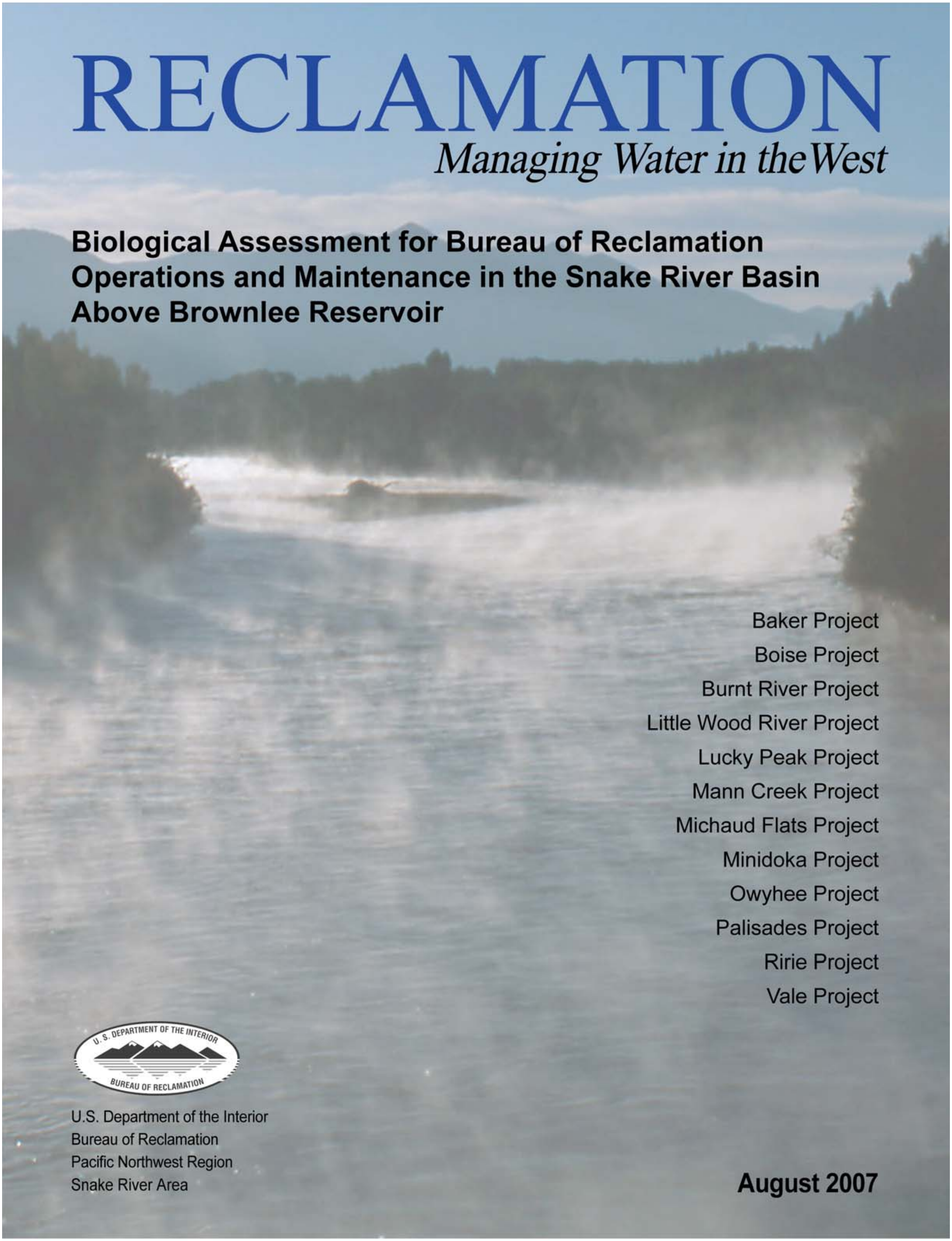

RECLAMATION

Managing Water in the West

Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin Above Brownlee Reservoir

Baker Project

Boise Project

Burnt River Project

Little Wood River Project

Lucky Peak Project

Mann Creek Project

Michaud Flats Project

Minidoka Project

Owyhee Project

Palisades Project

Ririe Project

Vale Project

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Snake River Area

August 2007

Acronyms and Abbreviations

APA	Administrative Procedures Act
BA	Biological Assessment
BiOp	Biological Opinion
BPA	Bonneville Power Administration
BRT	Biological Review Team
cfs	Cubic feet per second
CIG	Climate Impact Group
CREP	Conservation Reserve Enhancement Program
CWA	Clean Water Act
DCMI	Domestic, commercial municipal, and industrial
DPS	Distinct Population Segment
EFH	Essential fish habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESPA	Eastern Snake Plain Aquifer
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FPC	Fish Passage Center
FR	Federal Register
HUC	Hydrologic Unit Code
ICBTRT	Interior Columbia Basin Technical Recovery Team
IDEQ	Idaho Department of Environmental Quality
IDWR	Idaho Department of Water Resources
ISAB	Independent Scientific Advisory Board
ISG	Independent Study Group
IWRB	Idaho Water Resource Board
IWRRI	Idaho Water Resources Research Institute
kg/day	Kilograms per day
mg/L	Milligrams per liter
MPG	Major Population Group
NMFS	National Marine Fisheries Service
NWF	National Wildlife Federation
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
O&M	Operations and maintenance
PCE	Primary Constituent Element
PFMC	Pacific Fishery Management Council
PIT	Passive Integrated Transponder
Reclamation	U.S. Bureau of Reclamation
RM	River mile
RPA	Reasonable and Prudent Alternatives
RSW	Removable Spillway Weir
Settlement	2004 Nez Perce Water Rights Settlement
SRBA	Snake River Basin Adjudication
State	State of Idaho
TDG	Total dissolved gas
TFCC	Twin Falls Canal Company
TMDL	Total Maximum Daily Load
TMT	Technical Management Team
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	Viable Salmonid Population
WDOE	Washington Department of Ecology
WLCTRT	Willamette Lower Columbia Technical Review Team

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The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to tribes.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Chapter 1 OVERVIEW

1.1 Purpose of the Biological Assessment

In November 2004, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) initiated formal consultation under Section 7 of the Endangered Species Act (ESA) by submitting a biological assessment (BA) to the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). The *Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin above Brownlee Reservoir* (2004 Upper Snake BA) (USBR 2004a) described 12 separate actions involving operations and routine maintenance at 12 Federal projects located upstream of Brownlee Reservoir and evaluated the potential effects of those actions on ESA-listed endangered or threatened species and their designated critical habitat. The projects, collectively referred to as the upper Snake projects, were the Minidoka, Palisades, Michaud Flats, Ririe, Little Wood River, Boise, Lucky Peak, Mann Creek, Owyhee, Vale, Burnt River, and Baker Projects. Reclamation initiated consultation because the existing biological opinion (BiOp) expired before the start of the 2005 irrigation season, and some components of the proposed actions differed from the actions consulted upon in the previous consultation. Most notable was the development of the Nez Perce Water Rights Settlement that described the conditions for continued provision of salmon flow augmentation from the upper Snake.

Reclamation received a BiOp from NMFS in March 2005 (2005 Upper Snake BiOp) (NMFS 2005a). The 2005 Upper Snake BiOp concluded that Reclamation's proposed actions were not likely to jeopardize the continued existence of 13 Columbia River basin salmon Evolutionarily Significant Units (ESUs) and steelhead Distinct Population Segments (DPSs) listed or proposed for listing under the ESA or to adversely modify or destroy designated critical habitat for three ESUs.

In 2005, American Rivers and others filed a suit alleging Administrative Procedures Act (APA) and ESA violations (*American Rivers v. NOAA Fisheries*). On May 23, 2006, Oregon U.S. District Judge James Redden held that NMFS' March 2005 Upper Snake BiOp contained flawed analysis and did not comply with the ESA or APA. On September 26, 2006, Judge Redden issued an Opinion and Order of Remand providing details on how Federal defendants must revise the consultation to correct these deficiencies.

Reclamation has prepared this current biological assessment (2007 Upper Snake BA) to analyze its proposed actions consistent with the Court's findings and assist NMFS with the preparation of a BiOp that will comply with ESA and satisfy the direction given by the Court in its Orders. This 2007 Upper Snake BA builds upon and updates as appropriate information contained in the 2004 Upper Snake BA, incorporating by reference factual information and replacing the analyses in accordance with the Court's opinion. The reader is referred to that document for information about Reclamation's proposed actions. This 2007 Upper Snake BA proposes refinements to some of its proposed actions for the purposes of benefiting listed fish and designated critical habitat. Analytical information is also provided to supplement or update information provided in the 2004 Upper Snake BA.

Reclamation proposes to undertake 12 separate Federal actions in the Snake River basin upstream from Brownlee Reservoir (upper Snake River basin). While not required by the ESA or the ESA regulations, Reclamation has chosen, as a matter of administrative convenience, to address all proposed actions in a single BA. In turn, Reclamation is requesting that NMFS, as permitted by 50 CFR 402.14(c), enter into a single consultation and issue a single BiOp regarding all 12 proposed actions to the extent formal consultation is required by law.

1.2 Proposed Actions

Reclamation's future actions in the upper Snake are described in its 2004 Upper Snake BA (USBR 2004a) and supporting documents. That BA initially identified 11 separate proposed actions. The 2004 Upper Snake BA was later amended to add a twelfth action after it had been submitted to NMFS. A proposed action was defined by project facilities that are located within the same drainage and are operationally coordinated as one action. For example, the operations and routine maintenance of the Michaud Flats, Minidoka, Palisades, and Ririe Projects, located above Milner Dam on the Snake River near Twin Falls, Idaho, are defined as one separate action because the operations of these project facilities are coordinated with one another. Similarly, the operations and routine maintenance of the facilities on the Boise drainage (Anderson Ranch, Arrowrock, and Lucky Peak Dams and Reservoirs) are coordinated and are considered another separate action.

Reclamation has proposed some refinements to its proposed actions with respect to delivery of flow augmentation water. The proposed actions and these refinements are described further in Chapter 2. This 2007 Upper Snake BA analyzes the effects resulting from both the discretionary and non-discretionary components of these proposed actions.

1.3 Action Area

The action area for each individual proposed action remains the same as described in the 2004 Upper Snake BA at pages 3 through 5 and in Chapter 2. The features and facilities of the 12 Federal projects included in the proposed actions are all upstream of Brownlee Dam, an Idaho Power Company (Idaho Power) facility on the Snake River at river mile (RM) 285, and upstream of the occurrence of the 13 listed salmon ESUs and steelhead DPSs considered here. The combined effects of Reclamation's separate upper Snake actions on listed anadromous fish begin at Brownlee Reservoir and extend from Hells Canyon Dam downstream to the Columbia River estuary. This 2007 Upper Snake BA focuses on flow effects beginning at Brownlee Reservoir and resulting effects to listed fish downstream to the Columbia River estuary as this is the area relevant to the ESA-listed salmon and steelhead and their critical habitat.

1.4 Nez Perce Water Rights Settlement

Reclamation's actions in the upper Snake include the provision of flow augmentation to benefit migrating salmon and steelhead. Reclamation has provided flow augmentation to benefit fish since 1991. Longstanding disputes over water allocation were addressed by the 2004 Nez Perce Water Rights Settlement (Settlement) and the Snake River Water Rights Act of 2004 (P.L. 108-447), which includes provisions to allow Reclamation's continued delivery of flow augmentation water for a 30-year period (through 2034).

The Nez Perce Water Rights Settlement was negotiated through adjudication proceedings for the Snake River basin in Idaho, which began in 1987. The Snake River Basin Adjudication (SRBA) is a general adjudication of water rights In Idaho's Snake River basin. During general adjudication, the McCarren Amendment (43 USC 666) requires the Federal government to assert its water right claims for adjudication in State court. In 1993, the United States, as Trustee for the Nez Perce Tribe, and the Tribe in its own behalf, filed water right claims in the SRBA for fish habitat and habitat protection, with a "time immemorial" priority date. The claims involved substantial volumes of water.

After the initial rounds of negotiations failed to produce a settlement, the Court began proceedings on the Federal and Tribal claims in the fall of 1997. In 1998, private objectors to the Tribal claims suggested mediated negotiations, which later resulted in the Nez Perce Water Rights Settlement (Nez Perce Tribe et al. 2004) in May 2004. The United States approved the Settlement as the Snake River Water Rights Act of 2004. Idaho and the Tribe approved the Settlement on March 24, 2005, and March 29, 2005, respectively.

All actions required for full implementation of the Settlement were recently completed and, in accordance with the 2004 Act, the Secretary of the Interior executed a final Statement of Findings: Snake River Water Rights Act in the Federal Register (72 FR 27325) on May 15, 2007, certifying that all conditions for effectiveness of the agreement have been satisfied including:

- Execution of all necessary documents
- Approval and ratification by Congress and authorization of Federal expenditures
- Approval and ratification by the Idaho State Legislature and enactment of required State legislation
- Ratification by the Nez Perce Tribe
- Issuance of a final judgment and decrees by the SRBA District Court
- Issuance of BiOps for the Snake River Flow component

The Settlement consists of three components: the Nez Perce Tribal, the Salmon/Clearwater, and the Snake River Flow components. The following summarizes key elements of each component. Appendix A provides more information about the Settlement.

The Nez Perce Tribal component addresses the Tribe's consumptive water rights claims on-reservation, provides funds for water development, and resolves other on and near reservation issues. This component gave the Nez Perce Tribe, in conjunction with an intergovernmental board comprised of the Tribe, U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), NMFS, and the State, use of 200,000 acre-feet of water stored in Dworshak Reservoir, located on the North Fork Clearwater River on the Reservation. This water can be used for flow augmentation and temperature control (cooling) in the lower Snake River in August and September. This measure is intended to benefit juvenile and adult fall Chinook and adult steelhead by shaping cool flows into September.

The Salmon/Clearwater component addresses fish habitat protection throughout the Salmon and Clearwater River basins through a cooperative agreement under Section 6 of the ESA that includes adoption of minimum instream flows by the State and establishment of a habitat trust fund. Consequently, the Idaho Water Resource Board now holds in trust for the public, minimum streamflow rights on over 200 rivers, streams, and creeks in the Salmon and Clearwater River basins that the Tribe identified as Tribal Priority Streams for critical spawning and rearing habitat for ESA-listed spring Chinook salmon, steelhead ("A" and "B" run), and fall Chinook salmon. The objective of establishing minimum streamflows is to ensure these streams are not dewatered to a level that impairs spawning and rearing or other ecological functions that support salmon, steelhead, and the aquatic environment. Appendix A provides additional information about the Salmon/Clearwater minimum streamflows.

Another element is the contribution by the United States of $38 million (in 2004 dollars) over the course of 5 years, beginning in 2007, for a habitat trust fund to implement fish and habitat protection projects. The purpose of the fund is to supplement monies otherwise available for habitat protection and restoration in the Salmon and Clearwater River basins. Congress has appropriated the 2007 dollars. The out-year funding is anticipated to be appropriated on an annual basis.

The Snake River Flow component addresses flows from the Snake River upstream of Brownlee Reservoir and the conditions for use of water for flow augmentation. The proposed actions described in Reclamation's 2004 Upper Snake BA and this 2007 Upper Snake BA are consistent with the terms of the Snake River Flow component of the Settlement. Of significance to Reclamation's upper Snake flow augmentation activities, the Settlement increases the probability of delivering 427,000 acre-feet of flow augmentation water. Prior to the SRBA and the Nez Perce Water Rights Settlement, Idaho law limited the volume of water that could be protected for flow augmentation to 427,000 acre-feet from all sources. In addition, the laws addressing flow augmentation were short-term and were typically renegotiated every few years or annually. Under the Settlement, Idaho Code § 42-1763B was reenacted to authorize the rental and protection to the state line of up to 427,000 acre-feet of water annually for flow augmentation from traditional sources for the 30-year term of the agreement (through 2034). It also provided that Reclamation could rent or acquire for protection to the state line 60,000 acre-feet of water from natural water right holders along the Snake River. Also authorized was the release and protection of water stored in reservoir powerhead space to firm up the ability to provide 427,000 acre-feet. These provisions improve Reclamation's ability to provide water for flow augmentation by increasing the long-term probability of obtaining 427,000 acre-feet, and in some years providing as much as 487,000 acre-feet, and by minimizing the uncertainties related to the ability to protect the water in accordance with State law.

1.5 Integration with Federal Columbia River Power System Remand

In *American Rivers v. NOAA Fisheries*, Judge Redden ordered that the upper Snake remand be integrated with the Federal Columbia River Power System (FCRPS) remand to ensure a comprehensive analysis. However, he affirmed that the agencies were not required to address FCRPS and upper Snake actions in one BiOp and allowed for separate consultations and separate BiOps.

The FCRPS Action Agencies (Reclamation, USACE, and BPA) have undergone ESA Section 7 consultation on the effects of the FCRPS actions on listed salmon and steelhead since the early 1990s. The current FCRPS litigation began in 2001 when the National Wildlife Federation et al. (NWF) challenged the adequacy of the 2000 FCRPS

BiOp. In 2003, Judge Redden, U.S. District Court of Oregon, found the 2000 FCRPS BiOp “arbitrary and capricious” and remanded it to NMFS. NMFS completed a revised FCRPS BiOp in November 2004. The NWF challenged the 2004 FCRPS BiOp, and in October 2005, the Court ordered a remand of the 2004 FCRPS BiOp to make a jeopardy determination that complies with the ESA and legal deficiencies. In accordance with the Court’s instructions, NMFS and the Action Agencies are collaborating with four states and seven Tribes to revise the 2004 FCRPS BiOp to develop actions to include in the proposed action, clarify policy issues, and narrow areas of disagreement on scientific and technical information.

The remand consultation on Reclamation’s upper Snake actions is proceeding simultaneously with the FCRPS remand collaborative process. The Federal agencies are working together to implement the Court’s instructions in *American Rivers v. NOAA Fisheries* and have developed a comprehensive analysis of the effects of Reclamation’s upper Snake actions together with the effects of the FCRPS actions. The comprehensive analysis is contained in the *Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions* (hereafter *Comprehensive Analysis)* (USACE et al. 2007b) and includes an evaluation of the effects of: (1) the proposed FCRPS actions, (2) the proposed upper Snake actions, (3) the environmental baseline, and (4) cumulative effects. The analysis comprehensively evaluates all these effects, factoring species status, and applies the jeopardy framework described in memoranda prepared by Robert Lohn, NMFS Regional Administrator, dated July 12, 2006, and September 11, 2006 (Lohn 2006b and 2006a). Two separate BiOps are requested – one that addresses the effects attributed to the FCRPS and one that addresses the upper Snake effects. This 2007 Upper Snake BA provides information specific to the upper Snake that was incorporated into the *Comprehensive Analysis*.

