Chapter 4 SALMON AND STEELHEAD ANALYSIS

4.1 Introduction

This chapter addresses the potential effects of Reclamation's 12 upper Snake proposed actions on 13 ESA-listed Snake and Columbia River salmon ESUs and steelhead DPSs and on their designated critical habitat in the action area. An ESU or DPS is a distinct group of Pacific salmon or steelhead, respectively, that can be considered a species for purposes of the ESA. It is distinguished by genetics, meristics, life history characteristics, behavior, and geographical area occupied. This chapter provides a broad overview of the current listing status of relevant salmon ESUs and steelhead DPSs and water quality conditions within the action area. Background and base status for each salmon ESU and steelhead DPS are provided in the *Comprehensive Analysis*, Chapters 4 through 16 (USACE et al. 2007b).

The effects and conclusions for all listed ESUs and DPSs and designated critical habitat in the collective action area for all 12 proposed actions are described in this chapter. The analyses address flow-related effects of Reclamation's proposed actions on listed salmon and steelhead and designated critical habitat downstream of Hells Canyon Dam. As described in Reclamation's 2004 Upper Snake BA, operation of Reclamation's upper Snake projects generally decreases flows from October to June in most years and increases flows from July through September. In this 2007 Upper Snake BA, Reclamation proposes to adaptively manage its flow augmentation activities such as shifting the timing of some flow augmentation releases to an earlier spring delivery (May through mid-July period) as opposed to the late June through August period, pending verification of the biological effectiveness. This 2007 Upper Snake BA examines the potential effects of these refinements to flow augmentation releases on ESUs and DPSs and on essential features and Primary Constituent Elements (PCEs) identified by NMFS for designated critical habitat. The analysis also discusses any continued future effects attributed to flow depletions associated with upper Snake operations.

The action area and some designated critical habitats affected by Reclamation's upper Snake proposed actions are located in river reaches also affected by FCRPS operations. An analysis that comprehensively evaluates the combined flow effects from both actions (upper Snake and FCRPS) on the 13 ESA-listed salmon ESUs and steelhead DPSs and associated critical habitat is contained in a separate document, the *Comprehensive Analysis* (USACE et al. 2007b). That analytic approach considers the biological requirements for survival and recovery of the listed species in question, and evaluates whether the species are likely to survive and be placed on a trend toward recovery after considering the effects of the upper Snake and FCRPS actions when added to the environmental baseline and cumulative effects. As such, it is a life-cycle survival analysis that necessarily considers all mortality factors affecting the listed species, as well as all actions that have an impact on the species' survival, productivity, and population growth rates. Chapter 3 of the *Comprehensive Analysis* describes the analytical framework used for the analyses; Chapters 4 through 16 contains the biological analysis for each individual ESU or DPS.

4.2 Background

4.2.1 Listed Salmon and Steelhead, Action Area, and Designated Critical Habitat

The action areas for the 12 proposed actions extends above and below Brownlee Reservoir as described in the 2004 Upper Snake BA at pages 3 to 5 and in Chapter 2. The combined effects of Reclamation's upper Snake actions begin at Brownlee Reservoir, the upstream reservoir of the Hells Canyon Complex. The 13 listed salmon and steelhead species occupy the action area downstream of Hells Canyon Dam. Therefore, Reclamation's analysis focuses on the portion of the action area beginning with the Snake River at Brownlee Reservoir and immediately downstream from Hells Canyon Dam (or wherever an occupied tributary stream meets the Snake River below Hells Canyon Dam) to the confluence of the Snake and Columbia Rivers, and in the Columbia River (or wherever a tributary stream meets the Columbia River, downstream to its mouth). This is the farthest downstream point at which Reclamation's proposed actions in the upper Snake may influence listed anadromous salmonids. This shared action area applies to all of the 13 listed salmon ESUs and steelhead DPSs (because they use all or part of the action area) and designated critical habitat

Table 4-1 lists the 13 Pacific salmon ESUs and steelhead DPSs by common and scientific names, together with species status and critical habitat designation, which occur within the collective action area for all 12 actions.

Table 4-1. Listed anadromous salmonid species ESUs and DPSs and designated critical habitat in the upper Snake action area.

ESU/DPS	Status	Critical Habitat Designation
Snake River Spring/Summer Chinook Salmon ESU *(Oncorhynchus tshawytscha*)	Threatened; April 22, 1992 (57 FR 14653)	December 28, 1993 (58 FR 68543); October 25, 1999 (64 FR 57399)
Snake River Fall Chinook Salmon ESU *(O. tshawytscha)*	Threatened; April 22, 1992 (57 FR 14653)	December 28, 1993 (58 FR 68543)
Snake River Sockeye Salmon ESU (*O. nerka)*	Endangered; November 20, 1991 (56 FR 58619)	December 28, 1993 (58 FR 68543)
Snake River Basin Steelhead DPS (*O. mykiss*)	Threatened; August 18, 1997 (62 FR 43937)	September 2, 2005 (70 FR 52630)
Upper Columbia River Spring Chinook Salmon ESU (*O. tshawytscha)*	Endangered; March 24, 1999 (64 FR 14308)	September 2, 2005 (70 FR 52630)
Lower Columbia River Chinook Salmon ESU (*O. tshawytscha)*	Threatened; March 24, 1999 (64 FR 14308)	September 2, 2005 (70 FR 52630)
Upper Willamette River Chinook Salmon ESU (*O. tshawytscha)*	Threatened; March 24, 1999 (64 FR 14308)	September 2, 2005 (70 FR 52630)
Upper Columbia River Steelhead DPS (*O. mykiss)*	Endangered; June 13, 2007 (Court decision)	September 2, 2005 (70 FR 52630)
Middle Columbia River Steelhead DPS (*O. mykiss*)	Threatened; March 25, 1999 (64 FR 14517)	September 2, 2005 (70 FR 52630)
Lower Columbia River Steelhead DPS *(O. mykiss)*	Threatened; March 19, 1998 (63 FR 13347)	September 2, 2005 (70 FR 52630)
Upper Willamette River Steelhead DPS (*O. mykiss)*	Threatened; March 25, 1999 (64 FR 14517)	September 2, 2005 (70 FR 52630)
Columbia River Chum Salmon ESU (*O. keta)*	Threatened; March 25, 1999 (64 FR 14508)	September 2, 2005 (70 FR 52630)
Lower Columbia River Coho Salmon ESU (*O. kisutch*)	Threatened; June 28, 2005 (70 FR 37160)	Under Development

Source: http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Steelhead/Index.cfm May 18, 2007

Critical habitat was designated for Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, and Snake River sockeye salmon in December 1993 (58 FR 68543) and revised for Snake River spring/summer Chinook salmon in October 1999 (64 FR 57399) (see Table 4-1). Critical habitat was redesignated for Snake River basin steelhead and all other listed upper Columbia River, middle Columbia River, lower Columbia River (except coho salmon), and Willamette River anadromous salmonid ESUs and DPSs in September 2005 (70 FR 52630). Previous to this, critical habitat designations for these ESUs and DPSs were vacated on

April 30, 2002, when the U.S. District Court for the District of Columbia adopted a consent decree resolving the claims in *National Association of Homebuilders, et al. v Evans.* Designation of critical habitat for the Lower Columbia River coho salmon ESU is currently under development by NMFS (see Table 4-1).

Critical habitat for 12 of the ESA-listed Snake and Columbia River salmon ESUs and steelhead DPSs consists of four components: spawning and juvenile rearing areas, juvenile migration corridors, areas for growth and development to adulthood, and adult migration corridors (58 FR 68543, 70 FR 52630). The ESU and DPS discussions later in this chapter address the three freshwater (spawning, rearing, and migration) habitat components. Areas for growth and development to adulthood are not addressed because Pacific Ocean areas used by listed salmon and steelhead for growth and development to adulthood have not been identified.

Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) assesses the combined flow effects from the upper Snake River projects and the FCRPS projects on designated critical habitat for 12 of the listed salmon ESUs and steelhead DPSs (USACE et al. 2007b). The *Comprehensive Analysis* describes major factors limiting the conservation value of designated critical habitat for each species and the features and PCEs that are essential to the conservation and support one or more life stages of an ESU or DPS.

4.2.2 Current Hydrologic Conditions

As discussed in *Section 3.1, Historical and Current Hydrologic Conditions*, the construction and subsequent operations of Reclamation project facilities have contributed to hydrologic changes and present hydrologic conditions in the Snake and Columbia Rivers. Reclamation's upper Snake operations generally decrease flows into Brownlee Reservoir and downstream in the months of November through June and increase flows from July through September in dry and average water year types (see Table 3-1). In wet water year types, Reclamation's project operations generally increase inflows to Brownlee Reservoir and downstream during the January through March period for flood control operations and in the summer and fall months of August through October. Modeled data for the Snake River upstream of Brownlee Reservoir for water years 1928 through 2000 showed that the annual average depletive effect of Reclamation's upper Snake operations is about 2.3 million acre-feet (see Table 3-3, Without Reclamation model run). For comparison, the average annual flow from 1996 through 2006 was approximately 14 million acre-feet into Brownlee Reservoir and approximately 36 million acre-feet below Lower Granite Dam. This depletive effect represents less than 2 percent of the average annual flow of approximately 128 million acre-feet in the Columbia River at McNary Dam.

Modeled data for the Snake River basin also demonstrate that all upstream development, including Reclamation's upper Snake projects and other private projects, combined have depleted inflows into Brownlee Reservoir by about 6.0 million acre-feet (see Table 3-3, Naturalized Flow model run). This average annual depletion represents a 30 percent decrease of inflows to Brownlee Reservoir or less than 5 percent of the total Columbia River flow at McNary Dam. These findings represent the cumulative reductions in Snake River flows resulting from all irrigation (the Federal upper Snake projects and private development) above Brownlee Reservoir. *Section 3.1, Historical and Current Hydrologic Conditions,* provides further discussion of current hydrologic conditions in the Snake and Columbia Rivers. Figure 3-1 illustrates the magnitude of flow at various locations on the Columbia River compared to inflows from the upper Snake River at Brownlee Reservoir.

4.2.3 Current Water Quality Conditions in the Action Area

Reclamation's 2004 Upper Snake BA provides summary discussions of water quality conditions in the action area for water temperature, sediment, nutrients, total dissolved gas, and mercury, as well as dissolved oxygen levels in the Snake River downstream of Hells Canyon Dam (2004 Upper Snake BA, pages 248 through 252). Plans for achieving State water quality standards in water quality-limited stream reaches within the action area have been formulated through the Total Maximum Daily Load (TMDL) process specified under Section 303(d) of the Clean Water Act (CWA). Table 9-3 in Reclamation's 2004 Upper Snake BA provides the Section 303(d) listings and TMDL schedule, at the time, for achieving State water quality standards in the upper Snake River basin reaches and major tributaries within areas affected by Reclamation project operations. Because the states have not adhered to the schedule for a variety of reasons, the following text provides recent information on TMDLs and related activities and on water temperature monitoring in the upper Snake River basin since publication of the 2004 Upper Snake BA.

4.2.3.1 Total Maximum Daily Load Plans

Upper Snake River Basin TMDLs (Above Brownlee Reservoir)

Within the upper Snake River basin, Reclamation has participated, is currently participating, or plans to participate in the development and implementation of at least 15 separate TMDLs. In instances where TMDLs are currently in place, Reclamation has not received a load or wasteload allocation. Even so, Reclamation continues to participate in the development and, where applicable, implementation of TMDL water quality management plans in most waters affected by Reclamation projects.

While no explicit pollutant reduction requirements are assigned to Reclamation in any of the upper Snake River basin TMDLs, Reclamation has consistently provided technical and financial assistance to the States of Idaho and Oregon to help ensure that the water quality aspect of river and reservoir operations is fully understood. Data collected as part of Reclamation's Idaho and Oregon Investigation Programs (partners with states and local water users to identify solutions to water and related natural resource problems), regional reservoir monitoring effort, and river and reservoir monitoring for project operations have been consistently used by the states during TMDL development and implementation. These data provide valuable information that the states may not have been able to collect on their own. The monitoring activities associated with implementation of TMDLs described here are part of the O&M associated with the continued operations of Reclamation's projects, and therefore, are incorporated into Reclamation's proposed actions in this consultation.

Reclamation's Snake River Area Office and Pacific Northwest Region staffs also participate in watershed advisory group and watershed council meetings throughout the upper Snake River basin. These watershed advisory groups and councils are established to ensure that the Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ) develop and implement TMDLs and other water quality-enhancing activities with the best available knowledge by drawing on the resources of all stakeholders. Through Reclamation's participation in these meetings, financial assistance has been provided to numerous irrigation system operators and other appropriate entities throughout the upper Snake River basin. Reclamation typically provides analytical laboratory services for water quality samples through its Pacific Northwest Region laboratory.

The following paragraphs summarize the notable subbasin activities performed by Reclamation as they relate to TMDL development and implementation in the upper Snake River basin. Additional measures outside the TMDL arena taken by Reclamation for purposes of enhancing water quality also are discussed.

American Falls Reservoir

The American Falls Reservoir TMDL was submitted to the U.S. Environmental Protection Agency (EPA) in September, 2006, but has not yet been approved. Through its participation with the American Falls Watershed Advisory Group, Reclamation provides financial assistance for laboratory services to IDEQ for the characterization of water quality in the reservoir and Snake River directly upstream of the reservoir. These data were used to help create a water quality model for TMDL development. Once the TMDL is approved, the data will be used for TMDL implementation tracking purposes.

Reclamation also provides financial assistance for laboratory services to the Aberdeen-Springfield Irrigation District. This assistance allows the district to monitor water quality within their system for consistency with the TMDL.

Reclamation has strategically placed 15 miles of rock and other non-erodable material along the banks of American Falls Reservoir to help prevent shoreline erosion. Another 18 miles of shoreline is scheduled for erosion control work in the future. In addition, the reservoir is operated to avoid falling below a pool of 100,000 acre-feet.

In 2006, Reclamation initiated an environmental assessment (USBR 2007) for the implementation of a bank stabilization project for approximately 3,800 feet of streambank located in the Fort Hall Bottoms above American Falls Reservoir. The project would provide protection for a culturally significant landmark site while eliminating current and future, localized streambank erosion in the river channel through streambank modification and diversion of river flow.

Lake Walcott

The Lake Walcott TMDL was approved by EPA in June 2000. Through its participation with the Lake Walcott Watershed Advisory Group, Reclamation provides financial assistance for laboratory services to the Burley Irrigation District. This assistance allows the district to monitor water quality within their system for consistency with the TMDL.

