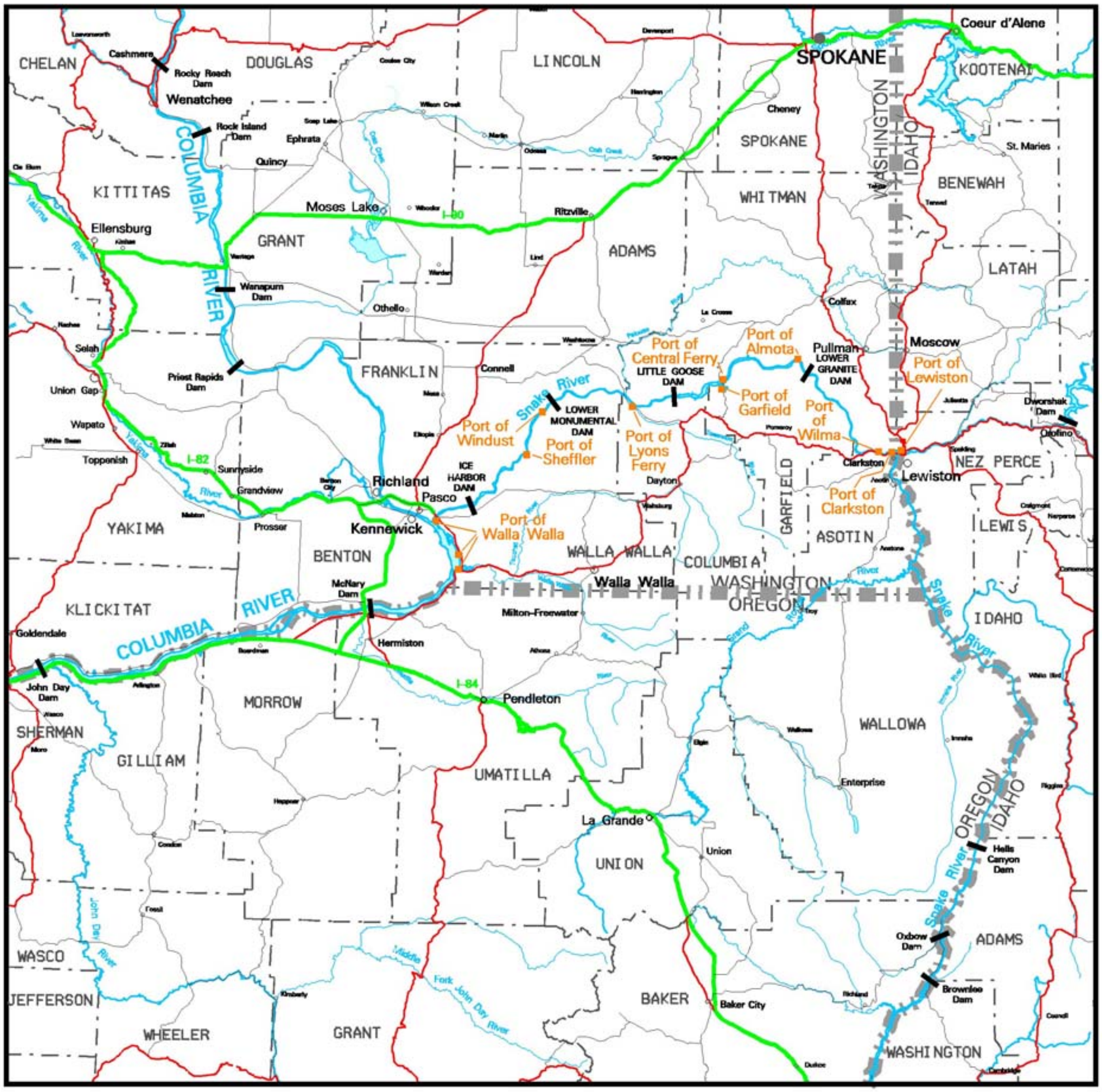
The highway network serving the study area includes Federal, state, and county highways (Figure 4.9-4). Primary and secondary routes that could be affected by potential diversion of commodities from barge transportation are identified in Table 4.9-9. Alternative routes north of the lower Snake River 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.

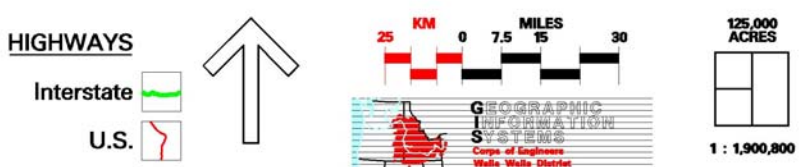
The four lower Snake River dams serve as bridges across the river. Lower Monumental Dam connects Lower Monumental Road on the south side of the river with Devils Canyon Road on the north. Lower Granite Dam connects Lower Deadman Road on the south side of the river with Almota Road on the north. The closest 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

	Segment/Location	
Highway	**From**	**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

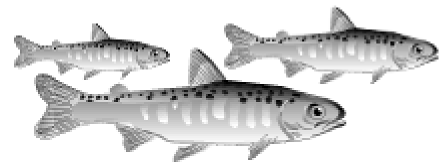
Source: Corps and NMFS, 1994





LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 4.9–4.
ROADS, HIGHWAYS, AND PORTS



4.10 Electric Power

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.