The upper Snake projects and the FCRPS are operated independent of each other. However, both operations hydrologically influence flows in the Snake and Columbia Rivers. Any flow-related effects to listed salmon and steelhead due to operation of Reclamation’s upper Snake projects occur well downstream of these projects, because no listed salmon or steelhead occur in the vicinity of Reclamation’s upper Snake storage reservoirs or diversion structures. The upper Snake actions directly affect inflows to Brownlee Reservoir. From here, Idaho Power Company regulates flows through the Hells Canyon Complex. The analysis of the effects of upper Snake actions in this 2007 Upper Snake BA begins at the toe of Hells Canyon Dam and extends downstream to the Columbia River estuary. FCRPS effects occur in much of the same area as well as other areas, such as reaches of the Columbia River and certain tributaries above its confluence with the Snake River.

1.6 Comprehensive Analysis

In order to integrate the upper Snake and FCRPS analyses, the action agencies incorporated information from both river basins into biological analyses for each ESU or DPS so that a collective or comprehensive conclusion can be made as to the status of each. These biological analyses provide the foundation for a comprehensive analysis that will inform the Upper Snake and FCRPS BiOps and are contained in a separate document entitled *Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions* (*Comprehensive Analysis*) (USACE et al. 2007b).

The analyses estimate changes in both survival and recovery metrics in a step-wise fashion taking into account recently implemented or planned changes in hydropower operations and configuration, improvements in tributary and estuary habitat (short- and long-term), reduced predation, and changes in hatchery and harvest management. The first adjustment of population-level metrics was from a historical base period to current conditions (base-to-current), and the second adjustment was from current conditions to expected future status (current-to-prospective). The analysis contained in the *Comprehensive Analysis* document relies on commonly used and accepted biological metrics that measure life cycle survival, as well as estimated extinction risk under different modeling assumptions.

This step-by-step process was followed to assess the collective effects and benefits for each ESU and DPS for actions in five areas—hydropower, habitat, harvest, hatchery, and predation. The upper Snake flow effects are combined with the FCRPS flow effects and evaluated in the hydropower effects analysis. The following generally describes this hydropower analysis. Refer to Chapter 3 and Appendix B of the *Comprehensive Analysis* (USACE et al. 2007b) for a more detailed description of this analysis.

The agencies relied on both hydrologic and biological model outputs and previous analyses for assessing the combined flow effects attributable to hydropower actions (Federal and private) on the Snake and Columbia Rivers. The analysis included an assessment of Federal storage, diversion, flood control, and hydropower generation both above and below Brownlee Dam and their effect on mainstem Snake and Columbia River flows. It also examined the combined flow effects attributed to Reclamation's and private activities in the upper Snake River as well as those attributed to FCRPS operations and private operations in the lower Snake and Columbia Rivers. The analysis incorporated an ESU-by-ESU (and DPS-by-DPS) analysis for three primary time periods of hydropower system existence: the base (corresponding to the general conditions that were experienced by juveniles during the 1980-2001 outmigrations); current; and prospective conditions—with results reported as an average across all water years.

Reclamation's MODSIM model was used to estimate the hydrologic effects resulting from operations and existence of the upper Snake projects. Reclamation's Upper Snake River MODSIM hydrology model (2007 version) developed monthly inflows to Brownlee Reservoir taking into account all Reclamation operations (storage of water, release from storage, diversion for irrigation or other purposes, delivery for flow augmentation, pumping of ground water, and project return flows), private activities (private storage dams, diversions of private water rights into private canals, private pumping of ground and surface water, and return flows), and variable weather conditions (based on the period from 1928 through 2000). Appendix B and Chapter 3 of this BA provide additional information about the Upper Snake MODSIM model and the modeled analyses.

The Brownlee Reservoir inflows developed by MODSIM were then incorporated as input into the HYDSIM model. The HYDSIM model, among other things, simulates flow conditions at key locations in the mainstem Snake and Columbia Rivers resulting from operation of the FCRPS, upper Snake, and non-Federal dams, including the major Canadian projects on the mainstem Columbia River. The modeled flows developed by HYDSIM are thus inclusive of all flow effects that occur in the Snake River basin above and below Brownlee Dam and on the Columbia River, including shifts in timing and depletions associated with Federal storage operations, flood control, hydropower generation, and water deliveries as well as all private activities, including depletions for irrigation, hydropower, and other activities. The HYDSIM model runs were made to simulate both the current and prospective operations.

Data output from the HYDSIM model, representing the combined flow conditions associated with Federal and non-Federal activities in the upper Snake, lower Snake, and Columbia Rivers, were then input into the NMFS' COMPASS model. The COMPASS model used the combined flow conditions and spill levels developed by HYDSIM (along with estimated water temperatures) as input to estimate the combined direct survival of smolts to below Bonneville Dam (the survival of smolts migrating "inriver" through the mainstem FCRPS dams plus the survival of smolts transported from the Snake River collector projects). Finally, the COMPASS smolt survival estimates were adjusted to derive estimated changes in below-Bonneville survival, based on changes in smolt-to-adult returns associated with estuary arrival time resulting from proposed management actions for "inriver" and transported juveniles (using the Scheurell and Zabel hypothesis). The COMPASS survival outputs were developed for current and prospective conditions (see Appendix B, *Comprehensive Analysis* for COMPASS results (USACE et al. 2007b).

Relative changes in hydropower survival were estimated for base-to-current and current-to-prospective periods. This information was then incorporated into the biological analysis, which combined the survival improvements calculated for hydropower with those developed for habitat, hatchery, harvest, and predation to determine the prospective or future status of each ESU and DPS. The methods used for analysis of habitat, hatchery, harvest and predation actions are described in Chapter 3 and Appendices C through G of the *Comprehensive Analysis* (USACE et al. 2007b) and form the basis for determinations about jeopardy and adverse modification to designated critical habitat for the combined actions.

1.7 Duration of Proposed Actions

In 2004, Congress passed the Snake River Water Rights Act of 2004 which implements the Nez Perce Water Rights Settlement Agreement. The Snake River Water Rights Act provides in pertinent part: "the Secretary of Interior and the other heads of Federal agencies with obligations under the Agreement shall execute and perform all actions, consistent with this Act, that are necessary to carry out the Agreement." See Snake River Water Rights Act § 4, Pub. L. No. 108-447, 2004 U.S.C.A. (118 stat. 2809, 3433). The Settlement in turn provides: "The term of this [Snake River Flow] component of the agreement shall be for a period of thirty (30) years with opportunity for renewal upon mutual agreement" (see Settlement Term Sheet at Section III.A and III.K, Nez Perce Tribe et al. 2004). Thus, as specified by Congress, the term of Reclamation's proposed actions and upper Snake consultation is 30 years, commencing in 2005 through 2034.

The provisions of the Snake River Flow component of the Nez Perce Water Rights Settlement form the foundation for the proposed actions for this consultation. The Settlement provides a framework for administrative and legislative actions that make possible certain aspects of the proposed actions. For example, State protection of water provided for flow augmentation has been achieved through changes to Idaho State law enacted by the Idaho Legislature for the 30-year duration of the Snake River Flow component of the Settlement (through 2034). Similarly, Reclamation has secured a 30-year lease of 60,000 acre-feet of private natural flow water rights, granted solely under the authorities of the State of Idaho, pursuant to the same Idaho statute.

The term of the FCRPS Reasonable and Prudent Alternatives (RPA) is 10 years. The objective of the FCRPS consultation is to determine whether the 10-year program of actions will avoid jeopardy and adverse modification of critical habitat and whether it will result in a trend toward recovery for the ESUs and DPSs and the conservation values of primary constituent elements for designated critical habitat, including its future effects, beyond the last year of the program's implementation. The *Comprehensive Analysis* (USACE et al. 2007b) evaluates the effects from the FCRPS activities occurring through 2017.

The *Comprehensive Analysis* (USACE et al. 2007b) contains a quantitative and qualitative analysis of the combined upper Snake and FCRPS actions and considers various factors in addressing the risks of extinction and prospects for survival and recovery for listed salmon and steelhead through the year 2017 (a 10-year period). Section 1.6 of this BA briefly describes this analysis.

Reclamation recognizes the temporal difference between the FCRPS proposed RPA and the upper Snake proposed actions and the resulting challenge of conducting a comprehensive analysis of both actions. Under existing case law, Reclamation is required to conduct an analysis that is coextensive with the 30 year duration of the actions proposed in this 2007 Upper Snake BA. In order to evaluate the effects of the upper Snake actions through the year 2034, Reclamation assumed that FCRPS operations would continue as proposed in the FCRPS BA (USACE et al. 2007a). Reclamation used modeled hydrologic data from MODSIM and HYDSIM to use as part of a qualitative analysis of the hydrologic effects of the upper Snake actions for the years 2017 through 2034. This qualitative analysis is contained in Chapter 4 of this 2007 Upper Snake BA. The modeled MODSIM and HYDSIM data are contained in Chapter 3.

Reclamation will review the upper Snake consultation in 2017 to determine whether a continuation of the proposed action is acceptable given the conditions of the various populations at the ESUs and DPS at that time. This commitment ensures that if the FCRPS action changes after 2017, Reclamation will re-evaluate its analysis. Further, Reclamation and NMFS will continually review the status of listed salmon and steelhead, Reclamation's performance, and other factors to determine whether the triggers specified in 50 CFR 406.16 require earlier reinitiation of consultation.

1.8 Summary of Determinations of Effects for Species and Designated Critical Habitat

Table 1-1 summarizes the determination of effects for species and designated critical habitat. *Section 4.3, Effects Analysis* provides the details and rationale for the determinations.

Table 1-1. Summary of determinations of effects for species and designated critical habitat.*

ESU/DPS	Species Effects Determination	Critical Habitat Effects Determination
Snake River Spring/Summer Chinook Salmon ESU (*Oncorhynchus tshawytscha*)	MA, LAA	Affect
Snake River Fall Chinook Salmon ESU (*O. tshawytscha*)	MA, LAA	Affect
Snake River Sockeye Salmon ESU (*O. nerka*)	MA, LAA	Affect
Snake River Basin Steelhead DPS (*O. mykiss*)	MA, LAA	Affect
Upper Columbia River Spring Chinook Salmon ESU (*O. tshawytscha*)	MA, NLAA	Unmeasurable
Lower Columbia River Chinook Salmon ESU (*O. tshawytscha*)	MA, NLAA	Unmeasurable
Upper Willamette River Chinook Salmon ESU (*O. tshawytscha*)	MA, NLAA	Unmeasurable
Upper Columbia River Steelhead DPS (*O. mykiss*)	MA, NLAA	Unmeasurable
Middle Columbia River Steelhead DPS (*O. mykiss*)	MA, NLAA	Unmeasurable
Lower Columbia River Steelhead DPS (*O. mykiss*)	MA, NLAA	Unmeasurable
Upper Willamette River Steelhead DPS (*O. mykiss*)	MA, NLAA	Unmeasurable
Upper Willamette River Chinook Salmon ESU (*O. tshawytscha*)	MA, NLAA	Unmeasurable
Columbia River Chum Salmon ESU (*O. keta*)	MA, NLAA	Unmeasurable
Lower Columbia River Coho Salmon ESU (*O. kisutch*)	MA, NLAA	Not applicable

* MA, LAA = may affect, likely to adversely affect; MA, NLAA= may affect, not likely to adversely affect

Chapter 2 DESCRIPTION OF THE PROPOSED ACTIONS

2.1 Introduction

Reclamation's proposed actions in the upper Snake are described in its 2004 Upper Snake BA and supporting documents. The 2004 Upper Snake BA described 11 actions. A twelfth action was added by submittal of an Amendment to NMFS. Figure 2-1 shows the locations of facilities in the upper Snake River basin associated with the proposed actions. Tables 2-1, 2-2, and 2-3 present summary information on the Federal storage, diversion, and power facilities included in the 12 proposed actions. These features and facilities are part of 12 Federal projects (Baker, Boise, Burnt River, Little Wood River, Lucky Peak, Mann Creek, Michaud Flats, Minidoka, Owyhee, Palisades, Ririe, and Vale Projects).

These actions are briefly described here with reference to documents for more information about operations and routine maintenance activities. This 2007 Upper Snake BA proposes some changes to the proposed actions from that described in the 2004 Upper Snake BA.

2.2 Proposed Actions Description

The 12 proposed actions described here are authorized, funded, or carried out by Reclamation by virtue of Congressional or Secretarial authorizations, Congressional appropriations, and contracts with Reclamation. Reclamation received authorization for each of its projects from either Congress or the Secretary of the Interior, who had authority under the 1902 Reclamation Act to approve construction after a finding of feasibility. The Congressional and Secretarial authorizations state the purposes to be served by each project. Congress has directed in the Reclamation laws that Reclamation enter into contracts with project water users. These contracts set out, among other things, Reclamation's obligations to store and deliver project water to irrigation districts, municipalities, and other entities. Additionally, the 1902 Reclamation Act requires that Reclamation comply with state law with regard to control, appropriation, use, and distribution of waters. Water can only be stored and delivered by a project for authorized purposes for which Reclamation has asserted or obtained a state water right in accordance with Section 8 of the Reclamation Act of 1902 and applicable Federal law. Reclamation must honor senior or prior water rights in storing and diverting project water. Conversely, project water is protected from diversion by junior appropriators by state watermasters. The active cooperation of the state water rights administrators is essential in ensuring that any water Reclamation delivers for flow augmentation or any other purpose reaches the targeted points of delivery. Reclamation has no discretion except to deliver water in accordance with the project water rights and in accordance with state water law.

The upper Snake proposed actions include one or more of the following activities:

- Future storage of water in reservoirs and its release from dams that the United States owns. Storage and releases occur in accordance with authorized project purposes, Reclamation contracts, Federal law, and state water law.
- Future diversion or pumping of water into facilities that Reclamation owns or operates.
- Future hydropower generation at Reclamation powerplants.
- Future routine maintenance activities at dams, reservoirs, on-stream diversion structures and pumping plants, and Reclamation hydropower plants, regardless of whether the operation and maintenance responsibility has been transferred to another entity.
- Future provision of salmon flow augmentation by acquiring water through rental pools and leasing or acquiring natural flow rights consistent with the Nez Perce Water Rights Settlement (Nez Perce Tribe et al. 2004).
- Surveys of ESA-listed aquatic snails below Minidoka Dam.

Reclamation’s 12 proposed actions are listed below:

- Future operations and routine maintenance (O&M) in the Snake River system above Milner Dam (Michaud Flats, Minidoka, Palisades, and Ririe Projects).
- Future operations in the Little Wood River system (Little Wood River Project).
- Future O&M in the Owyhee River system (Owyhee Project).
- Future O&M in the Boise River system (Arrowrock Division of the Boise Project and the Lucky Peak Project).
- Future O&M in the Payette River system (Payette Division of the Boise Project).
- Future O&M in the Malheur River system (Vale Project).
- Future O&M in the Mann Creek system (Mann Creek Project).
- Future O&M in the Burnt River system (Burnt River Project).
- Future O&M in the upper Powder River system (Upper Division of the Baker Project).

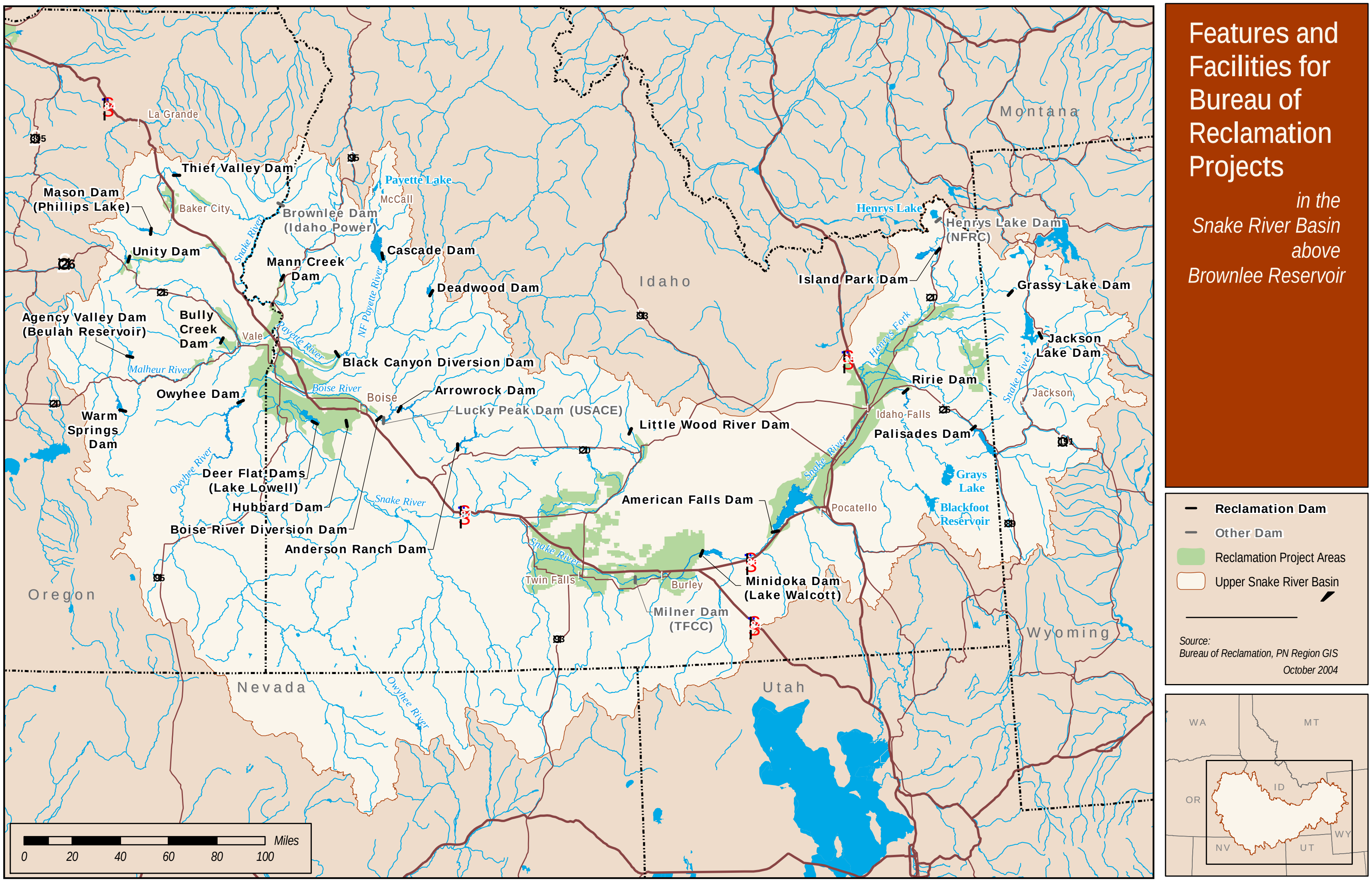

Figure 2-1. Features and facilities for Bureau of Reclamation projects in the Snake River basin above Brownlee Reservoir.