To help improve fisheries and water quality from American Falls Dam to Eagle Rock, Reclamation attempts to maintain a minimum river flow of 300 cfs. In addition, Idaho Power Company, which has power generation capability at American Falls Dam, provides artificial aeration of the discharge water when dissolved oxygen levels fall below the State water quality standard of 6.0 milligrams per liter (mg/L).

Snake River from Lake Walcott to King Hill

The Upper Snake River/Rock Creek and Middle Snake River TMDLs were approved by EPA in August 2000 and April 1997, respectively. Through participation with the Upper Snake/Rock Creek Watershed Advisory Group, Reclamation provides financial assistance for laboratory services to the University of Idaho and IDEQ. Reclamation provides the University with water quality sample analysis as it relates to drain water trend analysis in the Twin Falls area. Reclamation also provides financial assistance for laboratory services to IDEQ for TMDL implementation monitoring of the Upper Snake/Rock Creek TMDL.

South Fork Boise River

IDEQ anticipates completing a TMDL for the South Fork Boise River by December 2007. Reclamation will participate in the watershed advisory group to ensure that TMDL development integrates the known operational flexibilities at Anderson Ranch Dam.

Lower Boise River/Lake Lowell

The lower Boise River sediment and bacteria TMDLs were approved by EPA in January 2000. A nutrient TMDL is scheduled to be complete by the end of 2007. Reclamation provides financial assistance for laboratory services to IDEQ, Boise City, and the USGS for TMDL development and implementation monitoring. Reclamation also regularly participates in watershed advisory group meetings.

North Fork Payette River including Cascade Reservoir

The Cascade Reservoir TMDL, which was developed in two phases, was approved by EPA in 1996 and 1999. Reclamation participated in the watershed advisory group and continues to provide financial assistance for laboratory services to IDEQ for TMDL implementation monitoring.

Idaho Power Company has a water right for power generation at Lake Cascade that is senior to Reclamation's storage water right; this results in a release of 200 cfs during the winter in most years. Reclamation has established a conservation pool of 294,000 acre-feet by administrative decision at Lake Cascade. Water is typically released early from Deadwood Reservoir while maintaining the Lake Cascade elevation at a higher level to enhance water quality and fisheries resources.

At Black Canyon Park on Black Canyon Reservoir, Reclamation installed riprap to protect the shoreline from erosion.

Lower Payette River

The Lower Payette River TMDL was approved by EPA in May 2000. Reclamation participates in the watershed advisory group and continues to provide financial assistance for laboratory services to IDEQ for TMDL implementation monitoring.

Owyhee River

ODEQ anticipates completing TMDLs for the Owyhee River basin in 2009. In the meantime, Reclamation provides financial assistance for laboratory services to the Malheur County Soil and Water Conservation District for pre-TMDL development monitoring.

Malheur River

ODEQ anticipates completing TMDLs for the Malheur River basin in 2007. Reclamation is cooperating with ODEQ on temperature monitoring activities related to TMDL development. Reclamation also regularly participates in the Malheur Watershed Council meetings.

Powder River

ODEQ anticipates completing TMDLs for the Powder River basin in 2008. Reclamation will cooperate with ODEQ on water quality monitoring in the basin and participate in public outreach meetings.

Columbia and Snake River TMDLs (Brownlee Reservoir and Downstream)

Water quality downstream from Hells Canyon Dam is especially relevant to the listed salmon and steelhead in identifying current water quality conditions where these species exist. The following summarizes the status of TMDLs completed or in process for the Snake and Columbia River reaches downstream of the Hells Canyon Complex and current water quality conditions in these reaches

Snake River - Hells Canyon to Salmon River Confluence

IDEQ and ODEQ jointly developed the TMDL for the Snake River from the Idaho-Oregon border to the confluence with the Salmon River (Snake River – Hells Canyon TMDL, IDEQ and ODEQ 2003) which describes current water quality concerns for this reach. Primary water quality problems identified in the Snake River between the Idaho-Oregon border and the confluence with the Salmon River include water temperature, sediment, nutrients, total dissolved gas, and mercury (IDEQ and ODEQ 2003). The Snake River – Hells Canyon TMDL noted that natural heat exchange through elevated air temperature and direct solar radiation on the water surface plays a major role in summer water temperatures (IDEQ and ODEQ 2003). However, to address elevated temperatures occurring during salmonid spawning periods below Hells Canyon Dam, a load allocation in the form of a required temperature change at Hells Canyon Dam was identified such that the temperature of water released from Hells Canyon Dam is less than or equal to the water temperature at RM 345, or the weekly maximum temperature target of 13°C for salmonid spawning. Further, the TMDL allows for not more than an additional 0.14°C above the 13°C. (IDEQ and ODEQ 2003).

The sources of nutrient loading to Brownlee Reservoir were identified in the Snake River-Hells Canyon TMDL (IDEQ and ODEQ 2003). Of the non-point source tributaries identified, many are partially within Reclamation's project areas. While the allocations do not explicitly identify the sources, it is likely that some proportion of the total load is attributable to irrigated agriculture. The non-point source tributaries included in the Snake River-Hells Canyon TMDL are the Snake River inflow (1,912 kg/day), Owyhee River (265 kg/day), Boise River (1,114 kg/day), Malheur River (461 kg/day), Payette River (710 kg/day), Weiser River (392 kg/day), Burnt River (52 kg/day), Power River (126 kg/day), and several smaller drains (660 kg/day, cumulatively).

Snake River – Salmon River Confluence to Columbia River

According to the State of Idaho, Oregon, and Washington integrated §305(b)/§303(d) reports, the water quality concerns in the Snake River between the Salmon River confluence and the Columbia River include mercury and temperature. However, as of July 2007, the Washington Department of Ecology (WDOE) has not completed a TMDL for the Snake River below the Clearwater River confluence, nor has IDEQ or ODEQ initiated a TMDL for the Snake River from the Salmon River confluence to the Clearwater River. In 2001, WDOE, EPA, and other state and Federal stakeholders (including Reclamation) initiated development of the Columbia/lower Snake River temperature TMDL. However, the TMDL became stalled and was not completed. Recent (July 2007) discussions among EPA, USACE, Reclamation, and the States of Idaho, Oregon, and Washington suggested that the TMDL may be reinitiated by the end of 2007.

Columbia River – Snake River Confluence to Mouth

As noted above, in 2001, the EPA Region 10 and multiple stakeholders on the Columbia River below the Snake River confluence (including Reclamation) initiated development of the Columbia/lower Snake River temperature TMDL, which was not completed. However, an assessment of current water temperature conditions completed as part of the problem assessment showed that water temperature in the Columbia River frequently exceeds the state and Tribal water quality standards during the summer months. The TMDL may be reinitiated by the end of 2007.

4.2.3.2 Upper Snake River Basin Water Temperature Monitoring

Reclamation has developed and is implementing a basin-wide temperature monitoring study for the upper Snake River basin (above Hells Canyon Dam). Data collection for a comprehensive water temperature database was initiated in 2004 to support efforts to describe and evaluate water temperature characteristics of the upper Snake River and its major tributaries. This study has provided a continuous water temperature record at points upstream and downstream of major Reclamation storage reservoirs and at inriver locations among irrigated lands in the upper Snake River. This study is anticipated to continue through 2007 with the project culminating in 2008, although additional funding to continue the study into 2014 is being sought.

Reclamation currently has 52 water temperature monitoring sites throughout the upper Snake River basin. To supplement this, the USGS installed water temperature sensors at 10 of their active gaging stations. In addition, Reclamation installed real-time temperature sensors at 19 existing Hydromet stations and placed manual temperature sensors at 12 other locations.

Water temperature data in Figures 4-1 and 4-2 are displayed from upstream to downstream and discussed in the following text. The data are provisional and have not yet been reviewed for quality assurance or control. Furthermore, these data have not been analyzed for compliance with State standards. Also, several stations have a limited data set and collection through the end of this study period will be valuable. However, even with these limitations, general comparisons and observations discussed below illustrate water temperature differences in the Snake River.

Many factors interact to influence water temperature and contribute to temperature dynamics within the Snake River and its tributaries. Examples of influencing factors include irrigation withdrawals and return flows, dams and reservoirs, groundwater and spring discharges, seasonal changes in air temperature, degree of solar exposure, and elevation in the watershed of various river and tributary reaches. Figures 4-1 and 4-2 depict temporal and spatial variations of average monthly water temperatures in the Snake River beginning above Jackson Lake and extending downstream to directly below Hells Canyon Dam during 2005 and 2006, respectively. From the headwaters of the Snake River to below Hells Canyon Dam, a general warming trend occurs as water progresses downstream. The springs near the Snake River at King Hill generally tend to temper the range of monthly water temperatures at this location by producing a cooling effect during summer and a warming effect during winter. By the time Snake River water reaches Weiser and below Hells Canyon Dam over the course of the year, it is warmer than when it started in the headwaters (see Figures 4-1 and 4-2). These data will be analyzed further at the end of the monitoring study to better characterize the longitudinal temperature regime in the Snake River. If possible, relationships among water temperature and storage, irrigation, and hydropower facilities within the upper Snake basin will be identified. However a future predictive modeling effort is not anticipated at this time.

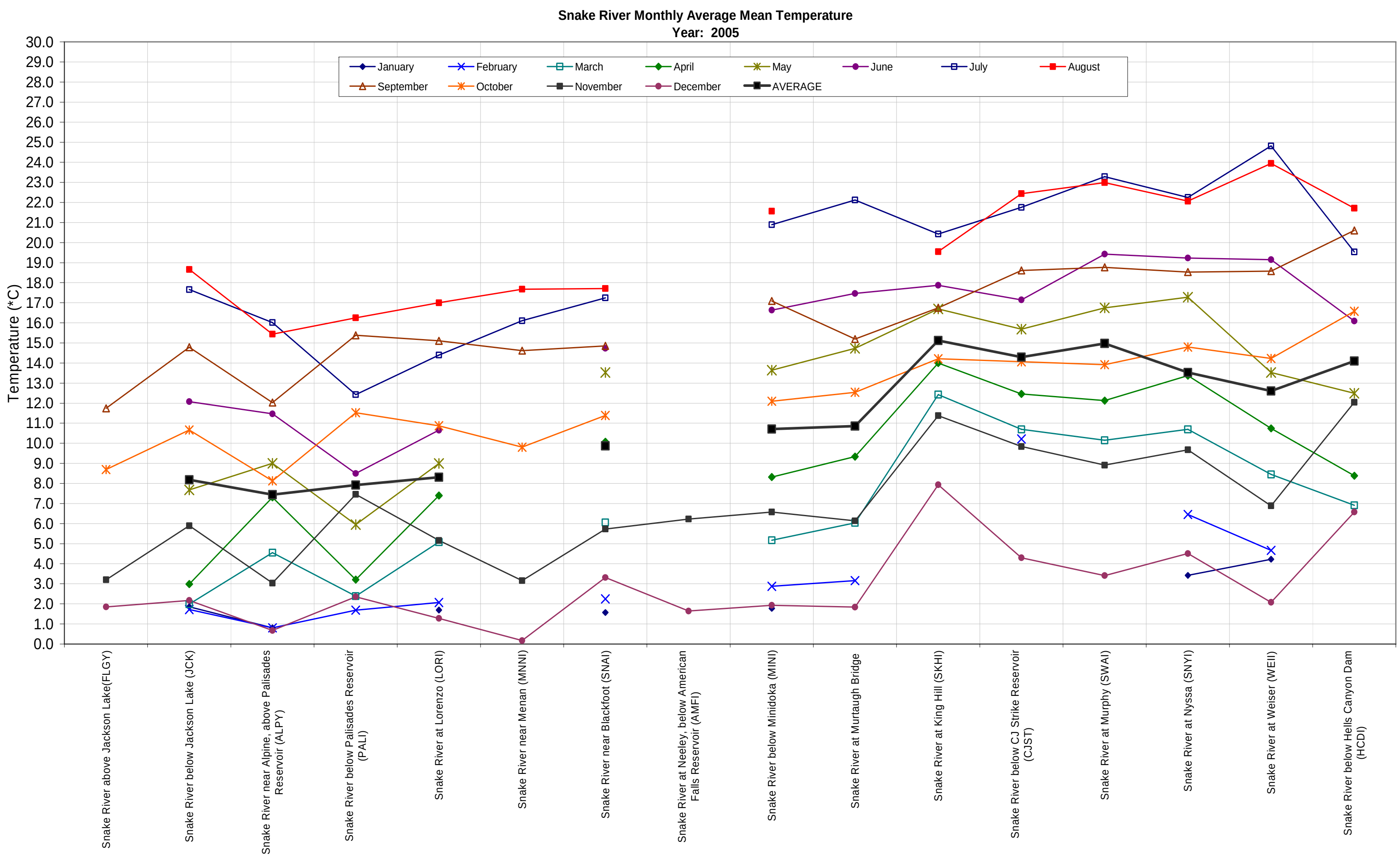

Figure 4-1. Average monthly water temperature at locations along the Snake River - 2005.