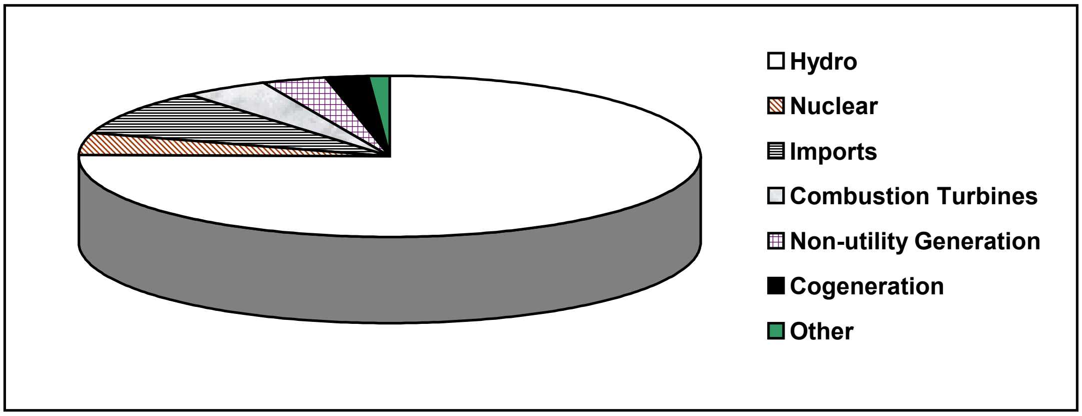
The four lower Snake River dams are currently operated in accordance with the Biological Opinions. The Corps operates Little Goose, Lower Monumental, and Ice Harbor Dams within one foot of MOP from approximately April 10 through August 31. Lower Granite Dam is operated within one foot of MOP from approximately 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.

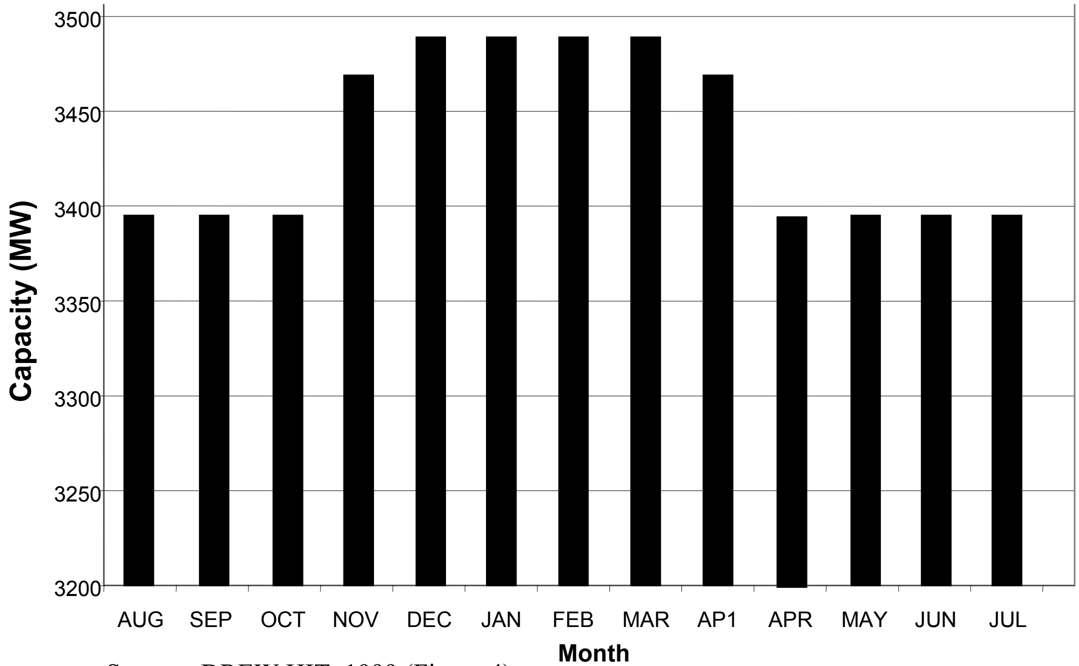
Table 4.10-2. Hydroelectric Power Plant Characteristics

	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)