Table 2-1. Federal storage facilities included in the proposed actions.

Storage Facility [1]	Stream and River Mile	Active Capacity [2] (acre-feet)	Powerplant Owner	Operating and Maintaining Entity
Minidoka Project				
Jackson Lake Dam	Snake River 988.9	847,000	No powerplant	Reclamation
Grassy Lake Dam	Grassy Creek 0.5	15,200	No powerplant	Fremont-Madison Irrigation District
Island Park Dam	Henry Fork 91.7	135,205	Non-Federal	Fremont-Madison Irrigation District
American Falls Dam	Snake River 714.0	1,672,590	Non-Federal	Reclamation
Minidoka Dam	Snake River 674.5	95,200	Reclamation	Reclamation
Palisades Project				
Palisades Dam	Snake River 901.6	1,200,000	Reclamation	Reclamation
Ririe Project				
Ririe Dam	Willow Creek 20.5	80,541	No powerplant	Reclamation
Little Wood River Project				
Little Wood River Dam [3]	Little Wood River 78.8	30,000	Non-Federal	Little Wood River Irrigation District
Owyhee Project				
Owyhee Dam	Owyhee River 28.5	715,000	Non-Federal	Owyhee Irrigation District
Boise Project				
Anderson Ranch Dam	S.F. Boise River 43.5	413,074	Reclamation	Reclamation
Arrowrock Dam	Boise River 75.4	272,224	No powerplant	Reclamation
Hubbard Dam	New York Canal	1,177	No powerplant	Boise Project Board of Control
Deer Flat Dams	New York Canal	159,365	No powerplant	Boise Project Board of Control
Deadwood Dam	Deadwood River 18.0	153,992	No powerplant	Reclamation
Cascade Dam	N.F. Payette River 38.6	646,461	Non-Federal	Reclamation
Lucky Peak Project				
Lucky Peak Dam [4]	Boise River 64.0	264,371	Non-Federal	Army Corps of Engineers
Vale Project				
Warm Springs Dam [5]	Malheur River 114.0	169,714	No powerplant	Warmsprings Irrigation District
Agency Valley Dam	N.F. Malheur River 15.0	59,212	No powerplant	Vale Oregon Irrigation District
Bully Creek Dam	Bully Creek 12.5	23,676	No powerplant	Vale Oregon Irrigation District
Mann Creek Project				
Mann Creek Dam	Mann Creek 13.2	10,900	No powerplant	Mann Creek Irrigation District
Burnt River Project				
Unity Dam	Burnt River 63.6	24,970	No powerplant	Burnt River Irrigation District
Baker Project				
Mason Dam	Powder River 122.0	90,540	No powerplant	Baker Valley Irrigation District
Thief Valley Dam	Powder River 70.0	13,307	No powerplant	Lower Powder River Irrigation District

1 Reclamation owns all facilities unless otherwise indicated.
2 Active capacity is the volume of storage space that can be filled and released for specific purposes.
3 The Little Wood River Irrigation District owns the Little Wood River Dam.
4 The Army Corps of Engineers owns Lucky Peak Dam; Reclamation administers water service and repayment contracts for irrigation.
5 Reclamation has a one-half interest in Warm Springs Reservoir and associated storage.

Table 2-2. Federal diversion facilities included in the proposed actions.

Diversion Facility	Stream	Owner	Operating and Maintaining Entity
Minidoka Project			
Cascade Creek Diversion Dam	Cascade Creek	United States	Fremont-Madison Irrigation District
Minidoka Northside Headworks	Snake River	United States	Minidoka Irrigation District
Minidoka Southside Headworks	Snake River	United States	Burley Irrigation District
Unit A Pumping Plant	Snake River	United States	A & B Irrigation District
Milner-Gooding Canal Headworks	Snake River	United States	American Falls Reservoir District No. 2
Michaud Flats Project			
Falls Irrigation Pumping Plant	Snake River	United States	Falls Irrigation District
Owyhee Project			
Tunnel No. 1	Owyhee River	United States	Owyhee Irrigation District
Dead Ox Pumping Plant	Snake River	United States	Owyhee Irrigation District
Ontario-Nyssa Pumping Plant	Snake River	United States	Ontario-Nyssa and Owyhee Irrigation Districts
Gem Pumping Plants #1 and #2	Snake River	United States	Gem Irrigation District
Boise Project			
Boise River Diversion Dam	Boise River	United States	Boise Project Board of Control *
Black Canyon Diversion Dam	Payette River	United States	Reclamation
Vale Project			
Harper Diversion Dam	Malheur River	United States	Vale Oregon Irrigation District
Bully Creek Diversion Dam	Bully Creek	United States	Vale Oregon Irrigation District
Mann Creek Project			
Mann Creek Dam Outlet	Mann Creek	United States	Mann Creek Irrigation District
Baker Project			
Savely Dam and Lilley Pumping Plant	Powder River	United States	Lower Powder River Irrigation District

* The Boise Project Board of Control operates and maintains the dam. Reclamation operates and maintains the powerplant.

Table 2-3. Federal powerplants included in the proposed actions.

Powerplant	Stream	Impoundment	Nameplate Rating
Palisades Powerplant	Snake River	Palisades Dam	176,600 kW
Inman and Minidoka Powerplants	Snake River	Minidoka Dam	28,500 kW
Anderson Ranch Powerplant	South Fork Boise River	Anderson Ranch Dam	40,000 kW
Boise River Diversion Powerplant	Boise River	Boise River Diversion Dam	1,500 kW
Black Canyon Powerplant	Payette River	Black Canyon Diversion Dam	8,000 kW

- Future O&M in the lower Powder River system (Lower Division of the Baker Project).
- Future O&M in the upper Powder River system (Upper Division of the Baker Project).
- Future O&M in the lower Powder River system (Lower Division of the Baker Project).
- Future provision of salmon flow augmentation from the rental or acquisition of natural flow rights.
- Surveys and studies of ESA-listed aquatic snail species on Snake River above Milner Dam.

Figure 2-1 shows the locations of the 12 projects. Tables 2-1 through 2-3 show the facilities associated with each project.

The 2004 Upper Snake BA and Amendment (USBR 2004a and 2005a) describes the activities associated with these proposed actions. The *Operations Description for Bureau of Reclamation Projects in the Snake River Basin above Brownlee Reservoir* (2004b) comprehensively describes the authorities, future operations, and routine maintenance activities. The future operation and routine maintenance of the upper Snake projects remain substantially as described in these documents. However, Reclamation is proposing to make adjustments in the timing of flow augmentation water delivery, if NMFS deems the changes will benefit the listed Snake and Columbia River salmon and steelhead and their designated critical habitat.

2.3 Refinements to Upper Snake Flow Augmentation

Flow augmentation activities are associated with several of the proposed actions listed above, using water stored in Reclamation projects and also acquired natural flow rights. Acquisition and delivery of stored water is associated with three of the actions: O&M actions in the Snake River system above Milner Dam, the Boise River system, and the Payette River system. Acquisition and delivery of natural flow rights for flow augmentation is associated with O&M in the Malheur River system and the lease of 60,000 acre-feet of natural flow rights in the Snake River below Milner Dam.

Reclamation has continually modified its operations in the upper Snake to help protect and recover species that have been listed under the ESA. Beginning in 1991, Reclamation committed to delivering water to Brownlee Reservoir to augment flows below the Hells Canyon Hydropower Complex in the lower Snake and Columbia Rivers. Reclamation has continued to work to improve the reliability and amount of water available to augment flows, operating within applicable institutional and legal constraints. Reclamation's delivery of salmon flow augmentation from upper Snake River projects includes a release regime that considers the needs of the ESA-listed salmon and steelhead and other ESA-listed species such as snails in the Snake River and bull trout in the Boise and Payette River systems.

Appendix C provides background information on the history of upper Snake flow augmentation activities, sources of flow augmentation water, and the conditions associated with providing flow augmentation from the upper Snake given the context of Reclamation's project operations and the Federal and state regulatory environment. The following sections describe the biological hypothesis for shifting the timing of some upper Snake flow augmentation water and describes how Reclamation proposes to operationally implement the proposed shift.

2.3.1 Overview

Emerging data on juvenile Snake River fall Chinook salmon migration and continued analysis of temperature data indicate that a change in timing of upper Snake flow augmentation releases may be desirable. Accordingly, Reclamation is proposing to refine its flow augmentation activities to provide water earlier in the spring season, during the May to early July period, inasmuch as possible, as opposed to the current emphasis on delivery in the June to August period. Under the current and historical patterns of releases, Reclamation has generally provided water beginning after the spring freshet when maximum storage has been achieved (which typically occurs in June) and continuing through August 31, the end of the juvenile migration season at Lower Granite Dam (April 3 through August 31). These summer augmentation flows were targeted primarily to improve conditions for Snake River fall Chinook salmon as they were then understood. However, after approximately mid-July, and especially in August, it is often necessary to provide releases of colder water from Dworshak Reservoir to prevent the occurrence of critically warm temperatures in the lower Snake River. While the current timing of augmentation releases from the Snake River provides a flow benefit, it can exacerbate this temperature control problem as water temperatures from Brownlee Reservoir releases can be warmer than desired.

NMFS staff have recommended that the regional priority on flow augmentation for the summer period be relaxed, with flow augmentation water from the upper Snake best delivered by July 31 (Graves et al. 2007). Since the 1990s, upper Snake flow augmentation was managed to benefit juvenile Snake River fall Chinook salmon migrating during the July and August period. At that time the ESU was at an extremely depressed level. However, data now indicate that the majority of the Snake River fall Chinook ESU are actively migrating primarily in June and early July rather than in July and August in the Snake River, with 95 percent of the juveniles migrating past Lower Granite Dam by mid-July in recent years (2004-to-2006) (Cook et al. 2007).

Population metrics for Snake River fall Chinook salmon are much stronger than those of most spring migrating ESUs in the interior Columbia River basin (Good et al. 2005). Accordingly, NMFS is recommending that upper Snake flow augmentation delivery be shifted to an earlier release to provide more benefit to spring and early summer migrants. This shift in timing is anticipated to benefit Snake River and Columbia River ESUs/DPSs. NMFS' staff recommendation is currently undergoing formal review by its Northwest Fisheries Science Center. Changing the release timing would also avoid increasing summer releases from Hells Canyon Dam when water temperatures are warmer than desired. In addition, providing water earlier may conserve Dworshak Reservoir storage and may improve the efficacy of Dworshak Reservoir releases. The proposed timing shift for upper Snake flow augmentation delivery has been incorporated into the *Comprehensive Analysis* (USACE et al. 2007b) and is included in the effects analysis of this BA. NMFS will also consider this proposed refinement as it prepares biological opinions for the FCRPS and Upper Snake remand consultations.

Based on these observations and NMFS' recommendations, Reclamation has investigated shifting reservoir releases for flow augmentation to earlier in the spring subject to confirmation of the biological benefits by NMFS. Reclamation reviewed system operational flexibility, state accounting procedures, and operational thresholds identified to minimize incidental take for other ESA-listed species (bull trout and aquatic snails) to determine if it would be possible to shift the timing of flow augmentation to release more water during the spring, which would more closely mimic the shape of the natural spring freshet. Reclamation has made an initial determination that it can achieve this and still operate within the range of operations articulated in the 2004 Upper Snake BA and supporting documents. This shift in delivery of flow augmentation water can be accomplished in accordance with the Nez Perce Water Rights Settlement.

Reclamation is willing to modify the flow augmentation releases, within the limits established by the Nez Perce Water Rights Settlement, in a manner that best serves the needs of listed salmon and steelhead as determined by NMFS and supported by the science. Reclamation proposes to use an adaptive management approach with respect to its flow augmentation releases from the upper Snake and can refine releases to an earlier timeframe if NMFS confirms its biological benefits. Conversely, if new data reveal that a different schedule would better benefit listed fish, or that a shift in timing from the mid-July through August period to the spring period is not helpful, Reclamation will adapt accordingly, within the constraints defined in the Nez Perce Water Rights Settlement and described in Chapter 2 and documents referenced there.

Anticipated flows under current flow augmentation management were modeled and described in the 2004 Upper Snake BA. Reclamation has conducted additional modeled analyses presented in this 2007 Upper Snake BA to assess operational flexibility to implement the proposed refinements to flow augmentation management. It is important to note that the annual volume would not change, only the timing of augmentation delivery.

Reclamation proposes to address its year-to-year decisions on managing reservoir releases for flow augmentation with the Technical Management Team (TMT), which coordinates in-season flow augmentation from the FCRPS. The TMT is an interagency technical team that makes recommendations on FCRPS dam and reservoir operations for ESA-listed salmon. Membership includes representation from the FCRPS action agencies (Reclamation, BPA, and USACE), NMFS, and Tribal and state fish managers. While Reclamation is proposing to follow an adaptive management approach in providing water for flow augmentation, it is important to note that limitations exist. For example, Reclamation typically makes flow augmentation decisions in April and May and may need significant lead time in order to change the start date for flow augmentation releases from those established. Possible effects on other ESA-listed species will need to be considered for the timing and volume of releases, as would constraints on changes in river stages after the spring freshet.

The proposed operations described here are an example of what could be done and also represent the system operational flexibility that Reclamation believes to be possible. Actual implementation of earlier spring flow releases may require a transition period to develop smooth operations and address the institutional and administrative issues. Some examples may include: agreement on accounting procedures; estimating available water for flow augmentation prior to full reservoir accrual; irrigator willingness to commit rental volumes prior to final fill; public concerns about not filling reservoirs completely; and the challenge of balancing these operations so as not to affect the resident ESA species including bull trout and aquatic mollusks. In spite of these considerations, Reclamation believes that most reservoir storage releases for flow augmentation can be shifted from the current period of June through the end of August to a primarily May to July period as described in the following text. Some storage releases will remain in August because of either operational constraints or water year type. Natural flow rights continue to be provided in the April 3 through August 31 period.

2.3.2 Proposed Flow Augmentation Operational Refinements

The following text describes the proposed operational refinements that can be implemented to shift flow augmentation delivery to the spring season. Appendix C provides background information on flow augmentation, including the potential sources of flow augmentation water.

2.3.2.1 Snake River above Milner Dam System

Reclamation obtains flow augmentation water using uncontracted storage, powerhead space in some years, and water leased from the Water District 01 Rental Pool and Shoshone-Bannock Tribes Tribal Water Bank (see Table C-1). The potential for earlier flow augmentation releases past Milner Dam, along with volume distribution, would largely depend on the water year type. Water is typically “spilled” past Milner Dam during the spring in most years. “Spill” past Milner Dam refers to natural flows that are in excess of demands for storage or irrigation, which essentially means any flow above zero cubic feet per second (cfs) (the State-recognized minimum flow). Flows are also released for a specific purpose, such as for flow augmentation or Idaho Power’s 200 cfs release to meet its Federal Energy Regulatory Commission (FERC) license requirement (when available) for the Milner Powerplant. The amount, rate, and timing of water passing Milner Dam are dictated most directly by the operations at American Falls Dam and Reservoir. A shift in the timing of flow augmentation delivery would attempt to provide augmentation water into the May through July timeframe, with the majority being released in May and June.

In very high runoff years, significant spill would occur throughout the entire spring past American Falls Dam, and subsequently Milner Dam (usually in excess of 10,000 cfs, and often lasting through most of June). Flood flows passing Milner Dam in high runoff years would likely preclude augmentation releases prior to late June/early July because of the magnitude of required reservoir releases for flood control. In addition, larger releases in those very wet conditions could exacerbate dissolved gas conditions at lower Snake and Columbia River dams. Once the high flood flows recede, flows from American Falls Reservoir could be held high and near the flood release rate (rather than ramping down to follow the receding inflow), to provide most or all of the annual flow augmentation volume during July. Alternatively, the flow augmentation release rate(s) could be selected to distribute the water into August if desired. In very low runoff years, the combination of low flows past Milner Dam and low volumes of flow augmentation water available would allow delivery of augmentation water in May, or even into April, if desired. Most years (53 of 73 years modeled) will fall in between the “very high runoff” and “very low runoff” year categories.

The spring freshet is spilled past Milner Dam as part of flood control operations; rather than quickly ramping down releases following the spring freshet, augmentation releases would begin at the tail end of the spring freshet, by continuing to release flows past Milner Dam at close to the same rate. For example, if 8,000 cfs were being spilled past Milner Dam, rather than ramping down at the end of the spring freshet, outflows could be held near the 8,000 cfs level for an additional 2 weeks to provide the entire flow augmentation volume from above Milner Dam. The start time each year would depend on flood control (spill) releases past Milner Dam and the volume of augmentation water to be provided, with flow augmentation provided after flood releases. Rates and timing would also rely on conditions in the lower Snake River and input from the Technical Management Team (or equivalent). In all years, American Falls Reservoir could be allowed to reach maximum contents before flow augmentation releases are started, yet still deliver the entire volume by mid-July.

Reclamation's current down-ramping rates at Milner Dam constrain the ability to accommodate an earlier delivery of augmentation water and would need to be relaxed. The 2004 Upper Snake BA proposed action defined augmentation release rates at Milner Dam of 1,200 cfs to 3,000 cfs, beginning after June 20 and continuing through August, with a down-ramping rate of 100 cfs per day. The release rates at Milner Dam required to effectively shift augmentation to earlier in the season will likely need to be in the 3,000 cfs to 8,000 cfs range. These rates cannot be achieved with a ramping rate of 100 cfs per day. For example, flows of 3,000 cfs would take about 50 days with ramp down of 100 cfs per day to deliver augmentation water, which may render the timing shift ineffective. With flows of 8,000 cfs, it is not possible to implement a 100 cfs per day ramp rate without far exceeding the available volume of augmentation water.