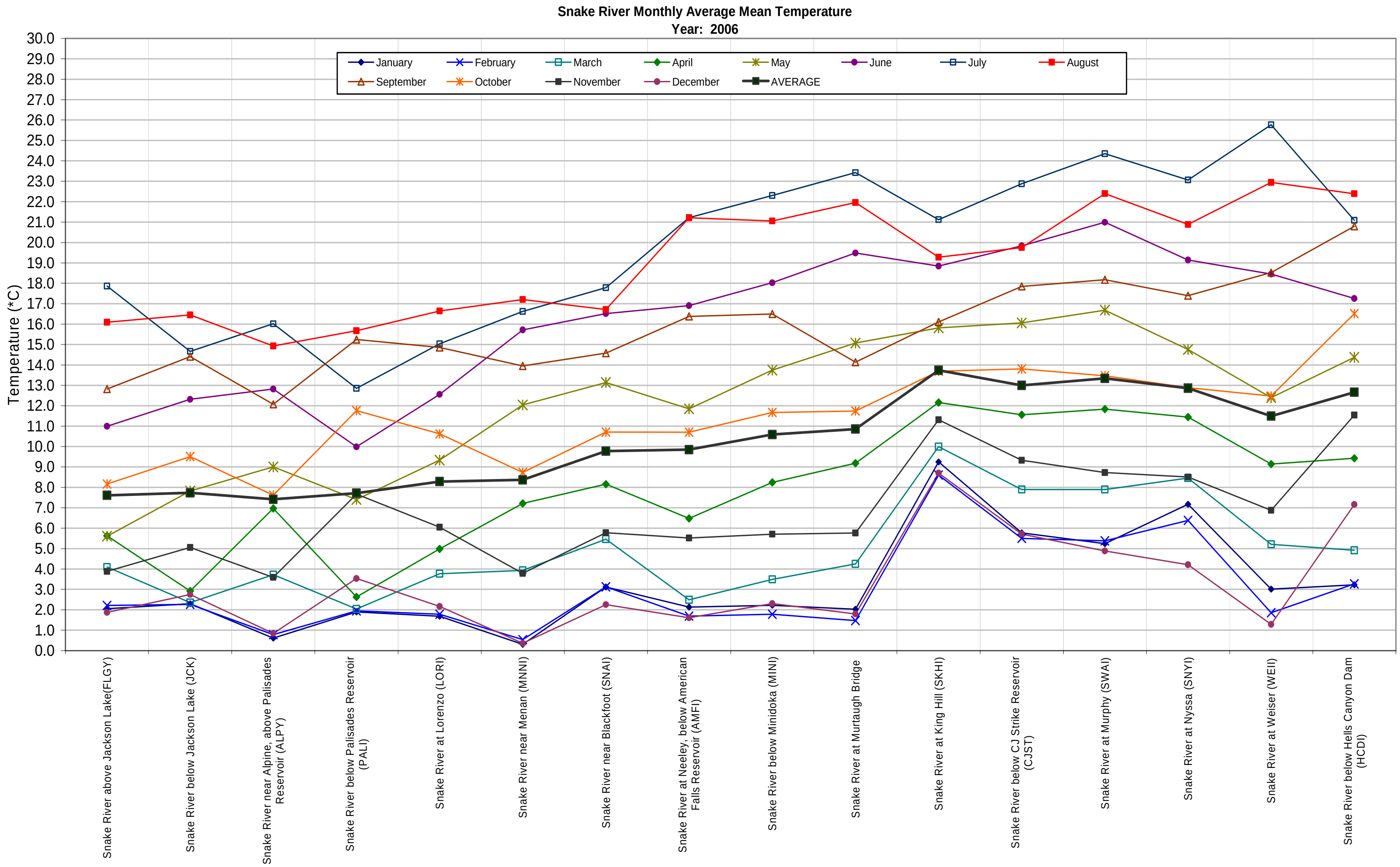

Figure 4-2. Average monthly water temperature at locations along the Snake River - 2006.

4.3 Effects Analysis

This section describes the effects of Reclamation's 12 proposed actions in the upper Snake River basin on ESA-listed salmon ESUs and steelhead DPSs and their designated critical habitat in the action area downstream from Hells Canyon Dam. The area of analysis for each ESU and DPS includes those river reaches and reservoirs where the ESUs or DPSs occupied geographic area overlaps the action area of Reclamation's proposed actions. The effects discussion considers the combined hydrologic effects of all 12 of Reclamation's proposed actions as well as cumulative effects associated with private diversions in the upper Snake. The continued future effects associated with operations and flow augmentation components of the proposed actions are discussed separately in some cases.

The ability to ascertain or determine effects of Reclamation's proposed actions on listed ESUs and DPSs is complicated by numerous factors, especially those effects on water quality and streamflow in the lower Snake River associated with the presence and operation of Idaho Power's Hells Canyon Complex located between Reclamation's projects and the occurrence of listed ESUs and DPSs. Upper Snake projects are located above areas where listed salmon and steelhead spawn, rear, and migrate. The upper Snake proposed actions do not directly affect fish passage, predation, or harvest and hatchery activities, but do affect the timing and quality of river flows into Brownlee Reservoir. Because the 13 ESA-listed ESUs and DPSs enter or use the action area at various locations downstream from Hells Canyon Dam, it is reasonable to expect that any measurable or tangible effect from Reclamation's proposed actions would be most pronounced in the Snake River just downstream from Hells Canyon Dam and diminish with distance downstream where tributary inflow and an array of other environmental and anthropogenic factors have greater influence.

The listed salmonid ESUs and DPSs in closest proximity to Reclamation facilities in the action area include predominantly Snake River fall Chinook salmon, and to a lesser extent, a few populations of Snake River spring/summer Chinook salmon and Snake River Basin steelhead. Most populations of Snake River spring/summer Chinook salmon and Snake River steelhead that use the Snake River as a migration corridor exit the action area and juvenile enter at the Salmon River, 58.8 miles downstream from Hells Canyon Dam. From the mouth of the Salmon River downstream, increasing numbers of Snake River spring/summer Chinook salmon and Snake River steelhead use the action area, as do Snake River sockeye salmon that turn off into the Salmon River. Downstream from the mouth of the Salmon River, effects of flow and water quality stemming from Reclamation's proposed actions are attenuated by the flow of the Salmon River and other tributaries, which seasonally contribute substantial inflows.

The analysis that follows describes potential adverse effects attributed to Reclamation's upper Snake operations through the year 2034 (the thirtieth year of the Snake River Flow component described in the Nez Perce Water Rights Settlement). As in any biological analysis, assumptions are made to define the analysis boundaries such as future hydrologic conditions in the Snake and Columbia River basins, future FCRPS operations, and future ocean and climate conditions. Defining some of these assumptions can be challenging. For example, the term of the FCRPS proposed RPA is 10 years, extending to the year 2017. The *Comprehensive Analysis* (USACE et al. 2007b) which evaluates the combined effects of the upper Snake and FCRPS actions extends to 2017. However, Reclamation is obliged to analyze the period up to and after 2017 through 2034 because its proposed actions extend through 2034 in accordance with the Nez Perce Water Rights Settlement. In doing so it is necessary to make certain assumptions about conditions as they might exist after 2017. Reclamation's analysis in this BA used a 73-year period of modeled hydrologic data (1928 to 2000) to evaluate flow effects for the 28 year duration of its proposed actions (2007 through 2034) as contemplated by the Nez Perce Water Rights Settlement. This analysis assumed that the range of upper Snake River hydrologic conditions for the 1928 to 2000 period are representative of the range of hydrologic conditions that will occur over the next 28 years and that FCRPS operations remain essentially constant after 2017. Reclamation has conducted a qualitative analysis of the adverse effects associated with its actions through 2034. The uncertainties and challenges associated with these assumptions underscore the need for regularly scheduled reviews to ascertain whether conditions require reinitiation of consultation. In this regard Reclamation proposes to review conditions in 2017 and 2027 for the expressed purpose of determining whether reinitiation of consultation is necessary.

4.3.1 Streamflows and Fish Survival

The potential effects of Reclamation's 12 proposed actions on anadromous fish are associated directly or indirectly with the hydrologic changes in the lower Snake and Columbia Rivers attributable to the proposed actions. The following text provides a brief overview of the current science pertaining to the relationship between flow (or other covariates) and survival of juvenile anadromous fish migrating downstream in the lower Snake and Columbia Rivers.

First, it is important to put into context the hydrologic changes resulting from the upper Snake proposed actions compared to flows downstream in the lower Snake and Columbia River migratory corridors where flows and FCRPS dam operations have the most controlling influence on fish. Reclamation's upper Snake River proposed actions directly affect inflows to Brownlee Reservoir, which indirectly affect outflows from Brownlee Reservoir, and ultimately from Hells Canyon Dam. On an annual average volume basis, Reclamation's proposed actions result in depletions of approximately 2.3 million acre-feet of water or 6.0 percent of lower Snake River flow as measured at Lower Granite Dam. By comparison the annual average runoff is 36 million acre-feet at Lower Granite Dam, 128 million acre-feet at McNary Dam, and 198 million acre-feet at the Columbia River mouth. These comparisons indicate that Reclamation's upper Snake River operations have a downstream diminishing impact on flows in the lower Snake and Columbia Rivers.

Flow augmentation and flow objectives have been central components of the Columbia River salmon management program since the early 1980s. The basis for this program was the hypothesis that more flow produced higher smolt survival as they migrated downstream. The hypothesis was based originally on the finding of Sims and Ossiander (1981), who described a positive relationship between river flow and the survival of yearling Chinook salmon and steelhead smolts migrating in the lower Snake and Columbia Rivers. The relationship they described was based on estimates for 7 years in the 1970s, of which 2 were dry years. As more scientific information became available in the late 1980s and early 1990s, several investigators began to identify the limitations associated with the Sims and Ossiander flow-survival relationship. Williams and Mathews (1995), while acknowledging the potential for a flow-survival relationship, noted that the 1970s data reflected conditions that no longer exist in the contemporary hydro system. Steward (1994) conducted a thorough review and re-analysis of the Sims and Ossiander data and also recommended that the flow-survival relationship not be generalized to existing fish populations and passage conditions. Steward (1994) identified a number of data collection and measurement errors in the previous study and noted that much better data are available, collected under more current conditions, and using better technology and analytical techniques.

Studies conducted since the early 1990s use advanced scientific tools (passive integrated transponder [PIT] tags) and have better defined the relationship between fish survival and flow. Considerable research has been focused on Snake River salmon and steelhead. Current thinking is that the flow-survival relationship is manifested through other variables associated with flow such as water temperature, water velocity, turbidity, and predation response (Williams et al. 2005, ISAB 2004, Anderson et al. 2000). In addition, operations affecting fish passage and survival at the FCRPS dams, such as fish passage through spillways, spill weirs, sluiceways, turbines, fish screening, and bypass systems, as well as efficiency of fish collection and transport systems are related in one way or another to flow (Ferguson et al. 2005). The influence of flow on these variables, and subsequently on fish survival, also can differ by species and within different portions of the migration period. Basically, the flow-survival relationship is complicated by numerous physical and biological factors, and the simple hypothesis that more flow is always better is no longer valid (Anderson et al. 2000). This conclusion is perhaps best summed up by the Independent Scientific Advisory Board (ISAB 2004), which stated: "The prevailing flow-augmentation paradigm, which asserts that inriver smolt survival will be proportionally enhanced by any amount of added water, is no longer supportable. It does not agree with information now available."

The summary presented in the previous text does not necessarily imply that flow augmentation cannot be a useful tool to increase smolt survival under certain circumstances. It simply means that many variables and uncertainties are at play, and those must be taken into account in any meaningful flow management decisions.

Despite the uncertainties and complexities involved in the flow-survival relationship, a positive relationship appears to exist between flow and survival in years when river flows are lowest, defining the drier and drought years. For Snake River flows measured at Lower Granite Dam, Smith et al. (2003) and Williams et al. (2002) present data suggesting a positive relationship between flow and survival for Chinook salmon smolts when flows are less than a threshold of approximately 70,000 cfs. For steelhead smolts, a similar flow threshold of between 85,000 cfs and 110,000 cfs has been suggested (Plumb et al. 2006, Williams et al. 2002). For flows greater than these thresholds, additional survival benefits have not been detected. More recently, Vadas and Beecher (2007) analyzed the available survival-flow data for Snake River spring/summer Chinook salmon using quadratic and polynomial regression models. Their results suggest a more typical "humped" relationship whereby survival increases with flow, most notably under low-flow conditions, and then declines at higher flows. The ambiguity in the flow-survival relationship at higher flows may be due to other factors associated with high flows, such as elevated total dissolved gas (TDG) concentrations or poorer performance of fish passage and protection systems at the dams. Research on the relationships of river environmental variables to fish survival is continuing, and the results will inform future management decisions.

The actual causal component(s) of flow that relates to survival in low-flow years is not fully known. The most commonly referenced causal factors include water temperature (affecting predation rates, metabolic cost, and residualization), turbidity (affecting predation rates), and water velocity (affecting smolt travel time). Anderson et al. (2003) provide analysis indicating that water temperature, not flow, best fits the flow-survival relationship. As noted by the ISAB (2001), it may not matter in the larger view what the causal factor(s) is as long as the result (of higher flows) is higher survival. However, this approach is valid only if consistent correlations exist among flow, temperature, turbidity, and water velocity in all years. This is often not true for the upper Snake River.

Inflows to Brownlee Reservoir, which are most directly affected by Reclamation's upper Snake River projects and private diversions upstream, pass through the three large reservoirs of Idaho Power Company's Hells Canyon Complex. These reservoirs have an overriding effect on water temperature and turbidity discharged from Hells Canyon Dam. By the time this water reaches Lower Granite Dam, inflows from the Salmon, Imnaha, Grand Ronde, and Clearwater Rivers largely influence the water temperature and turbidity in the lower Snake River, and these conditions vary from year to year. Water temperatures of these tributaries tend to be considerably colder than the discharges from Hells Canyon Dam during much of the year, and the Clearwater River especially is colder in the spring and summer. Thus, higher discharges from Hells Canyon Dam tend to warm (via dilution of cool tributary water) rather than cool the lower Snake River. These circumstances in the Snake River point out that managing flow augmentation from the upper Snake must consider other environmental variables, especially temperature, to benefit fish.

In addition, fish passage routes through the FCRPS dams in the lower Snake and Columbia Rivers affects fish survival metrics (Ferguson et al. 2005). As river flows increase, the proportion of water that is spilled also increases. Spillway fish passage is generally the safest route around the dams. Also, higher spill volumes have been shown to reduce migratory delays in the dam forebays. The USACE is installing removable spillway weirs (RSW) at the lower Snake River dams that are expected to make spill more effective and perhaps even safer for downstream migrants.

Streamflow volumes influence the proportion of smolts that are collected and transported to below Bonneville Dam. At lower flows a greater proportion of the smolt migration is collected and transported. The FCRPS BA provides additional information about smolt transportation. (see USACE et al. 2007a, Appendix B, Section B.2 – Operations to Benefit Fish)

Studies evaluating the transportation program indicate that when considering the effects of juvenile fish transportation (by using smolt-to-adult survival), transportation provided little or no benefit on a seasonal average basis for wild yearling Chinook salmon transported in all but very low flow years (FPC 2006). In the dry year of 2001, the transported wild Chinook salmon smolts survived approximately nine-fold greater than inriver migrants (FPC 2006). Recent analysis of several years of PIT tag data reveals considerable differences in survival between years and within years for both transported and inriver Chinook salmon migrants (ISAB 2007). In particular, it was found that transportation of stream-type Chinook salmon smolts was most beneficial for the migrants arriving later in the season at Lower Granite Dam (Muir et al. 2006). This information, as well as future information, will be used to adaptively develop strategies for improving the effectiveness of juvenile transportation. For steelhead smolts, which generally migrate at the same time as yearling Chinook salmon, transportation throughout the migration season has been shown to provide a significant survival benefit compared to inriver migrants (FPC 2006).

In summary, determining the effects of water withdrawals and flow augmentation on Snake and Columbia River anadromous fish, given the existence of dams and reservoirs that now define the system, is not simply related to the volume and timing of water storage and release from upstream reservoirs. Also critically important is how water is routed through the reservoirs and facilities at mainstem dams.