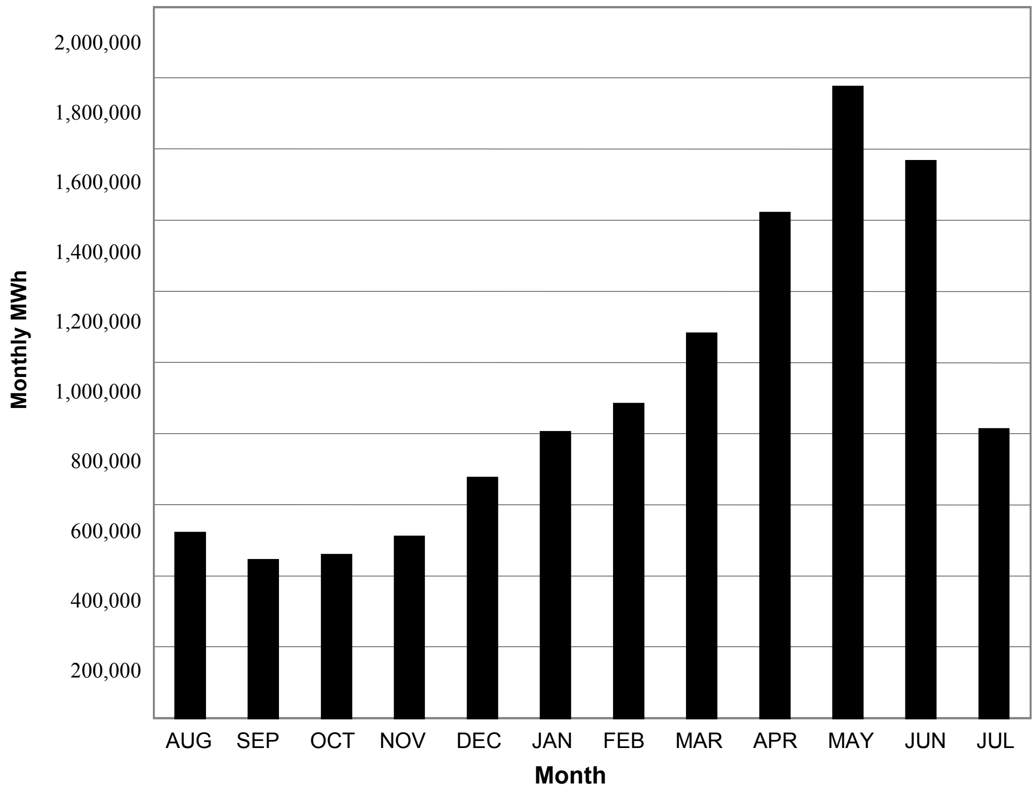
Figure 4.10-2. Combined Plant Capacity of the Four Lower Snake River Facilities

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)

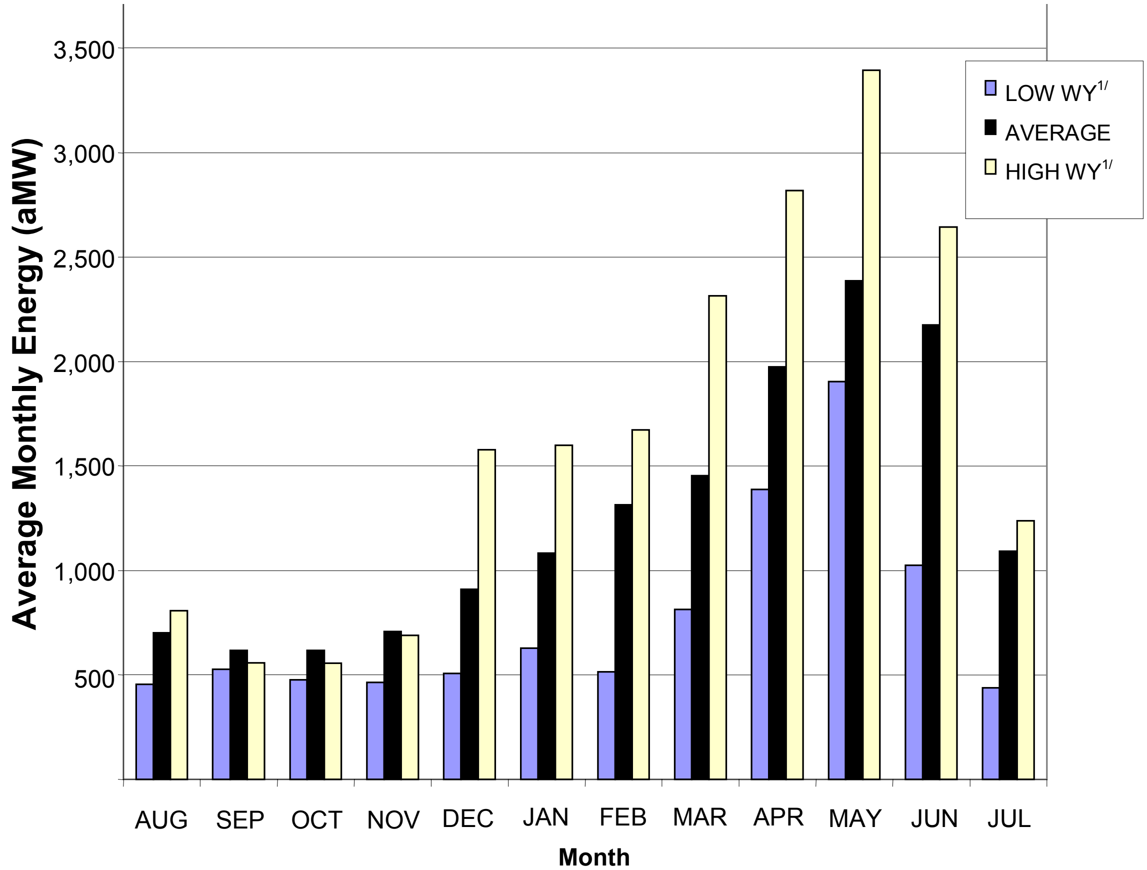
Figure 4.10-3. Average Monthly Generation by the Lower Snake River Facilities (combined)