Aquatic snails listed under the ESA occur in reaches of the Snake River above and below Milner Dam. Reclamation has initiated discussions with the U.S. Fish and Wildlife Service (USFWS) on this matter and expects to be able to change ramping rates in order to accomplish a shift in delivery timing without affecting the listed snails.

2.3.2.2 Boise River System

Reclamation obtains flow augmentation water in the Boise River system using uncontracted storage, powerhead space in some years, and, on rare occasions, water leased from the Water District 63 Rental Pool when made available by willing lessors (see Table C-1). Because of the relatively small volume of flow augmentation water that is derived from the Boise River system (approximately 41,000 acre-feet maximum), flexibility exists for refining releases to the May and June timeframe. However, flow augmentation releases must be balanced with the needs of ESA-listed bull trout that occur within and downstream of Arrowrock and Anderson Ranch Reservoirs.

In low runoff years with little or no flood control releases, operational flexibility exists to deliver flow augmentation water in May (or even April if desired). In all other water year types when flood control releases are necessary, two possible operating strategies could accomplish earlier delivery of flow augmentation. Flow augmentation releases could occur immediately after flood control operations. Flood control releases typically run several thousand cfs (or more) above irrigation demands. Near the end of flood control operations, rather than ramping down until irrigation demand is met, releases would be held at a higher rate until the entire flow augmentation volume is delivered. For example, an additional 2,060 cfs released for about 10 days would provide 41,000 acre-feet of flow augmentation. In years when the Boise River is near channel capacity, it would not be possible to release flow augmentation water until late June or early July. In most other years, operational flexibility would allow for earlier releases from late May to mid-June.

As an alternative strategy in years with flood control operations, Reclamation would operate to fill the Boise River system to a level less than an amount equivalent to the flow augmentation volume for that year (rather than filling to the maximum). For example, the capacity of the three storage reservoirs on the Boise River is 949,700 acre-feet. If Reclamation determined that 41,000 acre-feet is available for flow augmentation from those reservoirs, it would lower the target "full" volume to 908,700 acre-feet, and only fill to this reduced volume. It is important to recognize that in such an example, some water may be temporarily stored in the top 41,000 acre-feet of reservoir storage, depending on the magnitude and timing of the spring freshet, to safely manage spring flood flows. This water would, however, be evacuated as quickly as practical. The result of this activity would be that the physical peak reservoir storage would be 41,000 acre-feet less than reservoir capacity. This action would be completed by the time the spring freshet ended, which may occur as early as April in dry water years or as late as late June or even early July in wet years. Reservoir accounting would properly identify the flow augmentation volume provided.

2.3.2.3 Payette River System

Reclamation obtains flow augmentation water in the Payette River system using uncontracted storage and water leased from the Water District 65 Rental Pool (see Table C-1). Operational flexibility in the Payette River system to make earlier flow augmentation releases is not as great as for the Snake River above Milner Dam or Boise River systems because of a wide variety of issues that include high flood control releases, impacts to water quality, safety issues, and ESA-listed bull trout that are present within and below some reservoirs. However, there is some flexibility in most years to modify delivery of about 40,000 acre-feet from Cascade Reservoir into the May/June timeframe of the total 95,000 acre-feet of storage Reclamation has made available for flow augmentation in the Payette River system.

Cascade Reservoir is a water quality limited resource and it has been determined that reduced summer water volumes may contribute to failures to meet water quality standards. Therefore, Reclamation has limited ability to shift all Cascade Reservoir releases out of the late July through end of August period. Reclamation could reduce the maximum fill at Cascade Reservoir by 40,000 acre-feet (or 1.5 feet below full pool elevation), except during emergency flood control operations, thus releasing some flow augmentation water by the time the spring freshet is complete. Any water stored in this space during emergency flood control operations would be temporary and evacuated as soon as possible.

In an alternative operational strategy, Reclamation could provide 40,000 acre-feet of augmentation water by maintaining higher releases immediately following the spring freshet, rather than ramping down to follow the inflow recession.

In very low water years, when less than 40,000 acre-feet total augmentation water is available from the Payette system, it is assumed all augmentation water would be provided in May. This water year type occurs in only 3 of the 73 years modeled.

In other low water years, when total augmentation volumes from the Payette system are less than 95,000 acre-feet but greater than 40,000 acre-feet, it is assumed releases would occur in the May through July period, with no August releases available. This occurs in 10 of the 73 years modeled.

In all other years, provision of flow augmentation would continue into the months of July and August. The 40,000 acre-feet of augmentation provided in May and June is essentially shifted from the current July and August delivery timeframe

Deadwood Reservoir flow augmentation releases would continue to be managed to provide delivery by mid-July.

Cascade Reservoir would be drafted to the same September 1 elevation with this operational strategy as with current operations. The reservoir would be 40,000 acre-feet lower than typically occurs for current operations on July 1, and 20,000 acre-feet lower on August 1. However, these elevations are not considered significant differences and are still within the operational ranges described in the 2004 Upper Snake BA.

It is believed that this operation could be achieved without materially impacting water quality and could marginally improve some conditions by allowing for the establishment of vegetative cover along the shoreline. This operation would greatly reduce shoreline erosion that occurs at full pool elevation and also offer an additional flood control buffer against late season rain events.

Chapter 3 HYDROLOGIC CONDITIONS

This chapter provides modeled hydrologic information for the upper Snake River basin. This information updates hydrologic information provided in the 2004 Upper Snake BA and is presented in three parts. Section 3.1 provides additional information regarding past and current hydrologic conditions in the Snake and Columbia River basins. Section 3.2 replaces the modeled analysis of the hydrologic effects from Reclamation's proposed actions provided in the 2004 Upper Snake BA; specifically assessing upper Snake flow augmentation volumes and timing, and the resulting flow conditions in the lower Snake and Columbia Rivers. Section 3.3 describes anticipated future hydrologic conditions in the Snake River at Brownlee Reservoir and downstream attributed to cumulative effects of non-Federal actions.

Most of the modeled analyses described here were conducted using the Upper Snake River MODSIM model, a general-purpose river and reservoir operations computer simulation model. The surface water distribution model, MODSIM Version 7, was used to analyze the flow effects of water development activities occurring upstream of Brownlee Reservoir, including Reclamation's proposed actions as described in this document. The Upper Snake River MODSIM model is an updated version of the model version used to conduct analyses described in the 2004 Upper Snake BA. See Appendix B for further discussion about these recent updates to the Upper Snake River MODSIM model.

3.1 Historical and Current Hydrologic Conditions

The 2004 Upper Snake BA describes historical hydrologic environmental baseline conditions and changes that occurred as a result of Reclamation's past operations as well as private upstream water development activities. The following text provides additional information on environmental baseline hydrologic conditions for the upper Snake River basin and the Columbia River basin, placing the hydrologic contributions of the upper Snake River in the context of flows in the larger mainstem Columbia River system.

3.1.1 Depletions in the Upper Snake River Basin

Reclamation conducted modeled analyses using MODISM to describe current flow conditions and the depletive effects attributed to its proposed actions as well as from private water development activities upstream. This information replaces information presented in the 2004 Upper Snake BA and is the most current information regarding depletive effects from water development activities located above Brownlee Reservoir in the upper Snake River basin. This analysis entailed comparisons of modeled inflows to Brownlee Reservoir for the 2007 Proposed Action scenario and for two other simulations that remove specific facets of water system development and land use practices. These two simulations include a “Without Reclamation” scenario and a “Naturalized Flow” scenario.

The modeled “Without Reclamation” scenario isolates the effects of Reclamation’s actions on Brownlee Reservoir inflows and the resulting downstream flow conditions to determine associated effects to listed salmon and steelhead below the Hells Canyon Complex. Through a rather complex analysis, this simulation removed Reclamation project operations from the model. A Brownlee Reservoir inflow hydrograph was calculated under the assumption that Reclamation’s storage projects no longer operated while private diversions and storage projects continued to operate. The development of the “Without Reclamation” scenario made no other assumptions as to how water users would react if Reclamation operations are not occurring. The “without Reclamation” hydrograph was then compared to Reclamation’s Proposed Action scenario in order to quantify the amount of water depletion occurring as a result of Reclamation’s upper Snake projects (see Table 3-1).

The modeled “Naturalized Flow” scenario represents inflows to Brownlee Reservoir that would be observed without the cumulative influence of all reservoir operations, irrigation diversions and groundwater pumping, both Federal and private, above Brownlee Reservoir. This “naturalized” hydrograph was compared to Reclamation’s Proposed Action scenario in order to quantify the amount of water depletion occurring as a result of all (Federal and private) irrigation practices (see Table 3-2). Very limited data exist on very early (pre- and early 1900s) diversions, and no data are available on pre-development flows of the Snake River. Accordingly, this “Naturalized Flow” scenario is only able to generally characterize the magnitude of the proposed action and cumulative effects attributed to the historical irrigation practices within the Snake River Basin on flows into Brownlee Reservoir.

Table 3-1. Modeled changes in flow into Brownlee Reservoir 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 cfs	Hydrologic Change percent	Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change Cfs	Hydrologic Change percent	Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change cfs	Hydrologic Change percent
October	17,726	17,331	396	2	13,905	14,166	-262	-2	12,247	12,661	-414	-3
November	19,903	24,161	-4,258	-18	15,735	20,629	-4,894	-24	14,053	18,045	-3,992	-22
December	19,259	24,354	-5,095	-21	15,431	20,678	-5,247	-25	12,700	17,247	-4,547	-26
January	34,405	28,772	5,634	20	17,472	20,153	-2,681	-13	12,174	17,152	-4,977	-29
February	34,295	28,548	5,747	20	18,586	22,328	-3,742	-17	12,091	17,588	-5,497	-31
March	46,161	44,065	2,097	5	20,712	26,218	-5,506	-21	11,957	18,538	-6,581	-35
April	54,281	56,760	-2,479	-4	28,842	35,502	-6,661	-19	11,652	14,767	-3,115	-21
May	55,860	75,034	-19,173	-26	31,306	43,349	-12,043	-28	12,122	15,076	-2,954	-20
June	44,760	66,988	-22,227	-33	26,899	36,088	-9,189	-25	9,358	9,464	-106	-1
July	17,607	17,248	359	2	11,798	9,740	2,058	21	6,981	4,915	2,065	42
August	12,386	7,412	4,974	67	9,840	5,996	3,844	64	6,736	4,261	2,475	58
September	14,433	10,331	4,102	40	11,888	8,477	3,411	40	8,446	6,419	2,028	32

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: Upper Snake River MODSIM, May 2007 run.

Table 3-2. Modeled changes in flow into Brownlee Reservoir comparing Reclamation's Proposed Action and Naturalized Flow scenarios for dry, average, and wet water year types. [1]

Month	Wet				Average				Dry			
	Proposed Action [2] (cfs)	Naturalized Flow [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Naturalized Flow [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Naturalized Flow [3] (cfs)	Hydrologic Change	
			cfs	percent			Cfs	percent			cfs	percent
October	17,726	20,968	-3,242	-15	13,905	16,901	-2,996	-18	12,247	15,546	-3,299	-21
November	19,903	19,603	300	2	15,735	15,770	-35	0	14,053	13,026	1,027	8
December	19,259	20,373	-1,113	-5	15,431	16,601	-1,170	-7	12,700	13,000	-301	-2
January	34,405	25,758	8,648	34	17,472	16,618	854	5	12,174	13,501	-1,327	-10
February	34,295	25,692	8,603	33	18,586	18,888	-302	-2	12,091	13,864	-1,773	-13
March	46,161	43,451	2,710	6	20,712	24,435	-3,723	-15	11,957	16,041	-4,084	-25
April	54,281	64,277	-9,996	-16	28,842	41,542	-12,700	-31	11,652	22,120	-10,467	-47
May	55,860	94,161	-38,300	-41	31,306	60,186	-28,879	-48	12,122	30,605	-18,483	-60
June	44,760	90,330	-45,570	-50	26,899	57,851	-30,952	-54	9,358	22,844	-13,485	-59
July	17,607	40,817	-23,210	-57	11,798	25,632	-13,834	-54	6,981	10,174	-3,193	-31
August	12,386	21,612	-9,226	-43	9,840	14,359	-4,519	-31	6,736	8,056	-1,320	-16
September	14,433	20,495	-6,061	-30	11,888	14,913	-3,025	-20	8,446	9,683	-1,237	-13

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 Naturalized Flow scenario simulates hydrologic conditions removing the cumulative influence of Federal and private reservoir operations, irrigation diversions, and groundwater pumping above Brownlee Reservoir.

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: Upper Snake River MODSIM, June 2007 run.

These model configurations were based on the most current available information, and the data availability dictated the techniques or assumptions made in its development. These scenarios are designed to make relative comparisons of modeled simulations. While every attempt was made to quantify and identify all land use influences, other minor effects exist that were difficult to quantify or even identify. The analyses that follow provide additional information about hydrologic effects associated with actions in the upper Snake, focusing on the combined flow effects attributed to Reclamation's proposed actions as well as the effects attributed to private water development activities that occur upstream of Brownlee Reservoir.

Tables 3-1 and 3-2 provide the modeled monthly inflows to Brownlee Reservoir comparing Reclamation's Proposed Action to the "Without Reclamation" scenario (see Table 3-1) and the "Naturalized Flow" scenario (see Table 3-2) for wet, average, and dry water year types. The amount of water depleted varies depending on hydrologic conditions each year. Model output data for the 1929 to 1998 period of record were sorted and categorized into wet, average, and dry water year types based on the modeled total annual volume into Brownlee Reservoir for the MODSIM Proposed Action scenario. The wet and dry water year types each constitute 10 percent of the years, whereas the average group of water year types comprises the remaining 80 percent. For each of these categories, the data were averaged and are provided in Tables 3-1 and 3-2.

Table 3-1 indicates that the greatest volume of monthly depletions resulting from Reclamation's proposed actions occurs in May and June in wet and average years, and February and March of dry water year types. In dry years, monthly depletions are more evenly distributed from November through May, with the greatest depletions occurring in February and March. In all water year types, Reclamation's proposed actions improve inflows to Brownlee Reservoir for the summer months (July and August) and September by as much as 67 percent. Reclamation's proposed actions reduce the total inflow into Brownlee Reservoir for the months of April through June combined by 22 percent during wet water year types. Total inflow into Brownlee Reservoir for the same period is reduced by 24 percent during average years whereas flow reductions in dry years comprise about 16 percent of total Brownlee Reservoir inflow for these same months. Conversely, Reclamation's proposed actions result in increased flow into Brownlee Reservoir by 27 percent for July through September during wet water years. During average and dry water years, modeled Brownlee Reservoir inflow for this period increased by 38 percent and 42 percent, respectively. Reduced flows during the spring months are an artifact of Reclamation's projects storing a portion of the reservoir inflows for subsequent delivery during the summer irrigation months or flood control operations.

Table 3-2 indicates that the greatest volume of modeled monthly depletions from Reclamation's proposed actions and private diversions combined occurs in May and June in wet and average years. In dry years, the greatest volume of monthly depletions occurs in April through June. Increased flows occur in January and March in wet years because of project operations for flood control. Reclamation's proposed actions and private diversions combined reduce the total flow into Brownlee Reservoir for the months of April through June by 38 percent during wet water year types, reduce flow by 45 percent during average years, and reduce flow in dry years by 56 percent. During the summer months of July and August, depletions into Brownlee, comparing the Proposed Action to the Naturalized Flow scenario, comprise 52 percent of total flow under wet water year conditions, 46 percent of total flow in average water years, and about 25 percent in dry water years.

Table 3-3 presents the modeled average monthly and average annual depletion volumes for the Without Reclamation and the Naturalized Flow modeled scenarios. Average depletions into Brownlee Reservoir attributed to Reclamation's proposed actions total 2.3 million acre-feet annually for the 1928 to 2000 period of record. Modeled data for the Snake River basin for the 1928 to 2000 period indicate that all irrigation development, including Reclamation's actions and private diversions, have depleted average inflows into Brownlee Reservoir by approximately 6.0 million acre-feet annually.

3.1.2 Flow Conditions in the Snake and Columbia Rivers

Figure 3-1 shows the historical observed average monthly flows for the Snake and Columbia River systems from 1996 through 2006. Snake River flows are represented by plot lines showing observed inflows into Brownlee Reservoir and discharges at Lower Granite Dam. Columbia River flows are depicted for discharges below McNary and Bonneville Dams and below the Willamette River. The plot of the Columbia River below the Willamette River is the sum of the discharge from Bonneville Dam and the flow below Salem, Oregon, on the Willamette River. This calculation is an estimate of flows in the Columbia River near its mouth.

As shown in Figure 3-1, flows in the Snake and Columbia systems peak in May and June and are lowest in September and October. Higher flows in December and January at the Columbia River mouth result from higher flows on the Willamette River during these winter months (flows in the Willamette River are largely influenced by rainfall compared to the Columbia River which is largely influenced by snowmelt). Figure 3-1 shows the relative amount of water coming from the Snake River above Brownlee Dam and below Lower Granite Dam as compared to the total

Table 3-3. Modeled changes in average monthly volumes into Brownlee Reservoir comparing Reclamation's Proposed Action to the Naturalized Flow and Without Reclamation scenarios. [1]

Month	Comparing Proposed Action to Naturalized Flow				Comparing Proposed Action to Without Reclamation			
	Proposed Action [2] (acre-feet)	Naturalized Flow [3] (acre-feet)	Hydrologic Change		Proposed Action [2] (acre-feet)	Without Reclamation [4] (acre-feet)	Hydrologic Change	
			acre-feet	percent			acre-feet	percent
October	868,174	1,061,763	-193,589	-18	868,174	888,397	-20,223	-2
November	954,126	951,814	2,312	0	954,126	1,240,072	-285,946	-23
December	959,011	1,026,000	-66,989	-7	959,011	1,277,173	-318,162	-25
January	1,155,117	1,065,473	89,644	8	1,155,117	1,280,110	-124,994	-10
February	1,098,231	1,070,999	27,232	3	1,098,231	1,261,276	-163,045	-13
March	1,399,893	1,590,271	-190,378	-12	1,399,893	1,694,586	-294,693	-17
April	1,776,880	2,499,800	-722,920	-29	1,776,880	2,121,672	-344,792	-16
May	1,973,229	3,753,075	-1,779,846	-47	1,973,229	2,709,379	-736,149	-27
June	1,605,554	3,430,023	-1,824,470	-53	1,605,554	2,172,237	-566,684	-26
July	730,273	1,576,301	-846,028	-54	730,273	612,063	118,209	19
August	602,690	891,676	-288,987	-32	602,690	367,692	234,998	64
September	703,980	892,365	-188,385	-21	703,980	504,526	199,455	40
Average Annual	**13,827,157**	**19,809,559**	**-5,982,402**	**-30**	**13,827,157**	**16,129,185**	**-2,302,028**	**-14**

1 Period of Record: 1928 – 2000.

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

3 The Naturalized Flow scenario simulates hydrologic conditions removing the cumulative influence of Federal and private reservoir operations, irrigation diversions, and groundwater pumping above Brownlee Reservoir.