Reclamation's upper Snake flow augmentation is protected from all diversion to the Idaho/Oregon state line (Brownlee Reservoir). From that point and downstream, river flows are a function of FCRPS operations and the exercise of in-priority diversion rights. This complicates any analysis attempting to isolate the effects of Reclamation's upper Snake projects on downstream anadromous fish survival. It is the purpose of the *Comprehensive Analysis* (USACE et al. 2007b) to consolidate the flow effects of Reclamation's upper Snake River projects and the FCRPS actions in order to make meaningful determinations of potential effects and jeopardy for the 13 ESA-listed salmonid ESUs and DPSs in the action area. Appendix B of the *Comprehensive Analysis* contains modeled COMPASS results that comprise the quantitative analysis of these combined flows effects.

4.3.2 Effects on Water Quality

Reclamation's proposed actions will continue to affect to some degree the quality, quantity, and timing of water flowing in the Snake and Columbia Rivers. The proposed actions may have continuing effects on water quality in the mainstem Snake River and its major tributaries above Brownlee Reservoir, including the Boise, Payette, Weiser, Owyhee, Malheur, Burnt, and Powder Rivers—although the effects are difficult to quantify because of the lack of sufficient data. Primary effects are most likely related to shifts in suspended sediment and nutrient transport dynamics, as well as changes in the thermal regimes of the riverine and reservoir environments (USBR 2001). Because of limited data, it is also difficult to determine the extent to which Reclamation's future O&M actions in the upper Snake River basin will contribute to water quality conditions in the Snake River downstream from the Hells Canyon Complex. The extent to which water temperature below Hells Canyon Dam is affected by the action may be a function of the water year in the basin (for example, high or low water year type). This is because in high water years, Hells Canyon Dam typically releases stored cold water in the spring as part of flood control. In these years, the proposed actions may be less beneficial from a temperature standpoint. However, in low flow years, Hells Canyon Dam typically stores more water and would not release as much stored cold water in the spring. In these years, the proposed actions may be more beneficial from a temperature standpoint because more cold water would be released. Reclamation facilities are located a substantial distance upstream from the Hells Canyon Complex, and reaches of both free-flowing river and impoundments occur between these facilities and the area of analysis for the 13 ESUs and DPSs.

Section 4.2.3.1, Total Maximum Daily Load Plans, summarized notable subbasin activities performed by Reclamation as they relate to TMDL development and implementation in the action area and efforts to contribute to improved water quality. Additional measures outside the TMDL arena taken by Reclamation to enhance water quality also were discussed. Reclamation will continue to participate in TMDL development and implementation as described earlier. However, no explicit pollutant reduction requirements have been assigned to Reclamation in those instances where upper Snake River basin TMDLs are in place. Reclamation has consistently provided technical and financial assistance to the States of Idaho and Oregon to help ensure that the water quality aspect of river and reservoir operations is fully understood.

With respect to below the Hells Canyon Complex, no TMDLs are in place for the Snake River. A temperature TMDL is being contemplated by the EPA Region 10, with its development tentatively scheduled to be initiated by the end of 2007.

The IDEQ has developed numerous TMDL water quality management plans in the upper Snake River basin. TMDLs with geographic boundaries falling in Reclamation project areas on the Snake River proper include American Falls Reservoir, Lake Walcott, and the Snake River below Lake Walcott. TMDLs that affect major tributaries to the Snake River and are in Reclamation project areas include the Upper and Lower Boise River (including Arrowrock Reservoir) and the North Fork Payette River (including Cascade Reservoir). These TMDLs have been developed for a variety of pollutants, including bacteria, nutrients, sediment, and temperature. While these TMDLs are in Reclamation project areas and include Reclamation project works, Reclamation has received no load or wasteload allocations. This indicates that the State regulatory agency responsible for protecting water quality has not identified Reclamation as a designated management agency, and thus, not directly responsible for degraded water quality in the upper Snake River project areas.

4.3.2.1 Water Temperature

Above Brownlee Reservoir, water temperatures in the Snake River exhibit trends that are generally expected in arid Northwest river systems, with a warming trend of the Snake River from its headwaters at Jackson Hole downstream to above Brownlee Reservoir. Maximum water temperatures are typically near 18°C in the headwaters at Jackson Hole, Wyoming. The river then warms in the downstream direction, where it typically reaches a summer maximum of around 23°C near Weiser, Idaho (see Figures 4-1 and 4-2)

In most unregulated river systems, lower flows typically equate to warmer water temperatures in the spring and summer. In the regulated lower Snake River below the Hells Canyon Complex, however, this is often not the case. Flows and temperature below Lewiston, Idaho (measured at Lower Granite Dam) are highly influenced by discharges from Hells Canyon Dam on the Snake River and Dworshak Dam on the Clearwater River. Water temperatures in the lower Snake River are largely influenced by the ratio of water coming from these two sources. Typically, the releases from Hells Canyon Dam are cooler under low water year conditions than they are under high water year conditions. This is an artifact of how Brownlee Reservoir is being evacuated for flood control purposes. Under high water year conditions, cold water residing in the reservoir over winter is released in late winter and early spring to make room for the spring run-off which backfills the reservoir with water that is warmer than the water just released for flood control (IDEQ and ODEQ 2003). These early season releases in high runoff years generally produce warmer summer water temperatures down to the Clearwater River when compared to low water years. By comparison, in low water years, cooler water remains in the reservoir, keeping the summer temperatures below Hells Canyon Dam cooler than those measured during high flow years. Because of the physical configuration of Brownlee Reservoir and its outlet structure, water withdrawal from the reservoir generally occurs within the upper half of the water column.

Recent data and population metrics for fall Chinook salmon indicate that earlier delivery of flow augmentation water may provide benefits to the fishery in the Snake River (see Section 2.3.1). Water arriving at Lower Granite Dam is a combination of tributary inflow and managed water releases from Dworshak Dam and the Hells Canyon Complex. Temperature data also indicate that water released during the spring is generally cooler than water released during the summer below Hells Canyon Dam. Therefore, Reclamation's proposed actions would attempt to deliver a greater percentage of augmentation water to Brownlee Reservoir earlier in the spring, when the water is cooler. This should result in a smaller volume of augmentation water delivery during the summer, when the water leaving Hells Canyon Dam would be warmer. Reclamation surmises that this would result in a larger volume of cooler water in the lower Snake during the spring to benefit fall Chinook outmigration. Additionally, this would result in a reduced volume of warm water released below Hells Canyon Dam during the summer. The premise for this operation under the proposed actions is to provide cooler water from the Snake River in the spring during fall Chinook outmigration in order to offset the warmer summer releases below Hells Canyon Dam with cooler water releases from Dworshak Dam, thus making these releases more effective in cooling the Snake River into Lower Granite Reservoir. Reclamation is also assuming that the temperature benefit of the spring augmentation water delivery will be passed through the Hells Canyon Complex to the lower Snake River. While this operational scenario has not been substantiated with data or modeled output, Reclamation anticipates that this adaptive management approach, in coordination with NMFS, may provide a benefit to all ESA listed Snake River fish.

In the range of water temperatures observed in the lower Snake River during the spring and summer (8 to 24°C), warmer temperatures are generally associated with lower survival of juvenile salmonids (Anderson 2003). Temperatures at 20°C or lower are considered suitable for salmon and steelhead migration (EPA 2003).

Previous modeled analysis described in the 2005 Upper Snake BiOp indicated that although slight increases in summer water temperatures might occur with Reclamation's 2004 upper Snake proposed actions in place, in most years resulting temperatures did not exceed 20°C at Lower Granite Reservoir (NMFS 2005a, citing EPA 2005 and USACE 2005; see 2005 Upper Snake BiOp, Tables 6-10 and 6-11 and Appendix A). The modeled analysis also indicated that there would be a slight decrease in spring water temperatures at Lower Granite Reservoir under the 2004 upper Snake proposed actions. However, this 2007 Upper Snake BA proposes a different flow augmentation delivery schedule that is hypothesized to benefit temperatures downstream of Hells Canyon Dam. The modeled temperature information in the 2005 Upper Snake BiOp does not incorporate these upper Snake flow augmentation adjustments. However, the past modeled analyses and current available data suggest Reclamation's proposed actions appear to result in small water temperature effects in the spring and summer. All available information reviewed to date indicates that a shift in timing of flow augmentation would be beneficial to fish; however, the Northwest Fisheries Science Center has yet to weigh in on this proposed revision. NMFS' final upper Snake BiOp is anticipated to address any beneficial effects of the proposed adjustment to the upper Snake flow augmentation schedule.

4.3.2.2 Sediment

Reclamation's operations, in addition to other Federal and private projects, have most likely altered the timing, size, and quantity of sediment transported in the Snake River upstream from the Hells Canyon Complex (IDEQ and ODEQ 2001). The supply and movement of sediments above, through, and below projects are an important process for many resources within the Snake River basin. While reservoirs tend to trap most sediments entering from upstream, it is important to recognize the influence of hydrology on the sediment transport process. As described in *Section 4.2.3.1, Upper Snake River Basin Total Maximum Daily Loads,* Reclamation continues to implement actions with the objective of reducing any sediment contributions associated with its projects. It is anticipated that the existing sediment transport regime generally will continue into the foreseeable future. The effects of this transport regime are not expected to affect sediment dynamics below the Hells Canyon Complex due to the overriding nature of the Hells Canyon Complex.

4.3.2.3 Nutrients and Dissolved Oxygen

Brownlee Reservoir traps sediment, nutrients, pesticides, and mercury that would otherwise move freely downstream (Myers 1997; Myers and Pierce 1999; IDEQ and ODEQ 2001). The ambient pesticides and mercury are typically bound to sediments, but may be present in the water column under certain conditions. Biological processes within Brownlee Reservoir also reduce nutrient loads (primarily phosphorus) downstream from the Hells Canyon Complex by processing these nutrients in the reservoir. Higher Snake River flows entering Brownlee Reservoir as a result of either flow augmentation or natural conditions reduce water residence times to some extent, which has been shown to reduce substantially the size of the anoxic area in the reservoir that occurs seasonally (Nürnberg 2001).

Dissolved oxygen levels below the minimum criterion of 6.5 mg/L are most likely a secondary water quality condition attributable to excessive algal production associated with high nutrient levels entering the Hells Canyon Complex reservoirs. Levels below 6.5 mg/L typically occur between July and September, but may occasionally occur outside of these months. The Snake River-Hells Canyon TMDL identified the mean total phosphorus concentration below Hells Canyon as 0.083 mg/L, and also determined that dissolved oxygen concentrations in Brownlee Reservoir need to increase by more than 4.0 mg/L (in some conditions) to meet the 6.5 mg/L criterion (IDEQ and ODEQ 2003). The results of preliminary studies of dissolved oxygen from releases from the Hells Canyon Complex are under review. An Idaho Power Company (2000) study suggests the problems may not extend as far downstream as originally reported. However, no conclusions have been reached regarding the nature and extent of problems or the viability of potential solutions.

It seems reasonable to expect, in years when additional flows are available, marginally improved dissolved oxygen levels resulting from marginally cooler water temperature and higher total flows through Hells Canyon Complex reservoirs and downstream areas.

4.3.2.4 Total Dissolved Gas

Total dissolved gas levels below the Hells Canyon Complex ranged from 108 percent to 136 percent during hourly monitoring performed in 1999. There was a clearly defined relationship between spill and total dissolved gas levels below the dam with little relationship to upriver levels (Myers et al. 1999). Reclamation typically plans to evacuate space within the reservoirs during the winter months in anticipation of storing spring run-off events. Spill occurs at Reclamation and other projects when the inflowing water is in excess of hydraulic capacity. In effect, these upper Snake flood control operations serve to reduce the quantity of water spilled (and the resultant generation of supersaturated levels of total dissolved gas) at the Hells Canyon Complex (Myers et al. 1999) and FCRPS dams (EPA et al. 2000). This operating condition is expected to continue into the future under the proposed actions.

4.3.2.5 Mercury

Elevated concentrations of mercury in the Snake River below the Hells Canyon Complex are believed to be a result of historical gold mining and milling operations, particularly in the Jordan Creek area of the Owyhee River basin upstream from Owyhee Reservoir. Storage of water and sediment in Owyhee Reservoir may inhibit downstream transport of mercury from past mining operations, and thereby result in some reduction of mercury loads available for bioaccumulation in the river system downstream from the Hells Canyon Complex (USBR 2001; IDEQ and ODEQ 2001). Thus, Reclamation's proposed actions should continue to reduce, not increase, the downstream transport of mercury within the action areas.

4.3.3 Proposed Actions Effects on Listed ESUs and DPSs in the Snake River

Project operations, especially the action of seasonally storing and releasing water for irrigation and other purposes, have been ongoing in the upper Snake River basin for decades and for some projects more than a century. Development of Reclamation's upper Snake River projects resulted in incremental alterations in the hydrograph as described in Section 3.1.1 and riverine dynamics resulting in or contributing to environmental effects and current baseline conditions that will continue into the future. Reclamation's upper Snake project operations have included delivery of flow augmentation water beginning in 1991, with the delivery of up to 427,000 acre-feet of flow augmentation water since 1993, which has likewise resulted in or contributed to environmental effects and current baseline conditions. Beginning in 2005, the Nez Perce Water Rights Settlement authorized Idaho's protection of up to 487,000 acre-feet for flow augmentation from the upper Snake.

Any measurable effects from Reclamation's proposed actions on listed ESUs and DPSs and their designated critical habitat that are related to flow conditions created from continued alteration to the hydrograph are ameliorated to some extent by the provision of flow augmentation. The most direct hydrologic effects will occur below Hells Canyon Dam and would be expected to diminish progressively downstream because of substantial tributary inflows as well as the sheer volume of the Columbia River as described in Section 3.1.2. With the exception of fall Chinook salmon that spawn and initially rear in the Snake River upstream of the Salmon River, other ESUs and DPSs use the affected reaches of the lower Snake and Columbia Rivers primarily as a migratory route. The following describes the anticipated future effects from the continued operation of upper Snake projects, including the delivery of flow augmentation water, and the resulting flow conditions in the lower Snake River and Columbia River on the listed ESUs and their designated critical habitat.

Table 4-2 shows types of sites, essential physical and biological features designated as PCEs, and the species life stage of ESA-listed salmon ESUs and steelhead DPSs each PCE supports for designated critical habitat in the lower Snake River (Hells Canyon Dam to the confluence with the Columbia River).

Table 4-2. Site types, essential physical and biological features designated as PCEs, and species life stage each PCE supports for the lower Snake River (Hells Canyon Dam to the confluence with the Columbia River).