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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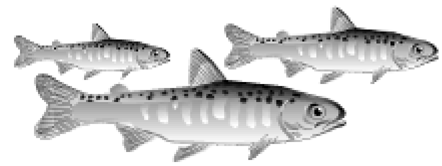


4.11 Water Supply

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.

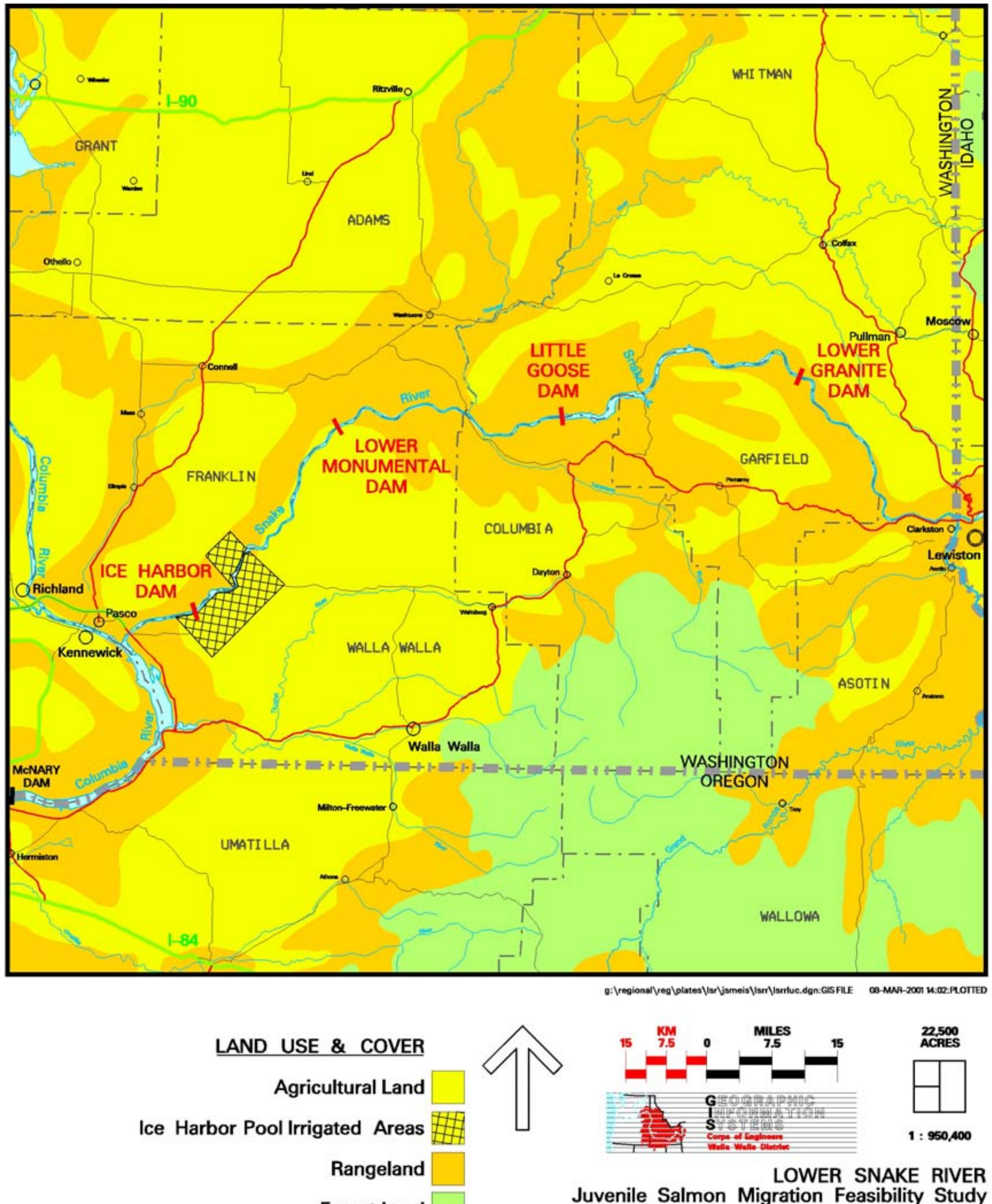


Figure 4.11–1.
REGIONAL LAND USE & COVER

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

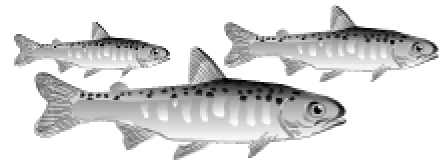
Wells located within one mile of the lower Snake River could be affected by a natural drawdown. State water well reports indicate that approximately 225 wells are located within 1 mile of the lower Snake River. Approximately 53 percent of these wells are used for either domestic or irrigation purposes. 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