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

Source: Upper Snake MODSIM, May and June 2007 runs flow in the lower Columbia River. When monthly flows are compared, Snake River flows at Brownlee Reservoir contribute between 6 percent (July) and 14 percent (March) to the total flow of the Columbia River at McNary Dam and slightly less to the total Columbia River flow downstream.

The scale of Figure 3-1 does not allow one to discern the shape of the Snake River inflow into Brownlee Reservoir hydrograph because the graph must include Columbia River flows that exceed 325,000 cfs, and Snake River flows into Brownlee Reservoir are much smaller (flows up to about 30,000 cfs). Figure 3-2 shows the same historical observed average monthly inflow data for Brownlee Reservoir for the same 1996 through 2006 period at a different scale that better illustrates the shape of the hydrograph. Inflows peak at approximately 30,000 cfs during April and May when snowmelt occurs and are less, around 11,000 cfs, during the irrigation season in July, August, and September. Because the scale of Figure 3-2 is much smaller (only showing flows to 35,000 cfs), the Snake River curve is more clearly defined than is shown in Figure 3-1.

The historical average annual flow from 1996 through 2006 was approximately 14 million acre-feet into Brownlee Reservoir and about 36 million acre-feet below Lower Granite Dam. Model runs that were updated in 2007 for the Snake River upstream of Brownlee Reservoir using data for water years 1928 through 2000 indicated that the annual average difference in flows with and without the effect of Reclamation's operations was 2.3 million acre-feet (see Table 3-3). This difference in annual flow represents approximately 14 percent of the annual inflow to Brownlee Reservoir, and approximately 2 percent of the average annual flow of about 128 million acre-feet in the Columbia River at McNary Dam. These calculations indicate that the modeled differences in Reclamation operations on the Snake River have a small relative impact on the lower Columbia River flows.

Approximately 6.0 million acre-feet of average annual depletions at Brownlee Reservoir from all upstream diversions represents a 30 percent decrease annually on average to Brownlee Reservoir inflows, but comprises less than 5 percent of the total Columbia River flow at McNary Dam. This modeled analysis indicates that reductions in Snake River flows resulting from Federal and non-Federal irrigation in the upper Snake River basin most directly affect the Snake River below Hells Canyon Dam and to a lesser extent to Lower Granite Dam. However, depletions associated with actions in the upper Snake have a small effect compared to the magnitude of flows in the lower Columbia River flows.

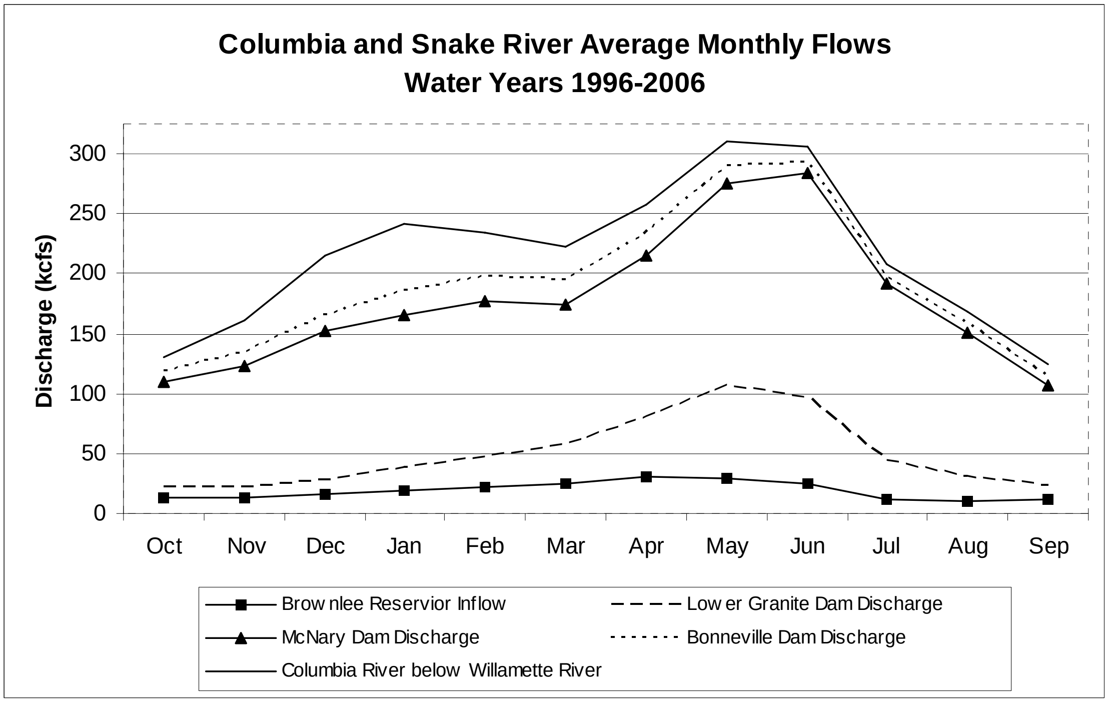

Figure 3-1. Average monthly flows for select locations on the Snake and Columbia Rivers.

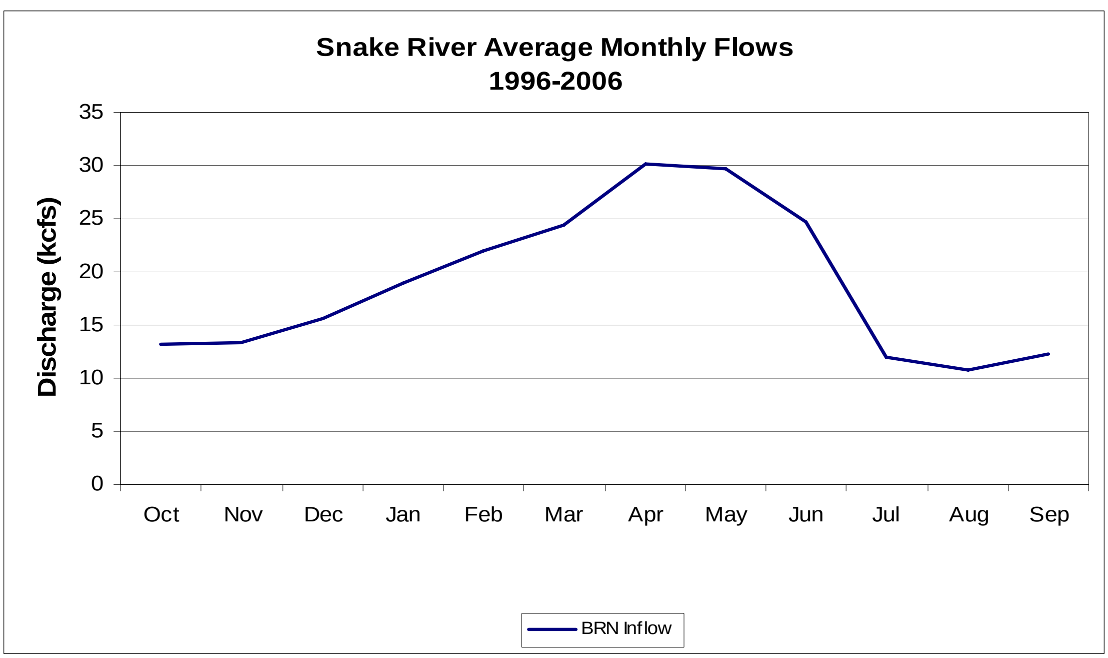

Figure 3-2. Average monthly flows for Snake River at Brownlee Reservoir.

With the exception of 2006, dry weather in southern Idaho has contributed to lower flows in the Snake River beginning in 2000. Figure 3-3 shows the annual average flows as measured by the U.S. Geological Survey (USGS) gage in the Snake River at Weiser. The lower flows in recent years are the result of a combination of low precipitation and the delayed influences of both groundwater pumping and water conservation practices.

Flow from springs along the Snake River has also decreased. The largest concentration of natural springs exists in the Snake River reach from Milner to King Hill, which includes the Thousand Springs. Figure 3-4 depicts spring discharge trends from 1902 to 2003, showing a general increase from 1902 to 1951 and a general downward trend to 2003. The flows peaked in 1951 at 6,820 cfs and had dropped to 5,200 cfs by 2003 (Ondrechen 2004; Kjelstrom 1995). Section 3.3 discusses the potential future hydrologic conditions in the upper Snake River basin given the current trends.

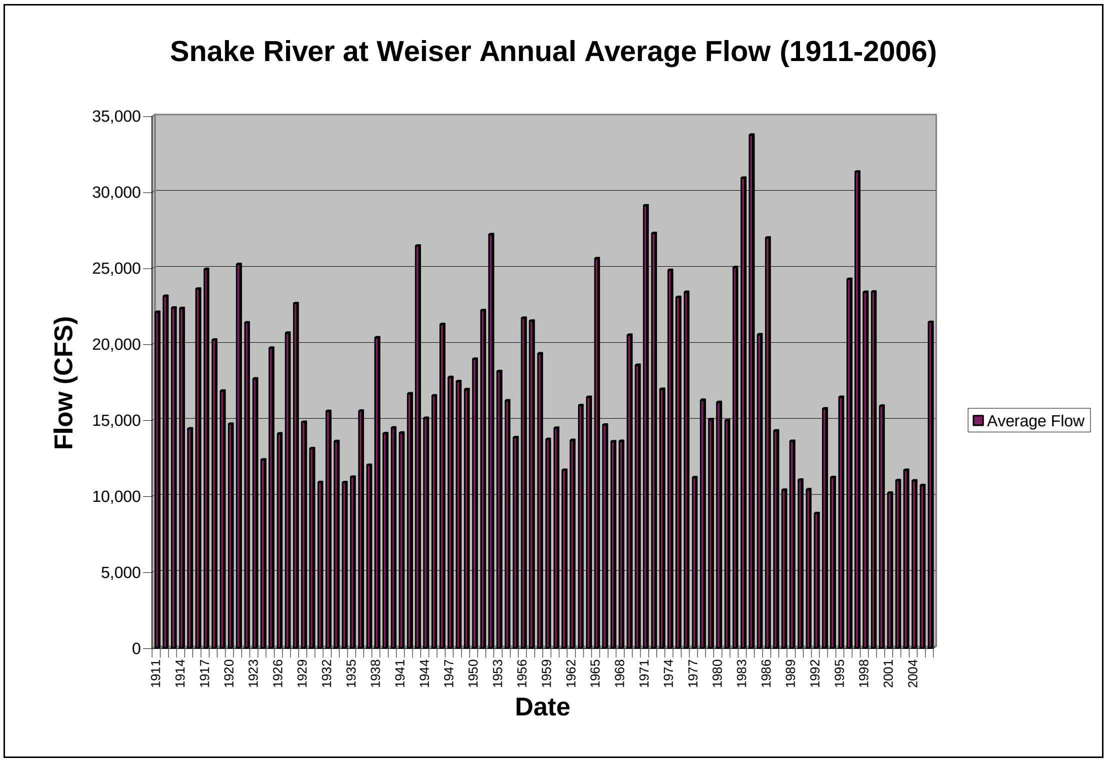

Figure 3-3. Average annual flow for the Snake River at Weiser for the 1911 to 2006 period.

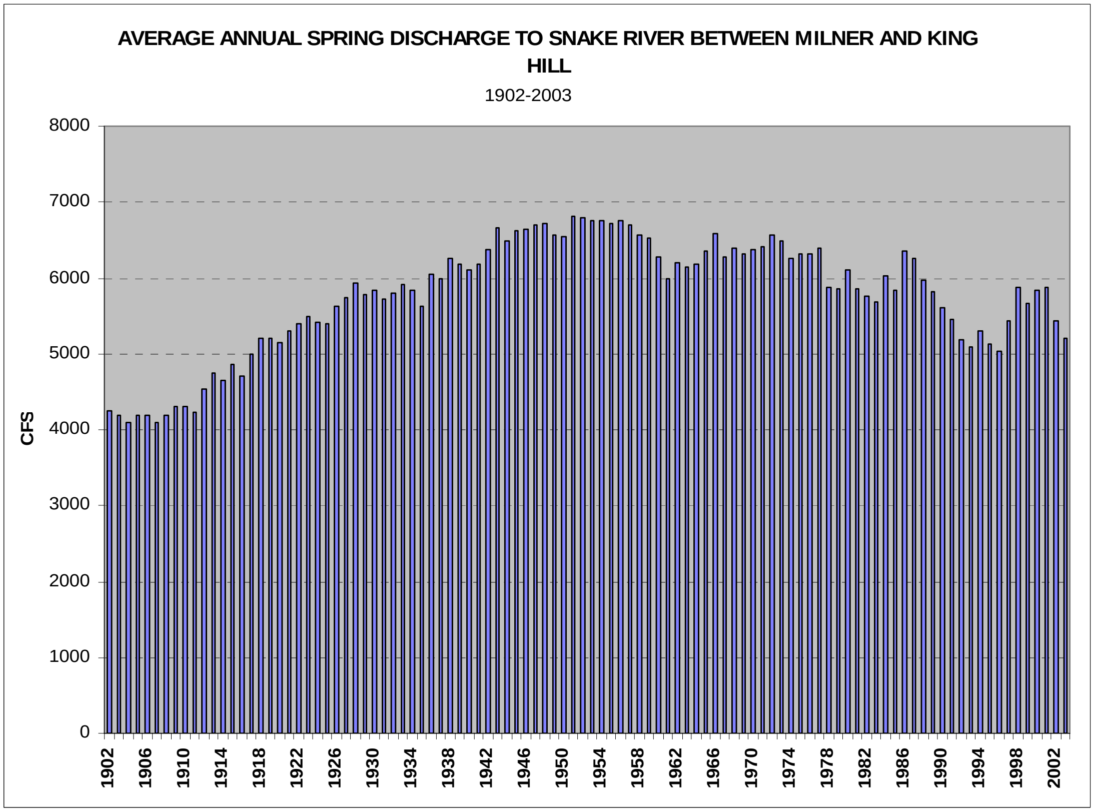

Figure 3-4. Average annual spring discharge to Snake River, Milner to King Hill reach, for 1902 to 2003 period (Source: Ondrechen 2004; Kjelstrom 1995).

3.2 Modeled Hydrologic Analysis of Proposed Actions

Chapter 2 described proposed refinements to Reclamation's proposed actions involving adjustments to the timing of upper Snake River flow augmentation delivery. The following text discusses the modeled hydrologic analyses of flow conditions anticipated to occur as a result of Reclamation's proposed actions, including the cumulative effects of private storage and diversions in the upper Snake on downstream flows. Information is provided on salmon flow augmentation quantities and frequencies during wet, average, and dry water years; the effect on river flows of shifting the timing of flow augmentation releases to earlier in the year; and the resulting flow conditions in the lower Snake River and Columbia River.

3.2.1 Modeled Analysis of Salmon Flow Augmentation

Reclamation has conducted modeled analyses to investigate the proposed refinements to flow augmentation management for this remand. The Upper Snake River MODSIM model used is an updated version of the model used in the 2004 Upper

Snake BA. The data summarized in the tables, graphs, and text were developed using the 2007 updated MODSIM model. Refer to Appendix B for background information on the MODSIM.

3.2.1.1 Upper Snake Flow Augmentation Volume Delivered

One of the challenges in providing flow augmentation is predicting the amount of available water. Reclamation is committed to improving the certainty of acquiring annual flow augmentation volumes. Flow augmentation largely relies on willing sellers offering water to Reclamation for lease. The availability of water for lease from Idaho's rental pools for flow augmentation varies with runoff volume, carryover storage, general rental pool conditions, and legal and institutional constraints. Many of these factors are outside of Reclamation's control. The best currently available estimate of Reclamation's ability to acquire water for this purpose under the proposed actions is that the future rental water availability will closely mimic recent conditions. Reclamation conducted a modeled analysis using the experience it has gained from past flow augmentation activities to identify flow augmentation volume goals by water year type to allow improved regional planning and management of river flows for the benefit of ESA-listed salmon and steelhead.

Table 3-4 is a matrix that represents the modeled range of potential augmentation water delivery to Brownlee Reservoir under various water year forecast and reservoir storage carryover conditions. The modeled data in Table 3-4 demonstrate that the April through September runoff forecast is the driving component for determining the potential volume available for flow augmentation each year. In general, the greater the runoff forecast volume, the greater the amount of augmentation water delivered. Similarly, the greater the volume of water in storage at the end of the previous irrigation season (carryover), the greater the amount of flow augmentation potential for the succeeding year. At this time, values in Table 3-4 represent a reasonable estimate of targeted flow augmentation volumes for delivery under recently experienced operating conditions and assumptions.

The relationship among forecast, carryover, and subsequent flow augmentation volume is not exact. Other factors, especially actual runoff versus forecast runoff (that is, effects of nature), can influence these relationships and, in turn, produce different results under actual operating conditions than those produced in the model. The flow of the Snake River above Hells Canyon Dam is highly variable. Total annual historical flows range from a minimum of 6,428,000 acre-feet in 1992 to a maximum of 24,504,000 acre-feet in 1984. Maximum annual storage volume in Reclamation's seven storage reservoirs above Milner Dam has ranged from 2,254,000 acre-feet in 2004 to 4,045,695 acre-feet, the maximum storage capacity. The system is rarely completely full, but fills to within 100,000 to 200,000 acre-feet of maximum in roughly 40 percent of the years.