Site	Essential Physical and Biological Features	Species Life Stage Supported
Snake River Spring/summer Chinook Salmon		
Migration	Substrate, water quality and quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, safe passage	Juvenile and adult
Snake River Fall Chinook Salmon		
Spawning & Juvenile Rearing	Spawning gravel, water quality and quantity, cover/shelter, food, riparian vegetation, and space	Juvenile and adult
Migration	Substrate, water quality and quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, safe passage	Juvenile and adult
Snake River Sockeye Salmon		
Migration	Substrate, water quality and quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, safe passage	Juvenile and adult
Snake River Steelhead		
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover	Juvenile and adult

4.3.3.1 Snake River Spring/Summer Chinook Salmon

The listed Snake River spring/summer Chinook salmon ESU consists of individual populations from the Imnaha, Salmon, Grande Ronde, and Clearwater Rivers that enter the Snake River between Hells Canyon Dam and Lower Granite Pool. Juvenile and adult spring/summer Chinook salmon from these populations use the Snake River primarily as a migration corridor from spawning and rearing areas to and from the ocean. The smolts outmigrate as yearlings between April and early June with the peak at Lower Granite Dam typically in early May (FPC 2006). See Chapter 5 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Upper Snake actions have the greatest potential to adversely affect Snake River spring/summer Chinook salmon because of hydrological alterations during the April through June migration season. Reclamation conducted a modeled analysis of its hydrologic effects into Brownlee Reservoir (above Hells Canyon Dam) using the Upper Snake MODSIM model. This analysis is described in sections 3.1 and 3.2. Table 4-3 repeats information from that analysis here for the reader's convenience. On average, Reclamation's projects deplete approximately 2.3 million acre-feet of water from the

Table 4-3. Modeled Lower Granite Dam discharge comparing Reclamation's Proposed Action and Without Reclamation scenarios for dry, average, and wet water year types. [1]

Month	Wet				Average				Dry			
	Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change	
			cfs	percent			cfs	percent			cfs	percent
October	23,518	23,122	396	2	20,108	20,369	-262	-1	18,135	18,549	-414	-2
November	30,658	34,916	-4,258	-12	23,604	28,497	-4,894	-17	19,759	23,751	-3,992	-17
December	33,602	38,697	-5,095	-13	31,241	36,488	-5,247	-14	25,672	30,220	-4,547	-15
January	56,646	51,013	5,634	11	34,923	37,603	-2,681	-7	26,689	31,666	-4,977	-16
February	71,001	65,255	5,747	9	42,883	46,624	-3,742	-8	28,709	34,205	-5,497	-16
March	96,397	94,300	2,097	2	49,065	54,571	-5,506	-10	30,051	36,632	-6,581	-18
April	116,680	119,158	-2,479	-2	82,852	89,513	-6,661	-7	52,094	55,208	-3,115	-6
May	151,043	170,217	-19,173	-11	107,231	119,274	-12,043	-10	62,200	65,154	-2,954	-5
June	149,023	171,251	-22,227	-13	103,085	112,274	-9,189	-8	42,420	42,526	-106	-0
July	63,818	63,460	359	1	48,864	46,806	2,058	4	28,465	26,400	2,065	8
August	37,457	32,483	4,974	15	32,240	28,396	3,844	14	23,794	21,320	2,475	12
September	30,921	26,819	4,102	15	26,627	23,216	3,411	15	20,480	18,452	2,028	11

1 Period of Record: 1929 - 1998 – Water year types based on annual Brownlee Reservoir inflows calculated using MODSIM Proposed Action scenario.

2 The Proposed Action scenario simulates future hydrologic conditions with implementation of the proposed actions (storing, releasing, and diverting project water).

3 The Without Reclamation scenario simulates hydrologic conditions if Reclamation's reservoirs and diversions were not operating.

Wet years: Average of years at or below 10 percent exceedance
Average years: Average of years between 10 percent and 90 percent exceedance
Dry years: Average of years at or above 90 percent exceedance

Source: HYDSIM – FRIII_BIOP2007Prosp_CRWMP run

Snake River as measured as inflow to Brownlee Reservoir (see Table 3-3). The amount of water depleted varies, depending on runoff conditions each year. In wet and average years, the greatest monthly depletions occur in May and June (see Table 4-2). In dry years, monthly depletions are more evenly distributed from November through May, with the greatest depletions occurring in February and March when Reclamation is storing. In drier years, the magnitude of depletions attributed to the proposed actions is less. For example, during the 3-month April to June period when Chinook salmon smolts are outmigrating, the dry-year depletions average 1,836 cfs compared to 9,588 cfs for wet years).

As noted in *Section 4.3.1, Streamflow and Fish Survival*, the effects of flow on smolt survival are evident primarily under low-flow conditions. In drier years, depletions from upper Snake project operations in April and May, although less in magnitude than in average and wet years, still would be likely to adversely affect survival of Chinook salmon smolts migrating through the lower Snake River. It is difficult to isolate or measure upper Snake flow depletion effects because smolt survival is associated with several factors including flow and co-occurring temperature and turbidity conditions, which are primarily influenced by runoff from the major tributaries entering the Snake River below Hells Canyon Dam. The potential adverse effects from reduced river flows in dry years may be minimized by other factors in those water year-types. First, flow augmentation delivery in May and June of dry years will allow smolts to more quickly move downstream. Second, the combined proposed actions will produce cooler water in the spring in the lower Snake River (by increasing the proportion of cooler tributary inflow). In the range of water temperatures observed in the lower Snake River during the spring and summer (8 to 24°C), warmer temperatures are generally associated with lower survival of juvenile salmonids (Anderson 2003). Temperatures at 20°C or lower are considered suitable for salmon and steelhead migration (EPA 2003). Third, in low-flow years a greater proportion of the migrating Chinook salmon smolts are collected at Lower Granite Dam and transported to below Bonneville Dam, improving survival compared to inriver migration.

Reclamation's delivery of flow augmentation from the upper Snake will shift to the spring months (mid-April through mid-June), especially in dry years, as discussed in *Section 2.3, Refinements to Upper Snake Flow Augmentation*. Shifting flow augmentation timing is for the purposes of benefiting spring-migrant anadromous smolts, including Snake River spring/summer Chinook salmon. Although the absolute amount of water available for flow augmentation is less in dry years than in average and wet years, averaging about 200,000 acre-feet in the driest years compared to averages of 360,000 to 487,000 acre feet in average and wet years, it constitutes a much greater percentage of the flow entering Brownlee Reservoir during April, May, and June (see Table 3-5). As stated previously in *Section 4.3.1, Streamflows and Fish*

Survival, the potential for flow augmentation to improve smolt survival for inriver migrants are most evident in dry years.

Critical Habitat

Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) describes the geographic extent, conservation role, and current conditions of designated critical habitat for the Snake River spring/summer Chinook salmon ESU. The ESA defines critical habitat as specific areas that possess those physical or biological features essential to the species' conservation. Essential features of Snake River spring/summer Chinook salmon spawning and rearing areas would not be affected by Reclamation's proposed actions because spawning and rearing occurs in tributaries downstream and are not affected by upper Snake operations. Essential features of juvenile and adult migration corridors listed in Table 4-2 are affected because these fish are actively migrating in the spring when the proposed actions would continue to affect flows, as described in the previous section, and other features associated with flow conditions. Chapter 19 of the *Comprehensive Analysis*, referenced previously, provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that, compared to current conditions, upper Snake River flow augmentation is expected to contribute to an improvement in the conservation role of safe passage for juvenile Snake River spring/summer Chinook salmon. The conservation role of the adult upstream migration corridor for this ESU is expected to continue to be functional.

Effects Conclusion

Overall, Reclamation's combined proposed actions are likely to adversely affect the Snake River spring/summer Chinook salmon ESU, primarily because Reclamation's project operations will continue to reduce flows in the lower Snake River during the spring migration period, with effects most likely occurring in drier years. For the same reasons, Reclamation's proposed actions would continue to affect designated critical habitat for migrating juvenile spring/summer Chinook salmon. The flow augmentation component of Reclamation's proposed actions is expected to improve migratory conditions from current conditions for the yearling smolts most significantly during the spring of dry years and thus will improve the safe passage essential feature of designated critical habitat.

4.3.3.2 Snake River Fall Chinook Salmon

Background

See Chapter 4 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

To properly assess the effects of Reclamation's proposed actions on Snake River fall Chinook salmon requires an understanding of: (1) the historical legacy of this population; (2) the significance of an alternate life history strategy that has recently been described; and (3) the effects of changes to its habitat from past and current flow management in the river system. These are briefly summarized here.

Fall Chinook salmon throughout their range, especially interior populations, primarily adhere to an ocean-type life history strategy whereby the young fry emerge from the gravel in late winter or early spring, rear for 2 to 3 months until they reach a migratory size, and then emigrate seaward before water temperatures become too warm (Healey 1991). Because of this narrow timing window between fry emergence and emigration, fall Chinook salmon usually spawn in stream reaches having relatively warm water that promotes early fry emergence and rapid juvenile growth. Historically, Snake River fall Chinook salmon spawned primarily in the upper Snake River above Swan Falls where significant contributions of spring water provided ideal conditions for the ocean-type life history strategy (Groves and Chandler 1999). Only limited spawning was believed to have occurred in or below Hells Canyon (Waples et al. 1991) or in tributaries (Connor et al. 2002; Tiffan et al. 2001). The construction of Swan Falls Dam in 1901 prevented fall Chinook salmon from accessing most of their upstream spawning habitat. With the construction of the Hells Canyon Dam Complex (1958 to 1967), fall Chinook salmon were further blocked from accessing their remaining historical habitat. This displaced population now spawns in the Snake River below Hells Canyon Dam and to a lesser extent in the lower reaches of the major tributaries, especially the Clearwater River (Connor et al. 2002). These contemporary spawning areas are cooler during the egg incubation period and less productive during the early rearing period compared to their historical habitat, thus providing less than optimal conditions for a successful ocean-type life history (Connor el al. 2002). In their current environment, fall Chinook salmon fry emerge in late spring (Connor et al. 2002), and many of the juveniles do not have enough growth time or exposure to suitable growth temperatures to reach a migratory size until the summer when warm water temperatures can then retard migratory behavior.

In recent years, the prevailing view that Snake River fall Chinook salmon primarily exhibit an ocean-type life history strategy of subyearling outmigrants has been questioned by new information showing that some later emerging and slower growing juveniles do not emigrate as subyearlings but rather over-winter in the lower Snake River reservoirs and resume their seaward migration the following spring as yearling smolts (Connor et al. 2005). This alternative life history strategy has been referred to as “reservoir-type.” Presumably, the cooler summertime water temperatures in the lower Snake River resulting from the coldwater releases from Dworshak Reservoir to benefit adult salmon migration has allowed this new life history type to develop. Although the proportion of the fall Chinook salmon population that exhibits this new life history strategy is unknown, it has been estimated from scale analysis of adult returns to Lower Granite Dam from 1998 to 2003 that 41 percent of the wild and 51 percent of the hatchery fish had over-wintered in freshwater and entered salt water as yearlings (Connor et al. 2005). The two life history strategies for Snake River fall Chinook salmon complicates an assessment of flow conditions and resulting effects.

In addition to the establishment of a successful reservoir-type life strategy, data have shown that those fish that migrate as subyearlings have shifted their outmigration timing progressively earlier by approximately 1 month since 1993 (see Figure 4-3), perhaps simply reflecting that more of the juveniles cease migrating earlier and adopt the reservoir-type life history (Graves et al. 2007). The great majority of the Snake River fall Chinook salmon subyearlings now migrate past Lower Granite Dam in late May through mid-July rather than in late July and August as observed in the 1990s. This shift in migration timing of the subyearling life history type as well as the development of the reservoir-type life history strategy are critical facts that must be considered in assessing any upper Snake flow effects, and specifically flow augmentation (delivered to Brownlee Reservoir and passed through the Hells Canyon Complex), on fall Chinook salmon.

Flows in the lower Snake River have been managed to benefit anadromous fish by drafting water from Idaho Power Company’s Hells Canyon Complex on the Snake River and the USACE’ Dworshak Reservoir on the Clearwater River, and releases from the upper Snake. A specific program of summer flow augmentation was begun in 1991, with water specifically for cooling the lower Snake River released from Dworshak Reservoir to benefit adult summer and fall Snake River Chinook salmon, sockeye salmon, and steelhead that migrate upstream at this time. Another objective was to improve the survival of fall Chinook salmon juveniles rearing and migrating through the system in the summer.

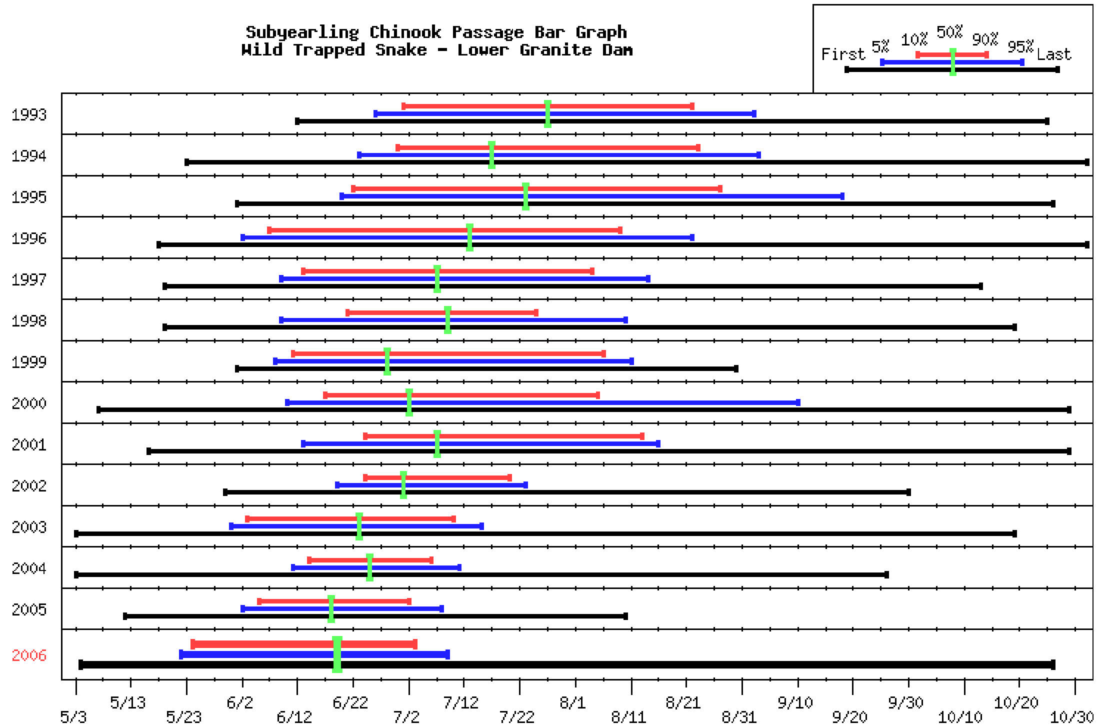

Figure 4-3. Migration timing of wild PIT tagged juvenile fall Chinook salmon tagged in the Snake River and detected at Lower Granite Dam (Source: FPC 2007).