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

County	Land Area (Acres)	BLM Acres	BLM %	Forest Service Acres	Forest Service %	Wilderness Acres	Wilderness %	Non-Federal Timberland Acres	Non-Federal Timberland %	Farms Acres	Farms %
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

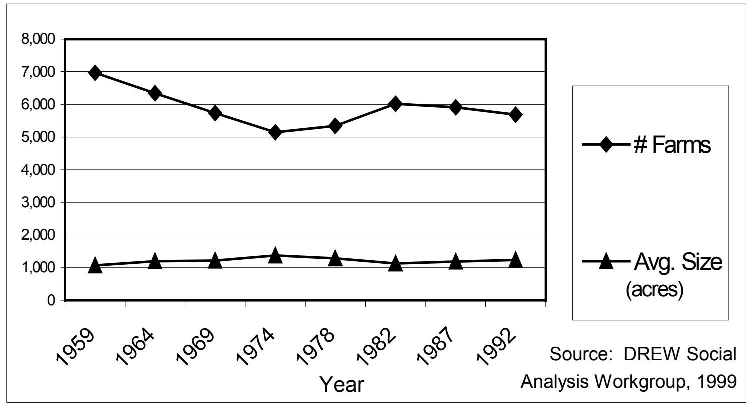


Figure 4.12-1. Number and Average Size of Farms in the Downriver Subregion, 1959 to 1992

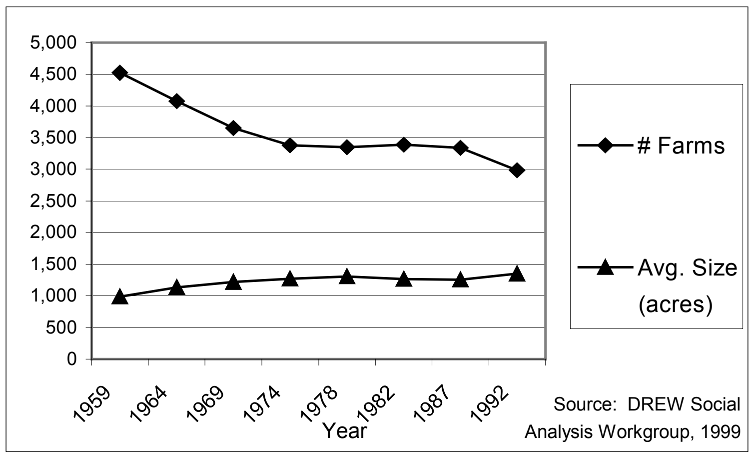


Figure 4.12-2. Number and Average Size of Farms in the Reservoir Subregion, 1959 to 1992

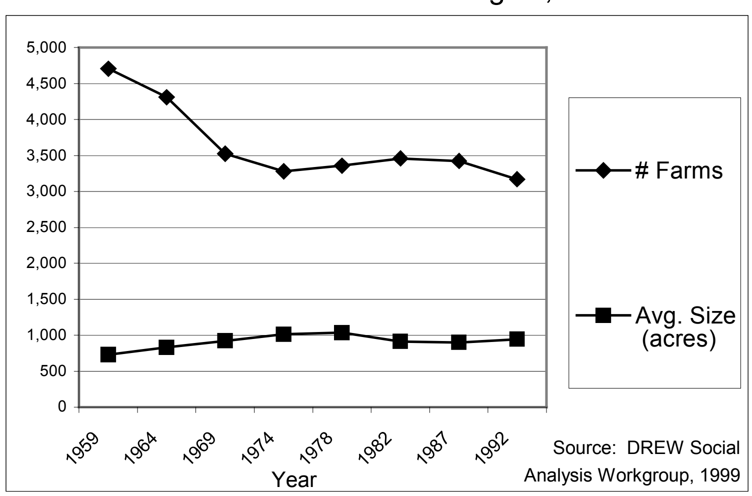


Figure 4.12-3. Number and Average Size of Farms in the Upriver Subregion, 1959 to 1992