Table 3-4. Matrix of modeled flow augmentation volume by water year type and reservoir carryover. [1]

Total November 1 Carryover Volume [3]	Total April 1 Forecast [2]		
	Less than 5,400,000 acre-feet *(represents dry years)*	**5,400,000 to 8,699,999 acre-feet** *(represents average years)*	**8,700,000 acre-feet or greater** *(represents wet years)*
Less than 2,400,000 acre-feet *(represents dry years)*	average: 198,000 minimum: 146,000 maximum: 254,000	average: 391,000 minimum: 277,000 maximum: 428,000	average: 452,000 minimum: 427,000 maximum: 477,000
2,400,000 – 3,599,999 acre-feet *(represents average years)*	average: 360,000 minimum: 191,000 maximum: 487,000	average: 475,000 minimum: 396,000 maximum: 487,000	487,000
3,600,000 acre-feet or greater *(represents wet years)*	average: 370,000 minimum: 204,000 maximum: 464,000	487,000	487,000

1 Assumptions: (1) The modeled period of record is from water years 1928 through 2000; (2) The calculated unregulated runoff volumes were sorted and divided into fourths, based on modeled output, to represent dry (bottom fourth), average (two middle fourths), and wet (top fourth) water years; and (3) The carryover volumes were similarly divided, based on modeled output, to represent dry, average, and wet water years.

2 Combined April 1 through September 30 total unregulated runoff forecast for Snake River at Heise, Payette River at Horseshoe Bend, and Boise River at Lucky Peak.

3 Combined November 1 contents (active storage) at Grassy Lake, Jackson, Palisades, Ririe, American Falls, Walcott, Island Park, Anderson Ranch, Arrowrock, Lucky Peak, Deadwood, and Cascade Reservoirs.

Source: Snake River MODSIM, May 2007

Table 3-4 illustrates a simplified version of a very complex system of water accounting and delivery on the Snake River. Actual operations are based on real-time, imperfect forecasts that ultimately influence the amount of water available for augmentation. In addition, actual augmentation volumes assume that a willing seller of reservoir storage water exists. Historically, rental water can be a substantial portion of the total augmentation water in the system comprising as much as 67 percent and as little as 10 percent of the total volume delivered. Rental water has averaged 42 percent of the total volume of flow augmentation delivered in a year.

Reclamation's modeled analyses predict that Reclamation will be able to provide a significant volume of water for flow augmentation in every year (see Table 3-4). Although the full 487,000 acre-feet cannot be guaranteed in all years, at least 400,000 acre-feet would be available in 7 of 10 years. In dry years, such as the 1-in-10 year occurrence, it is expected that 279,000 acre-feet would be available for flow augmentation. In dry years such as 1994, the modeled augmentation volume of 251,245 acre-feet would be 9.6 percent of the April through August inflows into Brownlee Reservoir. In wet years such as 1999, the modeled 487,000 acre-feet would equal 5.4 percent of the April through August Brownlee Reservoir inflows.

3.2.1.2 Timing of Salmon Flow Augmentation Water Delivery

As discussed above, Reclamation is proposing to refine its flow augmentation activities to deliver water at times most beneficial to ESA-listed salmon and steelhead. *Chapter 2, Description of the Proposed Actions* describes how Reclamation would operate to provide flow augmentation water earlier in the season.

Figure 3-5 illustrates current delivery of flow augmentation and how it can be adapted to shift the timing of some flow augmentation releases to earlier timeframes. These estimated volumes are an example of how Reclamation could release water for flow augmentation. Year-to-year water conditions and reservoir carryover storage will dictate specific operations.

Table 3-5 provides the modeled inflows to Brownlee Reservoir resulting from the proposed actions and other upstream water development activity under dry, average, and wet water year types. The table also identifies the proportion of inflows that are comprised of flow augmentation water. In wet water years, flow augmentation would be delivered predominantly in the summer months as system capacity and flood control operations would constrain the ability to deliver it in the spring, comprising 13 to 14 percent of Brownlee Reservoir inflow in the summer (see Table 3-5). In dry or average water years, Reclamation would have the operational flexibility to shift delivery of some flow augmentation water to earlier in the spring season to more closely mimic the spring freshet. In these years, modeled flow augmentation comprised 6 to 7 percent of May and June inflow to Brownlee Reservoir in average years and almost 12 percent of Brownlee Reservoir inflow in dry years.

Operational constraints at some Reclamation projects (described in *Section 2.3.2, Proposed Flow Augmentation Operational Refinements*) provide challenges to shifting the timing of flow augmentation water delivery to Brownlee Reservoir. The augmentation contribution in the month of April is consistent for all water year types. The dry water year types have low Brownlee Reservoir inflows when compared to the other years. However, Table 3-5 illustrates that in dry type water years, the flow augmentation contribution is almost 12 percent in May and June. The flow augmentation component in wet and average type water years ranges between 11.5 and 15.0 percent, but is instead delivered during the months of July and August.

In very wet years with high spring through early summer flows in the lower Snake and Columbia Rivers, dam operators are challenged to meet established standards for total dissolved gas. Reclamation would delay the start of augmentation releases in those situations, but would still attempt to provide augmentation releases before the end of July, where possible. The constraints associated with some project operations require that some flow augmentation water will still be provided during August.

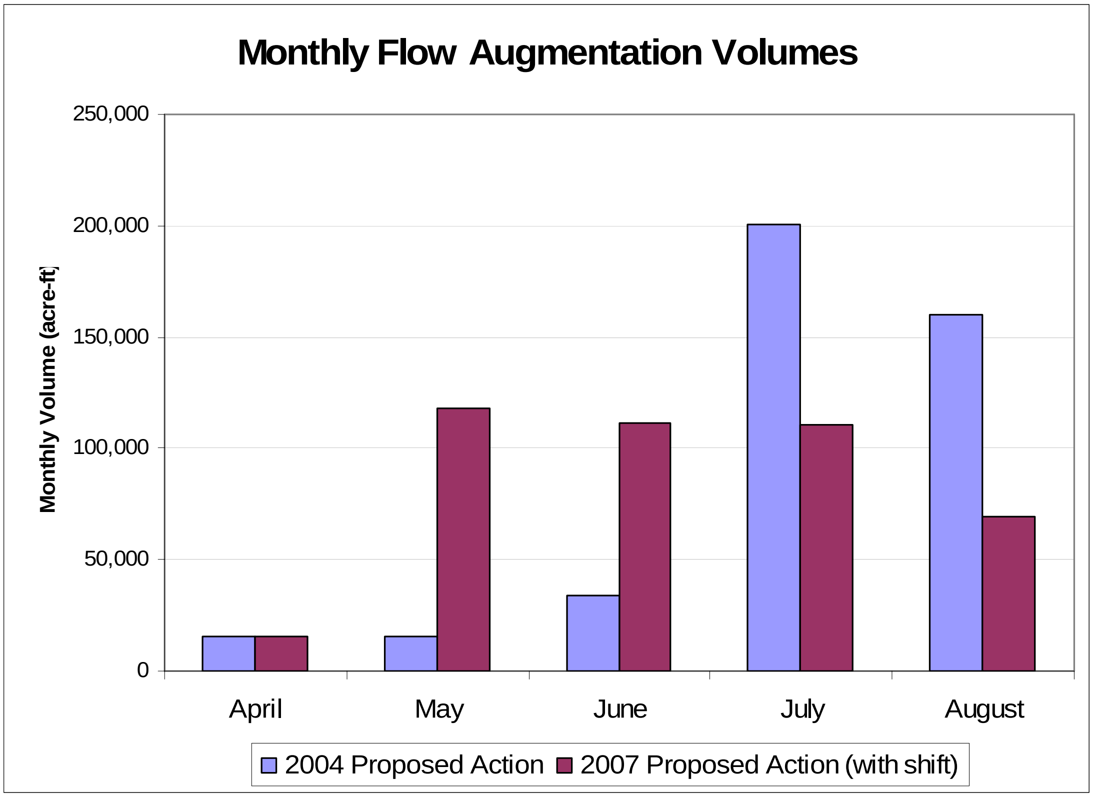

Figure 3-5. Comparison of average monthly flow augmentation volumes for the 2004 Proposed Action and the 2007 Proposed Action (water years 1928 to 2000).

Table 3-5. Modeled total Brownlee Reservoir inflows and flow augmentation component for the Proposed Actions using a 1928 to 2000 period of record.

Month	Average of Wet Years (at or below 10 percent exceedance)			Average of Average Years (between 10 percent and 90 percent exceedance)			Average of Dry Years (at or above 90 percent exceedance)		
	Total Inflows (cfs)	Flow Augmentation Component		Total Inflows (cfs)	Flow Augmentation Component		Total Inflows (cfs)	Flow Augmentation Component	
		cfs	percent		cfs	percent		cfs	percent
April	58,139	261	0.45	28,667	261	0.91	11,652	261	2.24
May	57,995	1,505	2.59	32,663	2,016	6.17	12,526	1,498	11.96
June	42,746	1,555	3.64	27,203	2,005	7.37	9,358	1,098	11.73
July	20,704	2,977	14.38	11,873	1,826	15.38	7,213	350	4.85
August	12,935	1,682	13.00	10,171	1,171	11.52	6,961	350	5.03

Source: Upper Snake MODSIM – May 2007

3.2.2 Modeled Lower Snake and Columbia River Flows

The Upper Snake River MODSIM database and output do not extend to control points below Brownlee Dam. In order to quantify potential flow effects at Lower Granite and McNary Dams from Reclamation's proposed actions (including the storage, release, and diversion of project water), it was necessary to integrate flows above Brownlee Dam with those of reservoirs in the FCRPS. This was accomplished by using BPA's HYDSIM model output for water years 1929 through 1998. See the *Comprehensive Analysis,* Appendix B (USACE et al. 2007b) for more information on the HYDSIM model.

The analysis assumed that inflows to Brownlee Reservoir were passed through the Hells Canyon Complex. To calculate the resulting flow conditions in the lower Snake and Columbia River, output from the HYDSIM model run FRIII_BIOP2007Prosp_CRWMP, representing modeled flows in the lower Snake and Columbia Rivers from the proposed upper Snake and FCRPS actions, were adjusted using output from MODSIM. Hydrologic changes at Brownlee Reservoir, calculated by comparing modeled inflows for the Proposed Action and Without Reclamation MODSIM scenarios (see Table 3-1), were used to adjust modeled HYDSIM discharge at Lower Granite and McNary Dams. Tables 3-6 and 3-7 display the adjusted HYDSIM data for discharge at Lower Granite and McNary Dams for the proposed actions and without Reclamation operating for dry, average, and wet water year types as measured by total annual inflow at Brownlee Reservoir for the 1929 to 1998 period. The tables indicate the resulting modeled flow conditions on the lower Snake and Columbia River from Reclamation's upper Snake operations as well as the FCRPS operations and all private non-Federal operations combined. The tables also show the modeled flow conditions that would occur without Reclamation's upper Snake proposed actions (Without Reclamation) and the hydrologic change attributed to the upper Snake actions in the lower Snake and Columbia Rivers.

Water year type conditions for the upper Snake basin do not always coincide with similar water year conditions in other watersheds within the Columbia River basin. For example, a dry year in the upper Snake may occur in the same year that the Clearwater or Salmon River basins experience average or wet year conditions.

Reclamation's upper Snake actions deplete monthly flows at Lower Granite Dam during the April to June spring period by 2 to 13 percent, with the greatest depletions occurring in wet and average water year types (see Table 3-6). The proposed actions increased flows at Lower Granite Dam during the summer months of July and August and in September for all water year types. Flows increased as much as 15 percent during this period in wet years and as high as 12 percent in dry years. As described in Section 3.1.2 and demonstrated in Table 3-7, Reclamation's depletive effects are

Table 3-6. 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

Table 3-7. Modeled McNary 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	113,969	113,573	396	0	109,961	110,223	-262	-0	105,341	105,755	-414	-0
November	121,881	126,139	-4,258	-3	119,542	124,436	-4,894	-4	126,376	130,368	-3,992	-3
December	131,555	136,650	-5,095	-4	134,494	139,741	-5,247	-4	140,949	145,497	-4,547	-3
January	221,659	216,025	5,634	3	172,270	174,951	-2,681	-2	148,664	153,641	-4,977	-3
February	202,129	196,382	5,747	3	156,580	160,321	-3,742	-2	139,786	145,283	-5,497	-4
March	244,257	242,160	2,097	1	150,712	156,218	-5,506	-4	119,933	126,514	-6,581	-5
April	270,498	272,976	-2,479	-1	202,221	208,882	-6,661	-3	162,709	165,824	-3,115	-2
May	352,652	371,825	-19,173	-5	277,896	289,940	-12,043	-4	186,050	189,003	-2,954	-2
June	373,074	395,301	-22,227	-6	301,663	310,852	-9,189	-3	199,657	199,763	-106	-0
July	247,655	247,296	359	0	199,514	197,456	2,058	1	171,141	169,075	2,065	1
August	167,569	162,595	4,974	3	147,783	143,939	3,844	3	135,412	132,937	2,475	2
September	103,334	99,232	4,102	4	100,224	96,813	3,411	4	90,526	88,498	2,028	2

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

small relative to total flows in the Columbia River. Additional information about the combined flow effects from the hydro operations of the Upper Snake and FCRPS actions are provided in the *Comprehensive Analysis,* Appendix B (USACE et al. 2007b).

3.3 Future Hydrologic Conditions

In the hydrologic analysis for this 2007 Upper Snake BA, Reclamation modelers adjusted the (1928 to 2000) historical gains data set to reflect the current level of surface and groundwater development. This was necessary because historical gains reflected groundwater irrigation practices that were different than those occurring today. Little groundwater pumping occurred before 1945, which resulted in little impact to Snake River flows. This changed with the introduction of the centrifugal pump after Word War II. Today, it is estimated that groundwater pumpers consume 2 million acre-feet of water per year upstream of King Hill, Idaho (Contor et al. 2004). Furthermore, surface water irrigators are currently using less water because of increased farm efficiency and the cessation of winter water deliveries through private canals for stockwater. Since the 1970s, water diversions from the Snake River decreased approximately 20 percent. The lagged effects of recent groundwater development and decreased surface water recharge, combined with possible climate change, may result in future flows in the Snake River at Brownlee Reservoir being different than those historically experienced.

3.3.1 The Lagged Effects of Past Groundwater Development

The Snake River is hydraulically connected to the Eastern Snake Plain Aquifer (ESPA). Approximately 2 million acre-feet of ground water is consumptively used each year above King Hill, Idaho. Additional groundwater irrigation occurs in the Boise and Payette basins. The impact of groundwater depletions to surface flow in the Snake River varies depending on the proximity of wells to the river, well pumping rates, and the hydrogeologic characteristics of the aquifer and the riverbed. Ultimately, all of the ground water pumped and consumptively used from the ESPA will be reflected as losses from the Snake River or its tributaries. The modeled hydrological response of the Snake River to groundwater pumping from the ESPA can span over 100 years, although in most cases the bulk of the impacts are expected to occur within the first 1 to 20 years. Groundwater pumping has two potential impacts that are of importance in this consultation; it reduces base river flows and potentially reduces the volume of water stored in Reclamation reservoirs, which indirectly could reduce the reliability or volume of flow augmentation water that Reclamation is able to provide.

The State of Idaho ordered a moratorium on new well permits in the Snake River basin upstream of Weiser in May 1992 (IDWR 1992). Because of the time delay for the effects to be seen to the river, the full impact of groundwater withdrawals has not yet been manifested (IWRRI 2004). It is estimated that approximately 10 percent of the depletive effects of groundwater pumping above King Hill have yet to occur. Consequently, of the approximately 2 million acre-feet of groundwater depletion above King Hill, it is estimated that about 200,000 acre-feet of annual depletions from groundwater pumping have yet to be experienced (USBR 2005).

The 200,000 acre-feet effect will be spread along the Snake River from King Hill to the eastern end of the ESPA and occur gradually over many decades. About 68 percent of the impacts are expected to occur above Milner Dam, where Reclamation's storage dams are located and Reclamation diversions from the Snake River occur. The remaining impacts are expected to occur between Milner Dam and King Hill, and affect the discharge at Thousand Springs. If not mitigated, much of the decrease in base streamflow above Milner Dam will result in decreased irrigation supply to surface water users and increased demand on the reservoir system. If not mitigated, some (the remaining) reductions above Milner Dam and essentially all of the decreases between Milner and King Hill will be experienced as reduced streamflows into Brownlee Reservoir.

Water users with senior priority water rights that are being affected by decreased spring and river flows have "called" for the State to regulate against the junior groundwater diversions. These calls ask the State to curtail groundwater pumping in order to meet the senior water rights. In addition, Idaho Power Company has filed suit in Idaho District Court asserting that Idaho must regulate groundwater pumping in order to meet their senior downstream water rights for power generation. Reclamation is required under the Reclamation Act of 1902 to comply with State law when appropriating water. Consistent with that mandate, projects in the upper Snake were developed and are operated with Idaho water rights. In addition to the project water rights, State protection of water provided for flow augmentation was extended to Reclamation consistent with terms of the Nez Perce Water Rights Settlement. To protect those rights, Reclamation joined in the call by surface water users above Milner Dam. Reclamation's interest in these proceedings is to protect the refill capability of project reservoirs in order to provide water to contracting entities and for flow augmentation.

The Idaho Department of Water Resources (IDWR) is responding to the calls in accordance with their Rules for Conjunctive Management of Surface and Ground Water Resources. In its Orders the IDWR required groundwater users to provide mitigation water to senior surface and spring rights or face curtailment. Hearings are set to begin later this year to address the IDWR Director's determinations and set the stage for court actions that will finally establish the legal and technical principles that will apply to conjunctive management.

In addition to its regulatory response, the State is considering means to stabilize the ESPA and thereby offset some of the impacts of groundwater pumping. Measures under consideration include managed aquifer recharge from river flows surplus to existing water rights and retirement of irrigated lands through the U.S. Department of Agriculture's Conservation Reserve Enhancement Program (CREP). The CREP program was established for a maximum of 100,000 acres, with expectations that the ultimate impact to the river would be about 200,000 acre-feet per year. As of May, 2007, owners of 45,644 acres have applied for the program (Patton 2007). About 2,000 acres have been rejected, and 18,445 acres have proceeded through the multi-step approval process. The IDWR estimated that about 50,000 acres will ultimately be approved, but it has taken steps to streamline the approval process and encourage additional participation (IDWR 2007).