The augmentation of flow with cold water from the Clearwater system (Dworshak) is a critical component of current flow management. Prior to these Dworshak releases, water temperatures in the lower Snake River reservoirs often exceeded 24°C, which can be fatal to juvenile Chinook salmon (WDOE 2000). The current policy is to regulate outflows so as to maintain water temperatures at the Lower Granite tailwater at or below 20°C.

The efficacy of summer flow augmentation for aiding the survival of fall Chinook salmon juveniles has been controversial since the policy was adopted (ISG 1996). In response, studies were initiated in the 1990s using the results of PIT-tagged fish. Using regression analysis, Connor et al. (1998) concluded that flow augmentation decreased travel time and increased inriver survival of wild juvenile fall Chinook salmon, thus supporting the benefit of flow augmentation. Muir et al. (1999) reached a similar conclusion using data from hatchery-raised fall Chinook salmon. However, other studies analyzing the same data demonstrated that survival of juvenile fall Chinook salmon was related to release date, water temperature, and turbidity (Dreher et al. 2000; Anderson et al. 2000; and NMFS 2000). Anderson (2002) concluded that if flow affects survival, it would most likely work indirectly through the effect of water temperature on smolts or their predators. He further noted that summer flow augmentation from the Hells Canyon Complex actually warms the lower Snake River, which presumably would increase predatory activity and decrease juvenile fall

Chinook salmon survival, suggesting a possible benefit to shifting upper Snake flow augmentation releases to the spring season. This temperature trend was described earlier in Section 4.3.2.1. Encouragingly, while the scientific information continues to unfold, adult returns for fall Chinook salmon to the Snake River have increased dramatically since 2000 (see Figure 4-4), perhaps indicating successful adaptation to current conditions in the lower Snake River.

Effects of Reclamation's Proposed Actions

Historical and recent scientific findings discussed above suggest flow management to benefit Snake River fall Chinook salmon during the summer should focus on controlling lower Snake River water temperatures to improve the survival of fish exhibiting the yearling reservoir-type life history strategy. Improved water temperature control could also benefit summer migrating adult and spring migrating juvenile salmon and steelhead (Graves et al. 2007). During the spring of dry years, increased flows, regardless of source, are likely to benefit the yearling reservoir-type fall Chinook salmon smolts migrating in early spring (Tiffan and Connor 2005), the subyearling fall Chinook salmon smolts migrating in late spring (May to early July), as well as the yearling migrants of other species. Benefits of high (and augmented) flows in average and wet years have not been demonstrated for fall Chinook salmon, but are not likely to be detrimental.

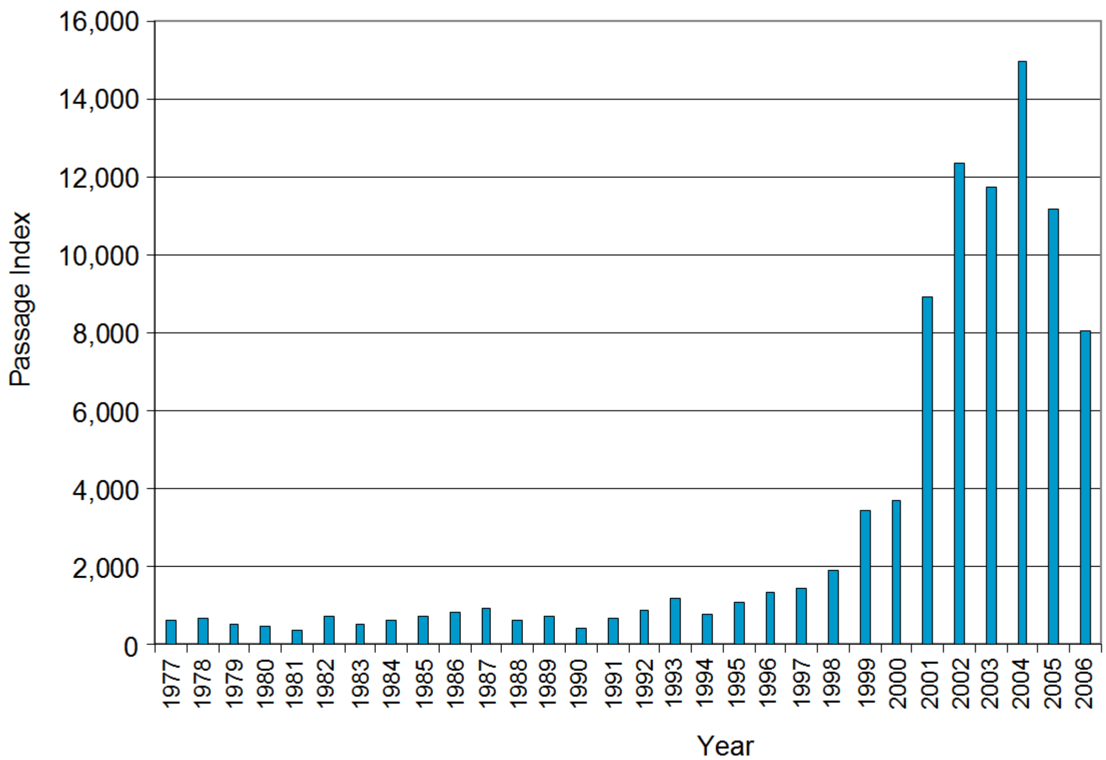

Figure 4-4. Adult passage of fall Chinook at Lower Granite Dam.

Reclamation proposes to deliver a portion of upper Snake flow augmentation in May and June (see Table 3-5). However, Reclamation's proposed actions will continue to deplete streamflow in the Snake River during May and June in wet and average years and May in dry years when most of the subyearling fall Chinook salmon are outmigrating (see Table 4-3). Therefore, the proposed actions are likely to adversely affect this life history strategy. However, these depletions will be less than they are currently with the shift of upper Snake flow augmentation to the spring. In the driest years, when survival effects of flow depletions would be most evident, modeled at Lower Granite Dam in June are nearly the same with and without Reclamation's proposed actions (see Table 4-3).

During the summer (July and August) months when the reservoir-type fall Chinook salmon juveniles are rearing in the lower Snake River reservoirs (mostly Lower Granite Pool [Tiffan and Connor 2005]), the proposed actions result in increased flows into Brownlee Reservoir and downstream at Lower Granite Dam (see Tables 4-3). No scientific information is available to indicate whether these higher summer flows affect rearing. However, it is hypothesized that warmer temperatures may result from summer releases at Hells Canyon Dam, which may adversely affect the rearing of juvenile fall Chinook salmon. However, cool water released from Dworshak Reservoir to maintain temperatures below 20°C at the Lower Granite tailwater would offset these slight increases in temperature. In addition, it has been observed that the fall Chinook salmon juveniles primarily use the lower portion of the reservoirs to take advantage of the cooler depth-stratified water (Tiffan and Connor 2005).

Reclamation's upper Snake operations include storing water in reservoirs during the winter, thereby reducing inflow to Brownlee Reservoir that presumably is passed through the Hells Canyon Complex. Fall Chinook salmon spawn in the Snake River below Hells Canyon in October and November, and the eggs incubate through the winter and early spring. Idaho Power Company maintains stable outflows from Hells Canyon Dam between about 8,500 and 13,500 cfs in October and November for spawning fall Chinook salmon. These flows are generally maintained or increased after that period to reduce the likelihood that incubating eggs in the redds would become dewatered and die (Groves and Chandler 2003). Despite the reduction of inflow to Brownlee Reservoir attributed to Reclamation's proposed actions during this time period, inflows to Brownlee Reservoir remain within the targeted range managed for this species downstream from Hells Canyon Dam (see Table 3-1).

Critical Habitat

Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) describes the geographic extent, conservation role, and current conditions of designated critical habitat for the Snake River fall Chinook salmon ESU. The ESA defines critical habitat as specific areas that possess those physical or biological features essential to the species' conservation. Table 4-2 lists the PCEs for Snake River fall Chinook salmon for spawning and juvenile rearing and migration. Essential features of Snake River fall Chinook salmon spawning and early rearing areas that occur in the free flowing section of river below Hells Canyon Dam would not be affected by Reclamation's proposed actions because flows will remain within the targeted range (8,500 to 13,500 cfs) managed for this species during the period when this occurs (see Table 3-1).

Essential features of critical habitat for juvenile migration corridors are affected by the proposed actions because this ESU outmigrates primarily in the spring when the proposed actions deplete streamflows. Reclamation's proposed shift of the delivery of some flow augmentation to the spring instead of the summer season would benefit the subyearling fall Chinook salmon juveniles that mostly outmigrate in the late spring. The reservoir-type fall Chinook salmon juveniles that over-summer in the reservoirs will benefit from the expected cooler water temperatures during mid- to late summer from reduced upper Snake flow augmentation releases during this period (some shifted to the spring). Essential features of adult migration corridors are not affected because these fish migrate upstream in the Snake River in late summer and early fall when Reclamation's proposed actions result in increased flows or minor decreases of a magnitude that would not affect upstream migration. Measures are in place to maintain adequate flow below Hells Canyon Dam during fall Chinook salmon spawning, incubation, and early rearing; Reclamation's proposed actions would not adversely affect the ability of these measures to continue to be implemented. Chapter 19 of the *Comprehensive Analysis*, referenced previously, provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat.

Effects Conclusion

Continued flow depletions and associated reduced water velocity in the late spring, especially in drier-than-average years, may adversely affect the subyearling fall Chinook salmon outmigrants. However, the delivery of flow augmentation in late May and June is expected to benefit or reduce adverse effects to subyearling outmigrants during this period. Also, the associated lower water temperatures below the Hells Canyon Complex expected from a shift in flow augmentation from the summer to the spring season may benefit the reservoir-type juveniles that over summer in the lower Snake River reservoirs. Flow related effects on summer rearing of reservoir-type juveniles are unknown.

Considering the multiple factors having both positive and negative effects under different water year types and for the different juvenile life history types, the net effect of Reclamation's combined proposed actions is difficult to determine for the Snake River fall Chinook salmon ESU. The proposed action of shifting much of the flow augmentation from summer to spring will benefit the subyearling life history type migrating in late spring and will benefit the hold over reservoir-type juveniles from the expected, although small, reduced summer water temperatures in the lower Snake River reservoirs, especially in average and drier years. Overall, however, Reclamation's combined proposed actions are likely to adversely affect the Snake River fall Chinook salmon ESU, primarily because Reclamation's project operations will continue to reduce flows in the lower Snake River during the late spring. For the same reasons, Reclamation's proposed actions would continue to affect designated critical habitat for the juvenile migration corridor.

4.3.3.3 Snake River Sockeye Salmon

Juvenile sockeye salmon enter the Snake River from the Salmon River, and they actively outmigrate through the lower Snake and Columbia Rivers at approximately the same time as juvenile Snake River spring/summer Chinook salmon. Because they are relatively few in number, sockeye salmon smolts have not been studied as much as Chinook salmon and steelhead in the Snake and Columbia Rivers. However, because of their similar outmigration timing, it is likely that the O&M effects associated with Reclamation's upper Snake River projects described above for Snake River spring/summer Chinook salmon (Section 4.3.3.1.) would be similar for sockeye salmon. See Chapter 6 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Juvenile sockeye outmigration occurs primarily in April and May. Water depletions from the continued operation of Reclamation's upper Snake projects would likely adversely affect migrating sockeye smolts especially in dry years. Flow augmentation provided in the spring months would be expected to reduce depletive effects. The extent to which increased transportation of sockeye smolts (occurring incidentally with transportation targeted for Chinook salmon and steelhead) in dry years might benefit survival is not known.

Critical Habitat

Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) describes the geographic extent, conservation role, and current condition of designated critical habitat for the Snake River sockeye salmon ESU. The ESA defines critical habitat as specific areas that possess those physical or biological features essential to the species' conservation. Table 4-2 lists these PCEs for Snake River sockeye salmon for adult and juvenile migration. Essential features of Snake River sockeye salmon spawning and rearing areas would not be affected by the proposed actions because spawning and rearing occurs in tributaries and lakes outside of the mainstem corridor. Essential features of juvenile migration corridors are affected because fish from this ESU migrate in the early spring when Reclamation's proposed actions deplete flows. Essential features of adult migration corridors are met because these fish migrate upstream in the Snake River in June and July when Reclamation's proposed actions would not alter flows to the extent that would affect upstream migration. Chapter 19 of the *Comprehensive Analysis*, referenced previously, provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that, compared to current conditions, upper Snake River flow augmentation is expected to contribute to an improvement in the conservation role of safe passage for juvenile Snake River sockeye salmon in the mainstem Snake River.

Effects Conclusion

Overall, Reclamation's combined proposed actions are likely to adversely affect the Snake River sockeye salmon ESU, primarily because Reclamation's project operations will continue to deplete flows in the lower Snake River during the spring migration season. Upper Snake flow augmentation would reduce these depletive effects to some extent and improve migratory conditions from current conditions during the spring, especially in dry years. For the same reasons, Reclamation's proposed actions would continue to affect the safe passage essential feature of designated critical habitat.

4.3.3.4 Snake River Basin Steelhead

Snake River steelhead smolts actively outmigrate from Snake River tributaries in the spring at approximately the same time as juvenile Snake River spring/summer Chinook salmon. The effects of continued operations of Reclamation's upper Snake projects and benefits associated with flow augmentation on juvenile steelhead should be similar to those for juvenile Snake River spring/summer Chinook salmon. See Chapter 7 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Adult steelhead migrate upstream in the Columbia and Snake River primarily in mid- to late summer. Some adults make it past Lower Granite Dam by the fall but some adults overwinter in the lower Snake River and continue their upstream migration in the following spring. Excessively warm water temperatures in the Snake River used to be problematic for adult steelhead migrants, but summer flow augmentation of cold water released since 1992 from Dworshak Reservoir in the Clearwater River system has mitigated this effect to some extent. Reclamation is proposing to reduce delivery of upper Snake flow augmentation in the summer months, when possible, which when coupled with cooler flow augmentation water from Dworshak Reservoir would minimize potentially warmer water temperatures in the Snake River and would be expected to benefit upstream migrant adult steelhead.