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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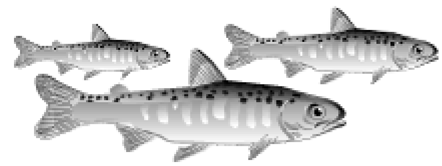


4.13 Recreation and Tourism

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	1	1		3	
Riparia					
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**

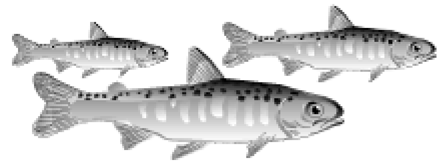
Source: Corps, 1998e

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

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.

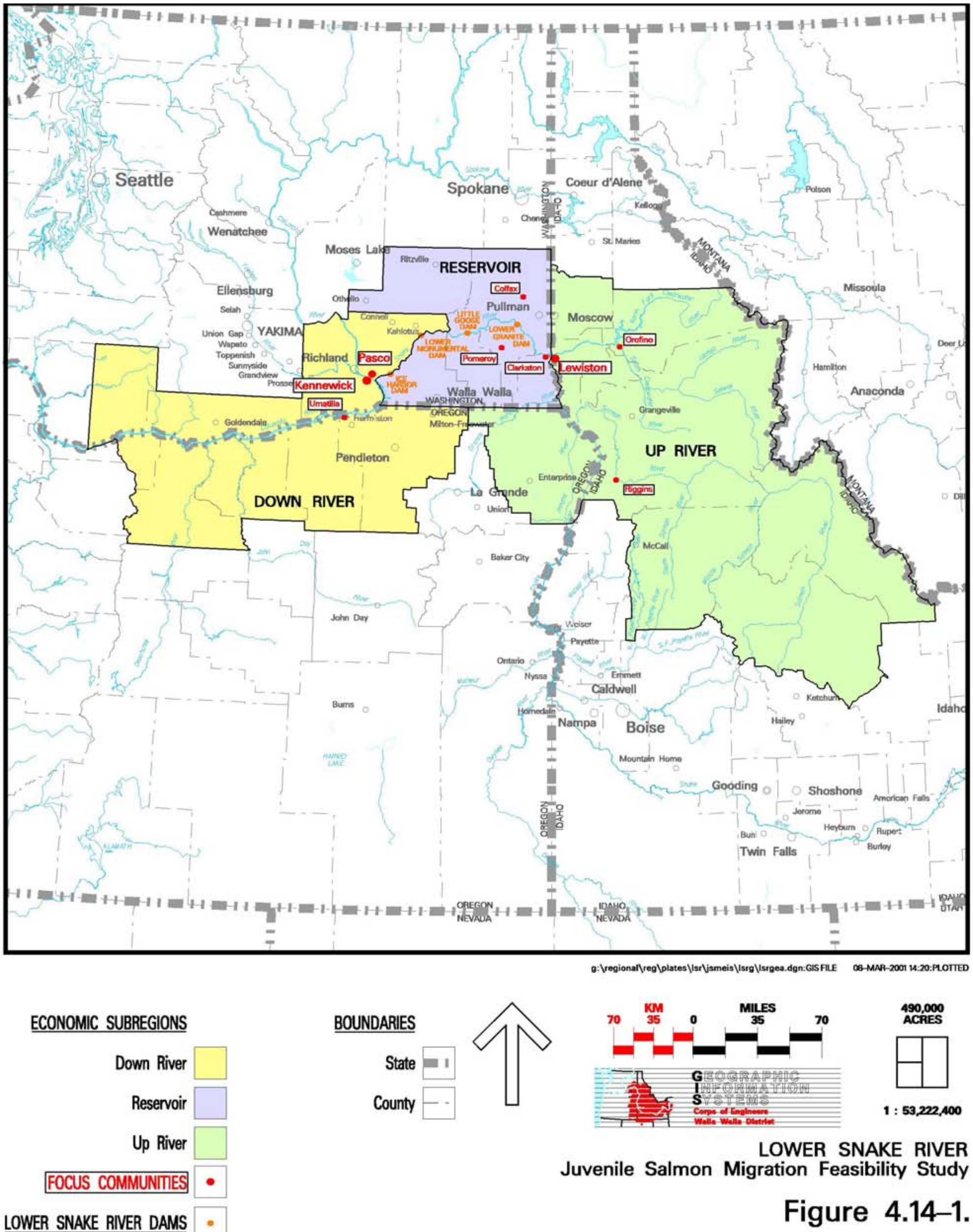
In addition to regional impacts that may occur in the vicinity of the lower Snake River, local economies that benefit from the fishing industry would also be affected by changing anadromous fish harvest levels. Anadromous fish have wide ranging ocean distributions and, as a result, changes in harvest 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.