The Idaho Supreme Court issued a ruling on the constitutionality of the State's Rules for Conjunctive Management of Surface and Ground Water Resources on March 5, 2007 (*American Falls Reservoir District No. 2 et al. v. The Idaho Department of Water Resources et al*., 154 P.3d 433 (Idaho 2007)). The case was brought by surface water right holders above Milner Dam. One provision of the Rules specifies that in determining injury from groundwater pumping to a surface water users' rights, the Director of the IDWR may take into account "reasonable carryover" of storage water. The surface water users asserted that this provision of the Rules is contrary to Idaho law. The Supreme Court held:

> While the prior appropriation doctrine certainly gives pre-eminent rights to those who put water to beneficial use first in time, this is not an absolute rule without exception. As previously discussed, the Idaho Constitution and statutes do not permit waste and require water to be put to beneficial use or be lost. Somewhere between the absolute right to use a decreed water right and an obligation not to waste it and to protect the public's interest in this valuable commodity, lies an area for the exercise of discretion by the Director. This is certainly not unfettered discretion, nor is it discretion to be exercised without any oversight. That oversight is provided by the courts, and upon a properly developed record, this Court can determine whether that exercise of discretion is being properly carried out. For the purposes of this appeal, however, the CM Rules are not facially defective in providing some discretion in the Director to carry out this difficult and contentious task. This Court upholds the reasonable carryover provisions in the CM Rules. (Opinion, page 24)

The 2007 Replacement Plan filed by groundwater user defendants (Ground Water Districts' Joint Replacement Water Plan for 2007 filed with the IDWR on May 8, 2007) asserts that the Department should account for:

> Any water released past Milner Dam during the 2007 water year for hydropower generation or related to ESA requirements…

The plan would also require that the mitigation required be reduced by the volume of water leased to Reclamation for flow augmentation. If approved, this provision would cause surface water user entities suffering injury from groundwater pumping to be more cautious in renting water for flow augmentation.

The manner in which the Director of IDWR exercises his/her discretion to comply with the Supreme Court's statement will determine whether the volume of water available for rental stays consistent with or is reduced below that anticipated by Reclamation when the Nez Perce Water Rights Settlement was adopted. Future curtailment is possible to meet the growing mitigation obligation for the Thousand Springs calls, any of the other calls, or for the Idaho Power Company lawsuit in the event efforts to enhance the aquifer through voluntary means fail. Therefore, the potential exists that yet to be realized impacts of groundwater pumping will be fully mitigated and base flows will not continue to decline as a result of groundwater depletions.

If the ultimate administration of groundwater pumping reduces the volume or reliability of Reclamation's flow augmentation expectations, it will be necessary to consider reinitiation of consultation under the provisions of 50 CFR 406.16.

3.3.2 Possible Effects of Future Climate Change

The Climate Impacts Group (CIG) at the University of Washington has analyzed the effects of global climate change on the Pacific Northwest (CIG 2006). In general, climate models project a future rate of warming in the Pacific Northwest of approximately 0.5°F (0.3°C) per decade through at least 2050 relative to 1970 to 1999 average temperatures. Much of the temperature increase is projected to take place in the summer months, June through August. Models also indicate that small changes in regional precipitation would occur. The model projects that rising temperatures could diminish mountain snow packs, decrease summer flows, increase winter flows, and peak spring flows might occur earlier. Winter hydropower production could increase, but less water could be available during the summer for agriculture, recreation, hydropower, and fish (CIG 2006).

According to a study by the CIG, southern Idaho's Snake River basin is thought to be at greater risk of impacts from climate change than the rest of the Columbia River basin because the Snake River is proportionally more developed when depletions are compared to streamflows (VanRheenen et al. 2006). At this time no comprehensive climate change studies have been completed for the Snake River basin. Reclamation is pursuing various activities and building partnerships with others to better understand and incorporate climate change information into future water resources management and project operations. On the local scale, Reclamation participates on the Climate Impacts Subcommittee of the Idaho Water Supply Committee to investigate the implications of climate change for southern Idaho. Reclamation is also currently conducting a climate change study in association with a water storage assessment for the Boise River system to determine its effects on water supply. The Pacific Northwest Region is developing "climate changed" water supply data sets in partnership with other entities for various watersheds in the Columbia River basin to improve modeled operational analyses. At a larger scale, encompassing the western United States, the Secretary of Interior has convened a Climate Change Task Force that will evaluate information needs and identify strategies for managing lands and waters, protecting fish and wildlife, and minimizing the Department's environmental footprint. Results and techniques learned from these efforts will allow a better understanding of potential climate impacts above Brownlee Reservoir and provide the tools to respond to any changing climate trends.

3.3.3 Summary

Future hydrologic conditions in the Snake River above Brownlee Reservoir will be affected by many factors including hydrologic variability, climate change, continued water storage and diversion activities by Reclamation and private irrigation projects, hydropower generation, and the State's administration of water rights. Some of these future effects and conditions have been described throughout this chapter. Reclamation's reservoirs are operated with a high level of flexibility in order to respond to a wide variety of hydrological and meteorological conditions. Reservoir operators can respond to changing conditions, whether natural or anthropogenic. This will continue to occur as new hydrologic information becomes available. Reclamation will continue to monitor Idaho's administration of groundwater pumping and investigate climate conditions to ensure proposed actions occur as described in this BA. If conditions do change from those described here, re-initiation of consultation may be necessary as triggered by 50 CFR 406.16.

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.

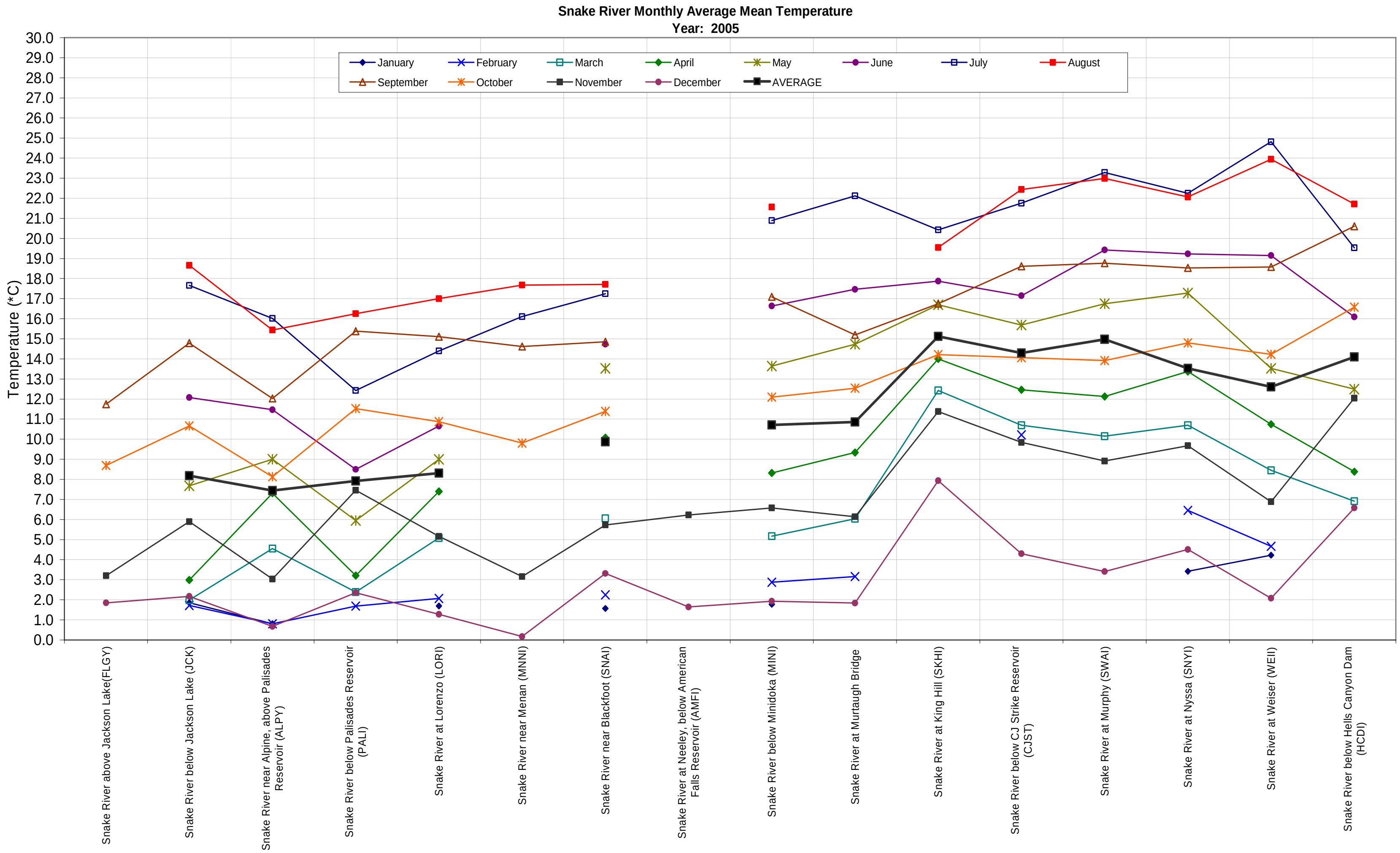

Figure 4-1. Average monthly water temperature at locations along the Snake River - 2005.

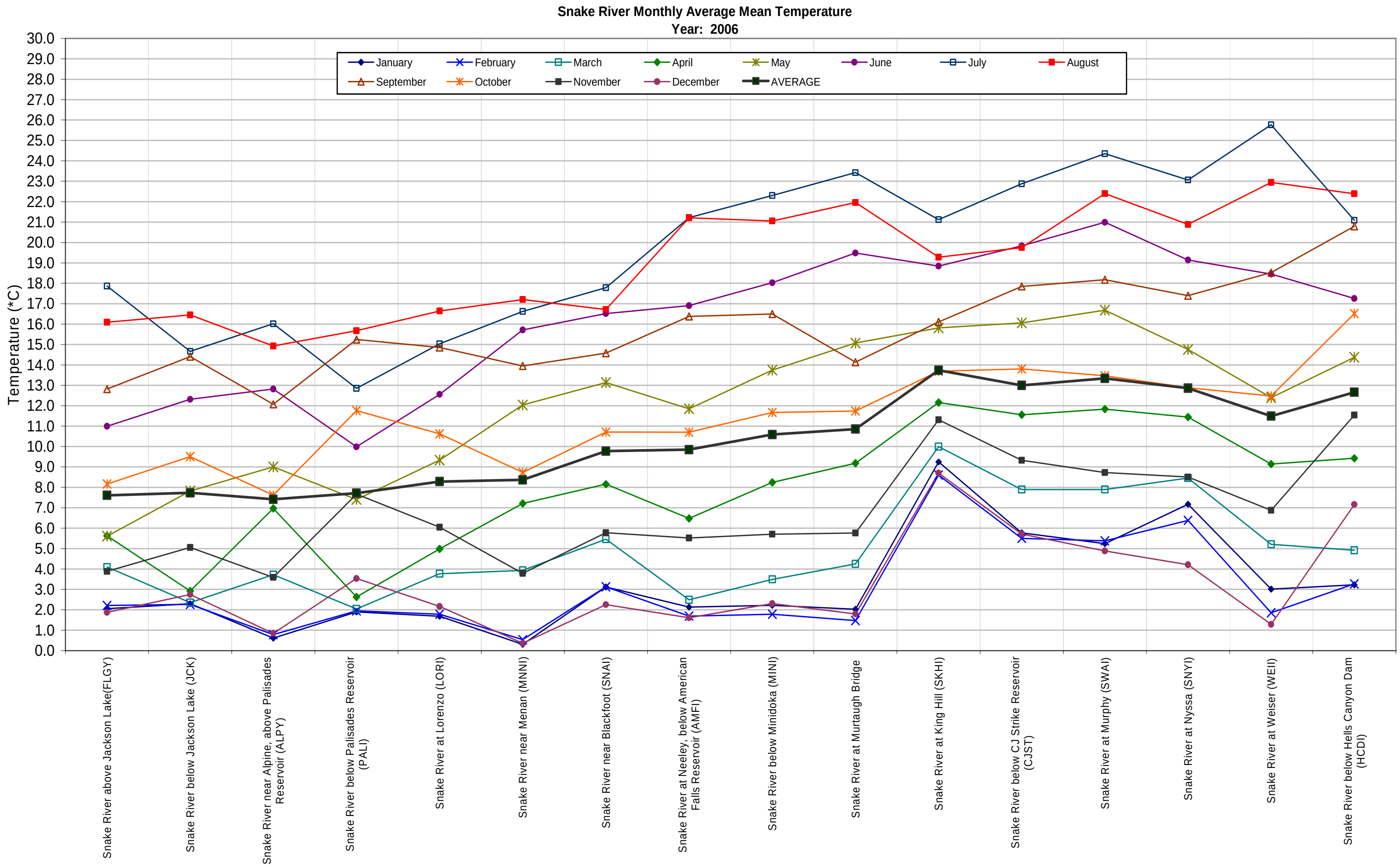

Figure 4-2. Average monthly water temperature at locations along the Snake River - 2006.

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.

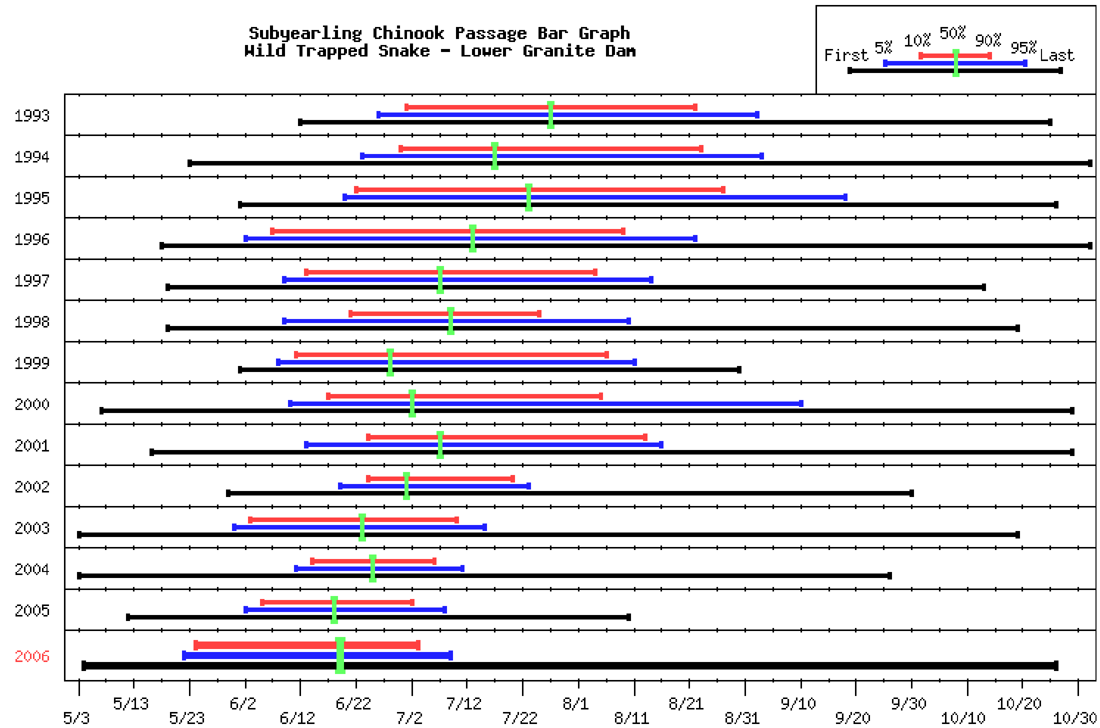

Figure 4-3. Migration timing of wild PIT tagged juvenile fall Chinook salmon tagged in the Snake River and detected at Lower Granite Dam (Source: FPC 2007).

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.

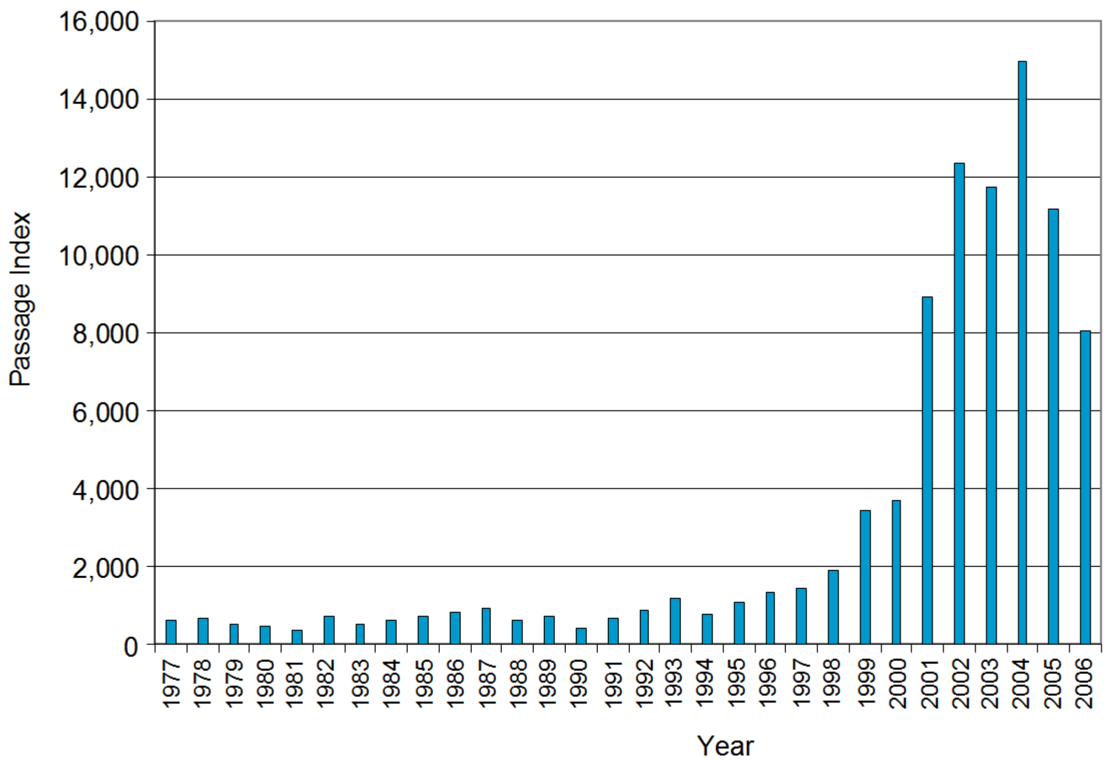

Figure 4-4. Adult passage of fall Chinook at Lower Granite Dam.

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.

Chapter 5 ESSENTIAL FISH HABITAT

5.1 Background

Essential fish habitat (EFH) has been designated for Federally managed groundfish, coastal pelagics, Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and Puget Sound pink salmon (*O. gorbuscha*) fisheries within the waters of Washington, Oregon, Idaho, and California (PFMC 1999).