Critical Habitat

Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) describes the geographic extent, conservation role, and current condition of designated critical habitat for the Snake River basin steelhead DPS. The ESA defines critical habitat as specific areas that possess those physical or biological features essential to the species' conservation. Table 4-2 lists these PCEs for Snake River basin steelhead for freshwater migration. Essential features of Snake River steelhead spawning and rearing areas would not be affected by Reclamation's proposed actions, because spawning and rearing occurs in Snake River tributaries. Essential features of safe passage in migration corridors are affected because this ESU migrates in the early spring when Reclamation's proposed actions deplete flows. Essential features of safe passage in adult migration corridors are met because these fish migrate upstream during mid- to late summer when Reclamation's proposed actions would result in cooler water temperatures in the lower Snake River as a result of the shift of upper Snake flow augmentation water to earlier in the season allowing releases from Dworshak Reservoir to cool lower Snake River water temperatures below Lewiston. Chapter 19 of the *Comprehensive Analysis*, referenced previously, provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that, compared to current conditions, upper Snake River flow augmentation is expected to contribute to an improvement in the conservation role of safe passage for juvenile migrant steelhead.

Effects Conclusion

Overall, Reclamation's proposed actions are likely to adversely affect the Snake River basin steelhead DPS, primarily because Reclamation's project operations will continue to deplete flows in the lower Snake River during the spring of dry years, except for June, although a shift to spring delivery of flow augmentation will minimize some of these effects. While Reclamation's project operations will continue to result in depletions in lower Snake River streamflows during the spring of all years, the potential adverse effects of these flow reductions are expected to be minimized to some extent from the increased spring flow augmentation provided in average and dry years. This shift in flow augmentation to the spring would improve migratory conditions during the spring of dry years below Hells Canyon Dam. For the same reasons, Reclamation's proposed actions would continue to affect the safe passage essential feature of designated critical habitat for juvenile migrant steelhead.

4.3.4 Proposed Actions Effects on Listed ESUs and DPSs in the Columbia River

The listed ESUs and DPSs discussed in this section, together with their designated critical habitat, occur in the action area beginning at the Columbia River's confluence with the Snake River, located 247 miles downstream of the Hells Canyon Dam, and downstream. Most spawn and rear in numerous tributaries to the Columbia River and use the Columbia River primarily for upstream and downstream migration. Some listed ESUs and DPSs, however, use the lower Columbia River for spawning and rearing, as well as migration. Juvenile or adult salmonids migrating through this area will experience substantially greater river flow volumes than fish migrating in the Snake River. In addition, those listed ESUs and DPSs originating farther down the Columbia River system will encounter even greater river flow volume because of the substantial inflows from other tributaries (see Figure 3-1).

Any effects, either positive or negative, on fish in this area or on their designated critical habitat as a result of Reclamation's proposed actions are expected to be too small to measure because of the overwhelmingly greater flows in the Columbia River compared to the Snake River and other environmental factors. The average annual difference in flows with and without Reclamation's upper Snake operations is 2.3 million acre-feet and is less than 2 percent of the average annual flow in the Columbia River at McNary Dam and less than 1 percent of the average annual flow in the Columbia River downstream of Bonneville Dam. Refer to Section 3.1.2 and Figure 3-1 which describes the relative difference in magnitude of average monthly Columbia River flows compared to Snake River inflows at Brownlee Reservoir and other locations in the system.

Table 4-4 shows types of sites, essential physical and biological features designated as PCEs, and the species life stage of ESA-listed salmon ESUs and steelhead DPSs each PCE supports for designated critical habitat in the Columbia River downstream of the Snake River. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) describes the geographic extent, conservation role, and current condition of designated critical habitat for each of the species listed in Table 4-4. The ESA defines critical habitat as specific areas that possess those physical or biological features essential to the species' conservation.

Table 4-4. Site types, essential physical and biological features designated as PCEs, and species life stage each PCE supports for the Columbia River downstream of the Snake River confluence.

Site	Essential Physical and Biological Features	Species Life Stage Supported
Upper Columbia River Spring Chinook Salmon		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Lower Columbia River Chinook Salmon		
Freshwater spawning	Water quality and quantity, spawning substrate	Adult
Freshwater rearing	Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Upper Willamette River Chinook Salmon		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Upper Columbia River Steelhead		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Middle Columbia River Steelhead		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Lower Columbia River Steelhead		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Upper Willamette River Steelhead		
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult
Columbia River Chum Salmon		
Freshwater spawning	Water quality and quantity, spawning substrate	Adult
Freshwater rearing	Water quality and quantity, floodplain connectivity, forage, natural cover	Juvenile
Freshwater migration	Water quality and quantity, natural cover	Juvenile and adult

4.3.4.1 Upper Columbia River Spring Chinook Salmon

This ESU spawns and rears in the Columbia River outside the action area, and enters the defined action area in the Columbia River at the confluence with the Snake River, 247 miles downstream from Hells Canyon Dam. This ESU has a stream-type life history (juveniles outmigrate as yearlings in the spring). Because Upper Columbia River spring Chinook salmon use the action area for migration, the potential effects of Reclamation's proposed actions on this ESU and its designated critical habitat pertain only to flows in the Columbia River migration corridor below the Snake River confluence. See Chapter 8 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Reclamation's modeled analysis indicates that past and present O&M actions have altered Snake River streamflows at Lower Granite Dam (see Table 4-3). These flow alterations combined with private water development activities in the upper Snake have contributed in some degree to present environmental conditions within the action area and are expected to continue into the future. Continued flow alterations attributable to the proposed actions may continue to affect migrating Upper Columbia River spring Chinook salmon in the Columbia River and this ESU's designated critical habitat when flows are reduced in drier years. However, given the magnitude of flows in the Columbia River relative to those in the Snake River affected by the proposed actions, the effects of such flow alterations are too small to measure. For example, in dry years, when flow effects on smolt survival would be most probable, the proposed actions deplete flows by a monthly average of 2,058 cfs during the April to June smolt migration period (computed data in Table 4-3). This flow depletion represents less than 2 percent of the annual flow in the lower Columbia River at McNary Dam under these conditions.

Flow augmentation from the upper Snake is intended to benefit spring migrant smolts in the lower Snake River and generally would produce minor, insignificant improvements in flows and related conditions in the Columbia River when compared to present conditions. Such flows would most improve migration conditions for Upper Columbia River spring Chinook salmon in drier water years during April through June. The effects of flow augmentation in average and wet years are uncertain but not likely adverse (see *Section 4.3.1, Streamflows and Fish Survival*).

Critical Habitat

Table 4-4 lists PCEs for Upper Columbia River spring Chinook salmon. Essential features of this ESU's spawning and rearing areas will not be affected by Reclamation's proposed actions, because spawning and rearing occurs in Columbia River tributaries. The effect of flow depletions for Reclamation's upper Snake River projects proposed actions in the Columbia River is small, estimated to be only about 2 percent of the annual average flow at McNary Dam. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that, compared to current conditions, upper Snake River flow augmentation is expected to contribute to an improvement in the conservation role of safe passage for juveniles.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Upper Columbia River spring Chinook salmon ESU or the safe passage PCE of designated critical habitat. Any effects are unmeasurable.

4.3.4.2 Lower Columbia River Chinook Salmon

This ESU includes both spring-run and fall-run Chinook salmon populations downstream from the Klickitat River, where populations first enter the action area approximately 391 miles downstream from Hells Canyon Dam. See Chapter 12 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Reclamation's proposed actions would be expected to have minimal effects on this listed species since it occurs a significant distance downstream from the Hells Canyon Complex and influence of upper Snake actions on streamflows are indistinguishable. Continued flow alterations attributable to Reclamation's proposed actions may continue to affect migrating Lower Columbia River Chinook salmon and this ESU's designated critical habitat in the Columbia River. However, given the magnitude of flows in the Columbia River relative to Snake River inflows, the effects of such flow alterations are unmeasurable. For example, in dry years, when flow effects on smolt survival would be most probable, the proposed actions deplete flows by a monthly average of 2,058 cfs during the April to June smolt migration period (computed data in Table 4-3). This flow depletion represents only about 1 percent of the flow in the lower Columbia River under these conditions.

Upper Snake flow augmentation is intended to benefit spring migrant smolts in the lower Snake River and generally would produce very slight improvements in flows and related conditions in the Columbia River when compared to present conditions. Such flows would most likely improve migration conditions for Lower Columbia River Chinook salmon in drier water years during April through June. The effects of flow augmentation in average and wet years are uncertain but not likely adverse (see *Section 4.3.1, Streamflows and Fish Survival*).

Critical Habitat

Table 4-4 lists PCEs for Lower Columbia River Chinook salmon for freshwater migration, spawning areas, and rearing areas. As noted previously for this ESU, the effect of flow depletions for Reclamation's upper Snake River projects proposed actions in the lower Columbia River is very small. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that the negative effect of flow depletions for Reclamation's upper Snake River projects proposed actions is unmeasurable in the lower Columbia River. The *Comprehensive Analysis* also concludes that, compared to current conditions, the conservation role of safe passage for both the juvenile downstream and the adult upstream migration corridor is expected to improve.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Lower Columbia River Chinook salmon ESU or the safe passage PCE of designated critical habitat. Any effects of the actions this far downstream are unmeasurable.

4.3.4.3 Upper Willamette River Chinook Salmon

This ESU spawns, incubates, and rears outside of the action area. Its designated critical habitat occurs in the action area where juveniles exit the Willamette River and enter the Columbia River approximately 469 miles downstream from Hells Canyon Dam, and even farther from Reclamation's upper Snake River projects. Upstream migrating adults leave the action area when they enter the Willamette River. Adults and juveniles use the lower 101 miles of the Columbia River for migration. See Chapter 15 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Reclamation's proposed actions are likely to have minimal if any discernible effect on this ESU as flow depletions from the proposed actions are very small and unmeasurable this far downstream in the lower Columbia River. For example, the depletive volume to Brownlee Reservoir resulting from the proposed actions (2.3 million acre feet) comprises about 1 percent of Columbia River flows in this reach on an annual average basis.

Critical Habitat

Table 4-4 lists PCEs for Upper Willamette River Chinook salmon for freshwater migration. Essential features of this ESU's spawning and rearing areas will not be affected by Reclamation's proposed actions, because spawning and rearing occurs in the Willamette River system. As discussed for this ESU, Reclamation's proposed actions are likely to have minimal if any discernible effect on designated critical habitat as flow depletions from the proposed actions are very small and unmeasurable this far downstream in the lower Columbia River. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Upper Willamette River Chinook salmon ESU or the safe passage PCE of designated critical habitat. Any effects are unmeasurable.

4.3.4.4 Upper Columbia River Steelhead

Adults and juveniles of this DPS use the Columbia River downstream from the confluence with the Snake River as part of their migration corridor. This DPS enters the action area approximately 247 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects. This DPS has a stream-type life history with yearling smolts outmigrating rapidly in the spring. See Chapter 9 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Because Upper Columbia River steelhead use the action area for migration, the potential effects of Reclamation's proposed actions pertain only to migration.

Continued flow alterations attributable to the proposed actions may continue to affect migrating Upper Columbia River steelhead and this DPS's designated critical habitat in the Columbia River to the extent that such alterations affect flow conditions for migration. Modeled depletions to Brownlee Reservoir inflow resulting from the proposed actions comprise less than 2 percent of Columbia River flows at McNary Dam in this reach of the Columbia River. Therefore, the effects of such flow alterations on Upper Columbia steelhead are considered very small and unmeasurable.

Upper Snake flow augmentation is intended to benefit spring migrant smolts in the lower Snake River and generally would produce relatively minor improvements in flows, based on modeled analysis, and related conditions in the Columbia River when compared to present conditions. Such flows would result in a small improvement in migration conditions for Upper Columbia River steelhead in drier water years during April and May. The effects of flow augmentation in average and wet years are uncertain but not likely adverse (see *Section 4.3.1, Streamflows and Fish Survival*).

Critical Habitat

Table 4-4 lists PCEs for Upper Columbia River steelhead for freshwater migration. Essential features of this DPS's spawning and rearing areas will not be affected by Reclamation's proposed actions, because spawning and rearing occurs in Columbia River tributaries. As discussed previously, the effect of flow depletions for Reclamation's upper Snake River projects proposed actions in the Columbia River is small, estimated to be only about 2 percent of the annual average flow at McNary Dam. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that, compared to current conditions, upper Snake River flow augmentation is expected to contribute to an improvement in the conservation role of safe passage for juvenile Upper Columbia River steelhead.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Upper Columbia River steelhead DPS or the safe passage PCE of designated critical habitat. Any effects this far downstream are unmeasurable.

4.3.4.5 Middle Columbia River Steelhead

Juvenile steelhead from the Yakima River population of this DPS enter the action area in the Columbia River at the mouth of the Snake River approximately 247 miles downstream from Hells Canyon Dam and migrate over McNary Dam. Upstream migrating adults leave the action area once they pass the mouth of the Snake River. Juveniles and adults from other populations in this DPS enter the action area as far downstream as the Deschutes River, or approximately 367 miles downstream from Hells Canyon Dam, and even farther from Reclamation's upper Snake River projects. See Chapter 10 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Any effects from Reclamation's proposed actions will diminish progressively downstream and will likely have less effect on listed DPSs and their designated critical habitat farther downstream. Inflows to Brownlee Reservoir affected by the proposed actions comprise less than 2 percent of Columbia River flow at McNary Dam in this reach. The potential effect of the proposed actions on Yakima River Middle Columbia River steelhead would be similar to effects described for the Upper Columbia River steelhead DPS (*Section 4.3.4.4., Upper Columbia River Steelhead*). Those populations entering the action area farther downstream would be less affected.

Critical Habitat

Table 4-4 lists PCEs for Middle Columbia River steelhead for freshwater migration. Essential features of this DPS's spawning and rearing areas will not be affected by Reclamation's proposed actions, because spawning and rearing occurs in Columbia River tributaries. As discussed previously, any effects from Reclamation's proposed actions will diminish progressively downstream and will likely have less effect on listed designated critical habitat farther downstream. The potential effect of Reclamation's proposed actions on designated critical habitat for Yakima River Middle Columbia River steelhead would be similar to effects described for Upper Columbia River steelhead (*Section 4.3.4.4., Upper Columbia River Steelhead*). Those Middle Columbia River steelhead populations entering the action area farther downstream would be less affected. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that, compared to current conditions, upper Snake River flow augmentation is expected to contribute to an improvement in the conservation role of safe passage for juvenile Middle Columbia River steelhead.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Middle Columbia River steelhead DPS and is not expected to affect the safe passage PCE of designated critical habitat. Any effects of the proposed actions are unmeasurable.