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

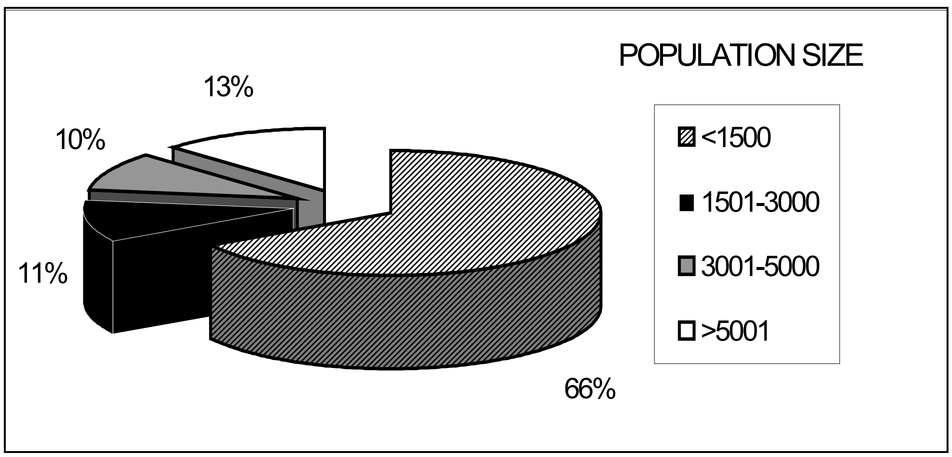
This section provides an overview of the communities located in areas that could be potentially affected by the proposed alternatives. The following sections focus on communities located in three potentially-affected geographic areas: the 25-county lower Snake River study area, the Washington and Oregon 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.

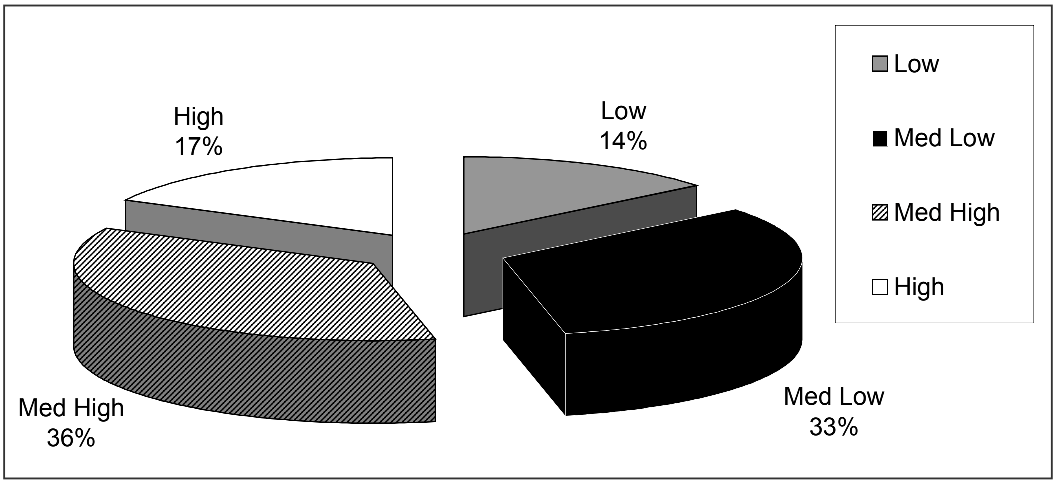


Source: DREW Social Analysis Workgroup, 1999 (Figure 10)

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.

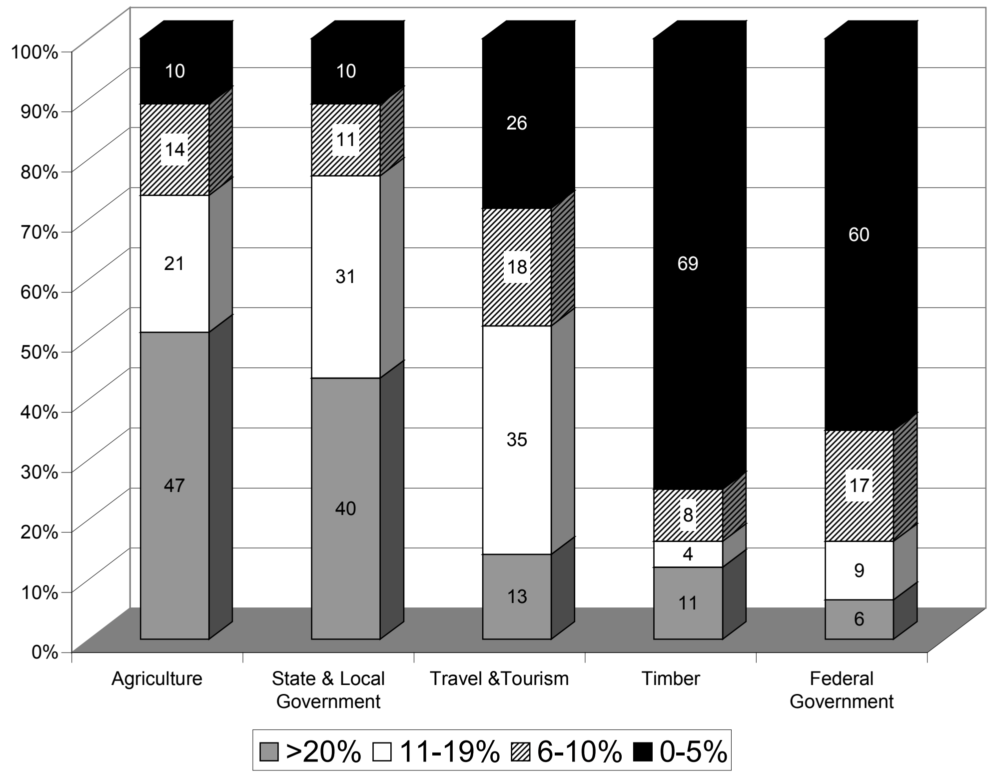


Source: DREW Social Analysis Workgroup, 1999

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).

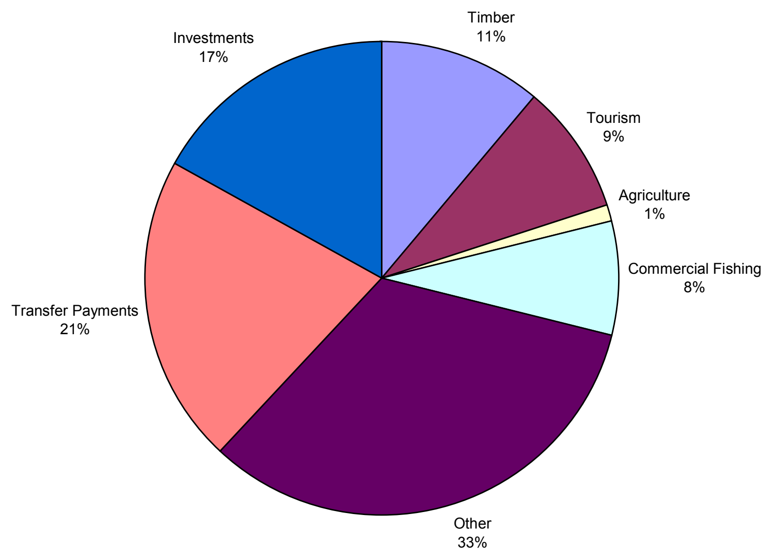
Table 4.14-9. Community Type Descriptions

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

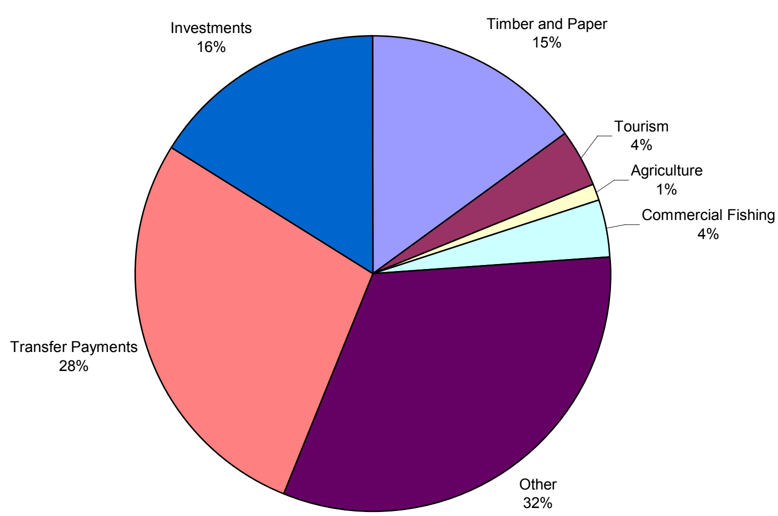
Typical Community Case	Population 1996-97	Subregion	Relation to Snake River	Economic Diversity	Dominant Industries
TRADE CENTER COMMUNITY TYPE					
Lewiston, ID	30,271	Reservoir	Port of Lewiston; Barging/Cruiselines/Transportation; Recreation	High	Travel & Tourism Forestry State/Local Government
Clarkston, 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			Total
		Idaho	Oregon	Washington	
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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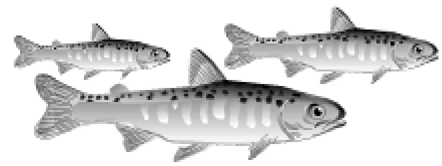

4.15 Aesthetics

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).