4.3.4.6 Lower Columbia River Steelhead

See Chapter 14 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Steelhead migrants of this DPS enter the action area downstream from the Hood and Wind Rivers, approximately 423 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects. At this location in the Columbia River the relatively minor flow alterations of Reclamation's proposed actions are likely to have a negligible effect on this DPS and its designated critical habitat. For example, inflows to Brownlee Reservoir as affected by the proposed actions comprise about 1 percent of Columbia River flows in this reach of the Columbia River.

Critical Habitat

Table 4-4 lists PCEs for Lower Columbia River steelhead for freshwater migration. Essential features of this DPS's spawning and rearing areas will not be affected by Reclamation's proposed actions, because spawning and rearing occurs in Columbia River tributaries. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that the negative effect of flow depletions from Reclamation's upper Snake River projects proposed actions is nearly unmeasurable in the lower Columbia River.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Lower Columbia River steelhead DPS and is not expected to affect the safe passage PCE of designated critical habitat. Any effects of the proposed actions are unmeasurable.

4.3.4.7 Upper Willamette River Steelhead

See Chapter 16 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Adults and juveniles of this DPS use the lower 101 miles of the action area in the Columbia River downstream from the Willamette River confluence as a migration corridor. This DPS enters the action area approximately 469 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects. The effects of the proposed actions on this DPS and its designated critical habitat would be substantially reduced, in fact, hardly measurable, in this downstream reach of the Columbia River below Bonneville Dam.

Critical Habitat

Table 4-4 lists PCEs for Upper Willamette River steelhead for freshwater migration. Essential features of this DPS's spawning and rearing areas will not be affected by Reclamation's proposed actions, because spawning and rearing occurs in Willamette River tributaries. As discussed previously, the effects of Reclamation's proposed actions on this DPS's designated critical habitat would be hardly measurable in this downstream reach of the Columbia River below Bonneville Dam. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Upper Willamette River steelhead DPS or the safe passage PCE of designated critical habitat. Any effects of the proposed actions are unmeasurable.

4.3.4.8 Columbia River Chum Salmon

Adults of this ESU use the action area in the Columbia River downstream from Bonneville Dam for migration, spawning, and rearing. Some adults pass above the dam, but it is unknown if they successfully spawn there. This ESU uses the portion of the action area that begins approximately 431 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects.
A chum salmon flow objective of approximately 125,000 cfs from the start of chum salmon spawning in November until the end of fry emergence in March is identified as an FCRPS action, although river stage downstream from Bonneville Dam rather than actual flow has been used to provide adequate habitat for spawning and incubating chum salmon. Flows are to be adjusted to compensate for tidal influence and any effect from the flows out of the Willamette River. See Chapter 11 of the

Comprehensive Analysis (USACE et al. 2007b) for background and base status information on this species.

Adult chum salmon use the action area at a time when Reclamation is storing water in its upper Snake River projects and thereby reducing flows entering Brownlee Reservoir. These flow alterations, which are generally in the 3,000 to 5,000 cfs range (see Table 3-1), have contributed in some degree to present environmental conditions within the action area and are expected to continue into the future. However, Reclamation's proposed actions in the upper Snake River reduce flows in the lower Columbia River below Bonneville Dam by about 1 percent; the magnitude of any effects from flow alterations on the Columbia River chum salmon ESU and the spawning and rearing PCEs of designated critical habitat would be too small to measure. Flows for incubation up to fry emergence are provided for the most part from upper Columbia River water management. Flow augmentation from the upper Snake would occur in the spring and summer months, outside the time when it would benefit Columbia River chum salmon spawning and incubation and associated designated critical habitat.

Critical Habitat

Table 4-4 lists PCEs for Columbia River chum salmon for freshwater migration, spawning areas, and rearing areas. As discussed for this ESU, Reclamation's proposed actions in the upper Snake River reduce flows in the lower Columbia River below Bonneville Dam by about 1 percent; the magnitude of any effects from flow alterations on this ESU's migration, spawning, and rearing PCEs of designated critical habitat would be too small to measure. Flow augmentation from the upper Snake would occur in the spring and summer months, outside the time when it would benefit designated critical habitat associated with spawning and incubation by Columbia River chum salmon. Chapter 19 of the *Comprehensive Analysis* (USACE et al. 2007b) provides detailed discussions of upper Snake and FCRPS projects combined effects on designated critical habitat. The *Comprehensive Analysis* concludes that the negative effect of flow depletions for Reclamation's upper Snake River projects proposed actions is nearly unmeasurable in the lower Columbia River.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Columbia River chum salmon ESU and is not expected to affect freshwater spawning and rearing PCES of designated critical habitat. Any effects of the proposed actions are unmeasurable.

4.3.4.9 Lower Columbia River Coho Salmon

Outmigrating juvenile lower Columbia River coho salmon enter the action area in the spring when they exit various lower Columbia River tributaries downstream of the Hood River, approximately 423 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects. The Hood River enters Bonneville Pool; the other streams supporting lower Columbia River coho salmon enter the Columbia River below Bonneville Dam. See Chapter 13 of the *Comprehensive Analysis* (USACE et al. 2007b) for background and base status information on this species.

Continued flow alterations attributable to Reclamation's proposed actions may continue to affect migrating lower Columbia River coho salmon in the Columbia River to the small extent that such alterations affect flow conditions for juvenile migrants in the spring or adult migrants in the fall. However, given the magnitude of flows in the lower Columbia River relative to the 1 percent reduction in flows from the upper Snake proposed actions upstream, the effects of such flow alterations would be difficult to measure.

Similarly, the flow augmentation component of Reclamation's proposed actions generally would be expected to produce unmeasurable improvements in flows and related migratory conditions in the lower Columbia River when compared to present conditions.

Effects Conclusion

In summary, based on the above analysis, Reclamation's proposed actions may affect but are not likely to adversely affect the Lower Columbia River coho salmon ESU. Any effects of the proposed actions are unmeasurable.

NMFS has not designated critical habitat for this ESU.

4.3.5 Effects Conclusion Summary

4.3.5.1 Listed Snake and Columbia River Salmon ESUs and Steelhead DPSs

Reclamation has determined that the continued operations and routine maintenance activities associated with its 12 proposed actions may affect and are likely to adversely affect four listed species: Snake River spring/summer Chinook salmon ESU, Snake River fall Chinook salmon ESU, Snake River sockeye salmon ESU, and the Snake River steelhead DPS. Adverse effects from Reclamation's upper Snake project operations to these species will occur primarily from continued reductions in flows during the spring migration season, although flow augmentation provided in the spring season may minimize these effects.

Reclamation has also determined that, overall, the 12 upper Snake proposed actions may affect but are not likely to adversely affect 9 ESA-listed species: Upper Columbia River spring, Lower Columbia River, and Upper Willamette River Chinook salmon ESUs; Upper Columbia River, Middle Columbia River, Lower Columbia River, and Upper Willamette River steelhead DPSs; Columbia River chum salmon ESU; and Lower Columbia River coho salmon ESU.

Although the overall effects determinations for the 13 listed ESUs and DPSs is either may affect not likely to adversely affect or likely to adversely affect, compared to current conditions, flow augmentation is expected to result in minor benefits to 12 of the 13 species (excluding the Lower Columbia River chum salmon ESU) in the drier-than-average water years, especially for the four listed Snake River species.

4.3.5.2 Designated Critical Habitat

Reclamation has determined that, overall, their combined proposed actions would affect the conservation value to a small unquantifiable degree for PCEs and essential features of designated critical habitat for the following:

- Snake River spring/summer Chinook salmon ESU
- Snake River fall Chinook salmon ESU
- Snake River sockeye salmon ESU
- Snake River Basin steelhead DPS

Reclamation has determined that, overall, their combined proposed actions would not appreciably diminish the conservation value of PCEs and essential features of designated critical habitat for the following:

- Upper Columbia River spring Chinook salmon ESU
- Lower Columbia River Chinook salmon ESU
- Upper Willamette River steelhead DPS
- Upper Columbia River steelhead DPS
- Middle Columbia River steelhead DPS
- Lower Columbia River steelhead DPS
- Upper Willamette River Chinook salmon ESU
- Columbia River Chum salmon ESU

Critical habitat has not been designated for the Lower Columbia River coho salmon ESU.

4.4 Cumulative Effects

Cumulative effects include the effects of future state, Tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions that are unrelated to the proposed actions are not considered in this section because they require separate consultation. A large number of actions associated with agriculture, aquaculture, transportation, construction, and rural and urban development occur in the action area. These will continue into the future, and their effects constitute cumulative effects. The impacts of future actions associated with these broad developmental activities are unknown at this time. We discuss here those activities that are reasonably certain to occur in the action area.

The cumulative effects associated with private water diversions in the upper Snake River basin have occurred since the late 1800s and early 1900s and are expected to continue into the future. The hydrologic effects of these non-Federal depletions have been incorporated into Reclamation's modeled analyses and include diversions of surface water and groundwater pumping.

Non-Federal water uses, primarily for irrigated agriculture, deplete a portion of the upper Snake River flows. These various water allocations are administered by the State of Idaho. Reclamation conducted a modeled analysis, described in *Section 3.1.1, Depletions in the Upper Snake River Basin*, to determine the total volume of depletions in the upper Snake attributed to Reclamation's proposed actions and non-Federal diversions. The combined hydrologic effects of Reclamation's proposed actions and the continued non-Federal water depletions on flows into Brownlee Reservoir are presented in Tables 3-2 and 3-3. On an annual average basis, non-Federal water uses comprise just under 2/3 of the approximately 6.0 million acre-feet of total depletions occurring in the upper Snake (see Table 3-3). Seasonally and on average the majority of water depletions occur primarily in the spring and summer agriculture growing season, which overlaps with the juvenile salmon and steelhead migratory period in the lower Snake and Columbia Rivers.

These conditions represent baseline flow conditions that are expected to continue in the future. The flow conditions in the lower Snake River at Lower Granite Dam and in the Columbia River at McNary Dam presented in Tables 3-6 and 3-7, respectively, represent the resulting flow conditions when these baseline flow conditions are combined with the future effects of Reclamation's proposed actions and continued cumulative effects from private diversions in the upper Snake. The combined Federal and non-Federal depletions of water from the upper Snake River basin will continue to adversely affect juvenile migrant salmonids in the lower Snake River by altering flows and associated water velocity through the river system. Effects will be greatest during drier-than-average years (less than 100,000 cfs at Lower Granite Dam – see Table 4-3). In wetter-than-average years the effects of the combined Federal and non-Federal water depletions on juvenile migrants would be uncertain because flows in the lower Snake River are at or above those for which survival benefits of increased flows have not been demonstrated (see Section 4.3.1). At the higher flows other factors such as elevated TDG or poorer performance of fish passage and protection systems at the dams may affect survival.

Potential future impacts of continuing water development in the upper Snake River basin are limited by the Nez Perce Water Rights Settlement's incorporation of the October 1984 Swan Falls Agreement, an agreement between the State and Idaho Power, to continue to protect Snake River flows at the Murphy gage (immediately downstream from Swan Falls Dam). This agreement stipulates that minimum flow levels in the Snake River at the Murphy gage are 3,900 cfs from April 1 to October 31, and 5,600 cfs from November 1 to March 31, not including flow augmentation.

As discussed in Chapter 1 and Appendix A, future actions associated with components of the Nez Perce Water Rights Settlement may potentially benefit ESA-listed fish analyzed in this BA. For example, a habitat restoration trust fund will be managed by the Nez Perce Tribe. Although specific restoration activities are conceptual at this time, it is reasonable to assume that many of the restoration projects that will occur in the future may contribute to improved habitat conditions for listed Snake River Chinook salmon and steelhead trout. Because specific projects have not been identified, any potential benefits are not incorporated into this analysis. The Settlement also includes a forestry practices program for the Salmon and Clearwater River basins identifying stream protection measures that will benefit listed species by improving water quality and fish passage. The State forest lands are currently implementing the program and in the future private timber lands may enroll (see Appendix A).

Section 303(d) of the Clean Water Act requires states and Tribes to periodically publish a priority list of impaired waters, currently every 2 years. For waters identified on this list, states and Tribes must develop TMDLs, which are water quality improvement plans that establish allowable pollutant loads set at levels to achieve water quality standards. Water quality standards serve as the foundation for protecting and maintaining designated and existing beneficial uses (for example, aquatic life, recreation). Each water quality standard consists of criteria that are meant to be protective of the beneficial uses and can be used to establish provisions to protect water quality from pollutants. These provisions are often in the form of TMDLs. The following TMDLs address the Snake and Columbia Rivers downstream of Brownlee Reservoir:

- **Snake River – Hells Canyon TMDLs.** Approved by the EPA September 2004 (cover the Snake River between where it intersects with the Oregon/Idaho border downstream to directly upstream of its confluence with the Salmon River). The States of Idaho and Oregon have been actively implementing this TMDL since its approval. The TMDL wasteload allocations are primarily being implemented through the National Pollutant Discharge Elimination System program, whereas the load allocations are being implemented through bi-state or state specific programs such as the Oregon Watershed Enhancement Board, Natural Resources Conservation Service Environmental Quality Incentive Programs, and EPA §319, among others.

- **Lower Columbia River Total Dissolved Gas TMDL.** Approved by the EPA November 2002 (covers the mainstem Columbia River from its confluence with the Snake River downstream to its mouth at the Pacific Ocean). Since approval of the Lower Columbia River Total Dissolved Gas TMDL, dam operators on the Lower Columbia River have operated in accordance with the TMDL's two implementation phases. The first phase, which is underway, is based on meeting the fish passage standards outlined in the 2000 FCRPS BiOp through spills that generate gas levels no greater than the waiver limits set by ODEQ and WDOE. The second phase, which is also underway, will evaluate the success of Phase I as well as move toward further structural modifications and reductions in spill if the 2000 FCRPS BiOp performance standards are met.

Further, numerous TMDLS have been developed or are in process for the Snake River and tributaries above Brownlee Reservoir as described in Section 4.2.3.1. Implementation of these plans by the states is anticipated to result in improved water quality conditions for these river reaches. While the TMDLs are part of the Federal CWA administered by EPA, the implementation of the various activities to meet the TMDLs will be undertaken by numerous state, local, and private entities. Implementation includes numerous activities with the goal of reducing pollutant loads to the established TMDL limits. The implementation phase of these TMDLs should result in improved water quality for the Snake and Columbia Rivers within and downstream from these reaches.