In previous consultations for Reclamation's upper Snake River projects, NMFS (2001) stated that:

> [d]esignated EFH for groundfish and coastal pelagic species encompasses all waters from the mean high water line, and upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon and California, seaward to the boundary of the U.S. exclusive economic zone (230.2 miles) (PFMC 1998a, 1998b). Detailed descriptions and identification of EFH for the groundfish species are found in the Final Environmental Assessment/Regulatory Impact Review for Amendment 11 to The Pacific Coast Groundfish Management Plan (PFMC 1998a) and NMFS Essential Fish Habitat for West Coast Groundfish Appendix (Casillas et al. 1998). Detailed descriptions and identifications of EFH for the coastal pelagic species are found in Amendment 8 to the Coastal Pelagic Species Fishery Management Plan (PFMC 1998b).
>
> Freshwater EFH for Federally managed Pacific salmon includes all those rivers, streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassable barriers identified by PFMC (1999). Chief Joseph Dam, Dworshak Dam, and the Hells Canyon Complex (Hells Canyon, Oxbow, and Brownlee dams) are among the listed man-made barriers that represent the upstream extent of the Pacific salmon fishery EFH. Freshwater salmon EFH excludes areas upstream of longstanding, naturally impassable barriers (e.g., natural waterfalls in existence for several hundred years). In estuarine and marine areas, designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (230.2 miles) offshore of Washington, Oregon, and California north of Point Conception to the Canadian border. Detailed descriptions and identification of EFH for Pacific salmon are found in Appendix A to Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999).

Appendix A to Amendment 14 of the Pacific Coast Salmon Plan (PFMC 1999) listed EFH for Chinook salmon and coho salmon in the Snake and Columbia Rivers downstream from Hells Canyon Dam. EFH was delineated by 4th field hydrologic unit codes (HUCs). An HUC is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as delineated by the USGS on State

Hydrologic Unit Maps. The fourth level of classification is the cataloging unit, the smallest element in the hierarchy of hydrologic units, representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. EFH for the two salmon species was listed without regard for whether the several ESUs of the two species were Federally listed under the ESA. The particular Chinook or coho salmon ESUs that occupied the area were not considered when designating EFH. For this consultation, Reclamation considers both ESA-listed and non-listed Chinook and coho salmon ESUs that spawn, rear, and/or migrate in the action area.

5.2 Proposed Actions

Reclamation's 12 proposed actions include: (1) the future O&M in the Snake River system above Milner Dam; (2) future operations in the Little Wood River system; (3) future O&M in the Owyhee, Boise, Payette, Malheur, Mann Creek, Burnt, upper Powder, and lower Powder River systems; (4) surveys and studies of ESA-listed aquatic snail species in the Snake River above Milner Dam; (5) and future provision of salmon flow augmentation from the rental or acquisition of natural flow rights. The features and facilities of the 12 Federal projects included in Reclamation's proposed actions are all in the Snake River basin upstream of Brownlee Dam, an Idaho Power hydropower facility on the Snake River at RM 285. Chapter 2 and the *Operations Description for Bureau of Reclamation Projects in the Snake River above Brownlee Reservoir* (USBR 2004b) describe the proposed actions.

5.3 Action Area

The action area with regard to EFH consultation includes the farthest upstream point at which Federally managed salmon smolts enter (or adults exit) the Snake River and Columbia River (at, and downstream from, its confluence with the Snake River) to the farthest downstream point at which smolts exit (or adults enter) the migration corridor to the ocean. The action area in the Snake River includes the area 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. In the Columbia River, the action area includes wherever a tributary stream meets the Columbia River, downstream to the farthest point at the Columbia River estuary and nearshore ocean environment for which designated EFH for groundfish, coastal pelagics, and Chinook and coho salmon might be influenced by the proposed actions.

This area encompasses nine 4th field HUCs beginning just downstream from Hells Canyon Dam and progressing through the lower Snake River and from the mouth of the Snake River in the Columbia River to its mouth. Figure 5-1 and Table 5-1 show the geographic extent and Snake River or Columbia River miles (RM) of these 4th field HUCs. Delineations of some of these 4th field HUCs are estimated from maps and may be approximate.

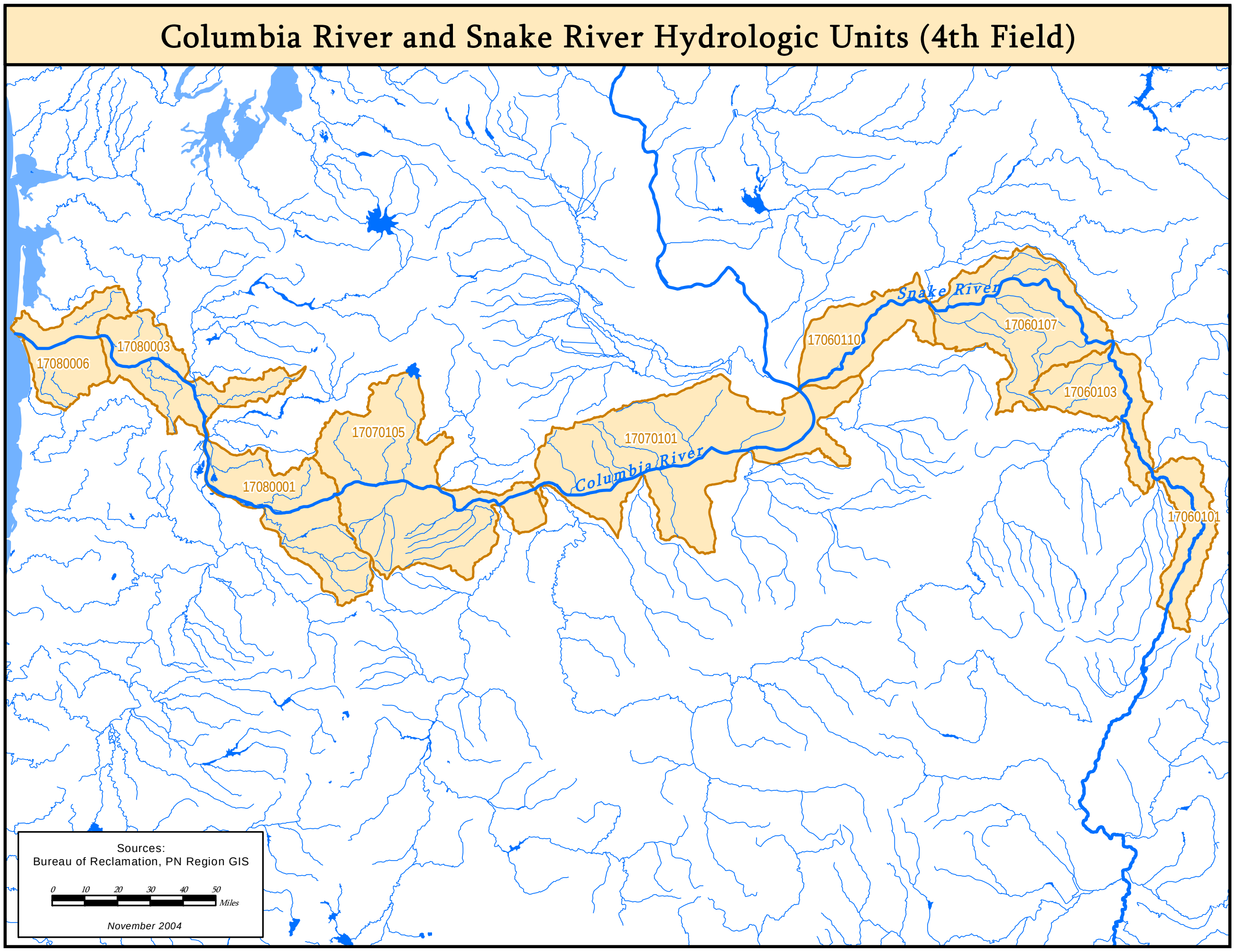

Figure 5-1. Map showing the nine 4th field HUCs in the action area.

Table 5-1. Approximate HUC starting and ending points in the EFH action area.

HUC	Hydrologic Unit Name	From	To
Snake River			
17060101	Hells Canyon	Hells Canyon Dam at RM 246.9	Mouth of Salmon River at RM 188.3
17060103	Lower Snake – Asotin Creek	Mouth of Salmon River at RM 188.3	Mouth of Clearwater River at Lewiston, ID, at RM 139.9
17060107	Lower Snake – Tucannon River	Mouth of Clearwater River at Lewiston, ID, at RM 139.9	Mouth of Tucannon River at RM 62.2
17060110	Lower Snake River	Mouth of Tucannon River at RM 62.2	Mouth of Snake River at RM 0
Columbia River			
17070101	Mid Columbia – Lake Wallula	Mouth of Snake River at RM 324.4	John Day Dam at RM 215.6
17070105	Mid Columbia – Hood	John Day Dam at RM 215.6	Bonneville Dam at RM 146.1
17080001	Lower Columbia – Sandy River	Bonneville Dam at RM 146.1	Mouth of Willamette River at RM 101.5
17080003	Lower Columbia – Clatskanie River	Mouth of Willamette River at RM 101.5	Jones Beach at RM 47
17080006	Lower Columbia River	Jones Beach at RM 47	Mouth of Columbia River at RM 0

EFH is designated for Chinook and/or coho salmon in the nine HUCs in Appendix A of Amendment 14 (PFMC 1999). Table 5-2 shows these nine HUCs with the EFH-designated species, affected ESU, and life history use.

In the case of the lower Snake River HUC (17060110), Table A-1 of Appendix A of Amendment 14 (PFMC 1999) lists only Chinook salmon, while Table A-6 indicates that this HUC has currently accessible but unutilized historical habitat for coho salmon. Similarly, for the Mid Columbia – Lake Wallula HUC (17070101), Table A-1 of Appendix A of Amendment 14 (PFMC 1999) lists only Chinook salmon, while Table A-6 indicates that this HUC is current habitat for coho salmon. Reclamation will focus analysis and discussion on the species listed in Appendix A, Table A-1 (PFMC 1999). EFH listing did not differentiate specific Chinook or coho salmon ESUs, nor consider any ESA listing status. For purposes of this EFH consultation, Reclamation includes all Snake and Columbia River Chinook and coho salmon ESUs, whether ESA-listed or not, that use the Snake and Columbia River action area for either spawning, rearing, or migrating. Many of the ESUs use the action area only for migration.

Table 5-2. Snake River and Columbia River basin HUCs with designated Chinook and coho salmon EFH, ESU, and life history use (from Tables A-1 and A-6 in PFMC 1999).

HUC	Hydrologic Unit Name	Species	Current or Historical Distribution	ESU	Life History Use [1]
17060101	Hells Canyon	Chinook salmon	Current habitat	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon	S, R, M
17060103	Lower Snake – Asotin Creek	Chinook salmon	Currently accessible but unutilized historical habitat	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon	S, R, M M
		Coho salmon	Currently accessible but unutilized historical habitat	None	M
17060107	Lower Snake – Tucannon River	Chinook salmon	Current habitat	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon	S, R, M M
		Coho salmon	Currently accessible but unutilized historical habitat	None	M
17060110 [2]	Lower Snake River	Chinook salmon (Coho salmon)	Current habitat (Currently accessible but unutilized historical habitat)	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon	S, R, M M
17070101 [3]	Mid Columbia – Lake Wallula	Chinook salmon (Coho salmon)	Current habitat (Current habitat)	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon Upper Columbia River spring Chinook salmon Middle Columbia River spring Chinook salmon Upper Columbia River summer/fall Chinook salmon	R, M M M M M
17070105	Mid Columbia – Hood	Chinook salmon	Current habitat	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon Upper Columbia River spring Chinook salmon Middle Columbia River spring Chinook salmon Upper Columbia River summer/fall Chinook Deschutes River summer/fall Chinook salmon	R, M M M M M M
		Coho salmon	Current habitat	Lower Columbia River coho salmon	S, R, M
17080001	Lower Columbia – Sandy River	Chinook salmon	Current habitat	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon Upper Columbia River spring Chinook salmon Middle Columbia River spring Chinook salmon Upper Columbia River summer/fall Chinook Deschutes River summer/fall Chinook salmon Lower Columbia River Chinook salmon	M M M M M M S, R, M

Table 5-2. Snake River and Columbia River basin HUCs with designated Chinook and coho salmon EFH, ESU, and life history use (from Tables A-1 and A-6 in PFMC 1999), continued.

HUC	Hydrologic Unit Name	Species	Current or Historical Distribution	ESU	Life History Use [1]
17080001, cont'd.	Lower Columbia – Sandy River, cont.	Coho salmon	Current habitat	Lower Columbia River coho salmon Southwest Washington coho salmon	S, R, M M
17080003	Lower Columbia – Clatskanie River	Chinook salmon	Current habitat	Snake River fall Chinook salmon Snake River spring/summer Chinook salmon Upper Columbia River spring Chinook salmon Middle Columbia River spring Chinook salmon Upper Columbia River summer/fall Chinook salmon Deschutes River summer/fall Chinook salmon Lower Columbia River Chinook salmon Upper Willamette River Chinook salmon	M M M M M M S, R, M M
		Coho salmon	Current habitat	Lower Columbia River coho salmon Southwest Washington coho salmon	S, R, M M
17080006	Lower Columbia River	Chinook salmon	Current habitat	Snake River fall Chinook salmon (T) 4 Snake River spring/summer Chinook salmon (T) Upper Columbia River spring Chinook salmon (E) Middle Columbia River spring Chinook salmon (N) Upper Columbia River summer/fall Chinook (N) Deschutes River summer/fall Chinook salmon (N) Lower Columbia River Chinook salmon (T) Upper Willamette River Chinook salmon (T)	M M M M M M S, R, M M
		Coho salmon	Current habitat	Lower Columbia River coho salmon (T)	S, R, M

1 S = spawning, R = rearing, M = migration

2 EFH is listed for Chinook salmon in HUC 17060110 on Table A-1 (PFMC 1999), while Table A-6 lists current habitat for Chinook salmon and currently accessible but unutilized historical habitat for coho salmon in that HUC (PFMC 1999). Since Table A-1 lists EFH for species within HUCs, Reclamation shall not consider EFH for coho salmon in this HUC.

3 EFH is listed for Chinook salmon in HUC 17070101 on Table A-1 (PFMC 1999), while Table A-6 lists current habitat for both Chinook and coho salmon in the same HUC (PFMC 1999). Since Table A-1 lists EFH for species within HUCs, Reclamation shall not consider EFH for coho salmon in this HUC.

4 ESA listing status as of May 2007 - NMFS ESA Salmon Listings Website: E = Endangered, T = Threatened, N = Not Warranted, U = Undetermined.

Reclamation considers the following Chinook and coho salmon ESUs in this EFH consultation, listed from upstream (closest to the downstream extent of Reclamation's upper Snake River projects) to downstream:

- Snake River fall Chinook salmon
- Snake River spring/summer Chinook salmon
- Upper Columbia River spring Chinook salmon
- Middle Columbia River spring Chinook salmon
- Upper Columbia River summer/fall Chinook salmon
- Deschutes River summer/fall Chinook salmon
- Lower Columbia River Chinook salmon
- Upper Willamette River Chinook salmon
- Lower Columbia River coho salmon

Some of these ESUs are ESA-listed (see Table 5-2 at bottom), while others that are not warranted or have undetermined status for ESA listing have relatively robust populations, although not at historical levels of abundance.

5.4 Status, Life History, Habitat Requirements, and Effects Analysis

The Chinook and coho salmon ESUs are listed and discussed as they are encountered in geographic order proceeding downstream from Hells Canyon Dam to the mouth of the Snake River, then from the upper Columbia River to its mouth.

5.4.1 Snake River Fall Chinook Salmon

5.4.1.1 Species Information

Chapter 4 of the *Comprehensive Analysis* (USACE et al. 2007b) contains information about the life history and population status of the Snake River fall Chinook salmon ESU and is incorporated here by reference. This ESU is currently listed as threatened under the ESA.

Specific to this EFH consultation, many Snake River fall Chinook salmon spawn, rear, and migrate in the mainstem downstream from Hells Canyon Dam, primarily in the Hells Canyon (17060101), Lower Snake – Asotin Creek (17060103), and Lower Snake – Tucannon River (17060107) HUCs. This last HUC is farther downstream and receives substantial inflow from the Salmon River, Clearwater River, and other tributaries. Spawning in the Lower Snake River HUC (17060110) is uncertain, although the Biological Review Team (BRT) (2003) noted that spawning occurs in small mainstem sections in the tailraces of lower Snake River hydroelectric dams.

Table 5-3 shows the number of adults returning to Lower Granite and Ice Harbor Dams from 1977 to 2006. These fish are primarily destined for the Hells Canyon (17060101) and Lower Snake – Asotin Creek (17060103) HUCs. Fall Chinook salmon also spawn in several of the larger Snake River tributaries downstream from Hells Canyon Dam. Table 5-4 shows the several Snake River tributaries in addition to the mainstem where fall Chinook salmon spawning has been documented. Across most years, spawning occurs predominantly in the Snake River mainstem, as indicated by the redd counts from the mainstem and tributaries (see Table 5-4). This area encompasses the Hells Canyon (17060101) and Lower Snake – Asotin Creek (17060103) HUCs. The Lower Snake River HUC (17060110) supports fall Chinook salmon rearing and migration for all the juveniles produced there or upstream in the mainstem and tributaries. Once juvenile fall Chinook salmon leave the Snake River and enter the Columbia River, they continue to rear and migrate to the ocean through five additional 4th field HUCs.

The number of adult Snake River fall Chinook salmon counted at Lower Granite Dam has increased substantially since 2000, and high numbers of adults have continued to return since 2001 with a peak of 14,960 in 2004 (see Table 5-3). Redd counts in the mainstem Snake River between Asotin, Washington, and Hells Canyon Dam, as reported by Garcia et al. (2006), have also increased and in 2003, 2004, and 2005 numbered 1,512 redds, 1,709 redds, and 1,442 redds, respectively—exceeding the recovery goal of sufficient habitat upstream of Lower Granite Reservoir to support 1,250 redds (Groves and Chandler 2003). However, this 3-year exceedance of the redd recovery goal should be viewed as a positive sign but not in itself as evidence of recovery of Snake River fall Chinook salmon. These numbers may include some hatchery-origin fish spawning in the wild, and abundance of returning adults has varied in the past and may continue to do so in the future. The interim abundance target for fall Chinook salmon is an 8-year geometric mean of 2,500 annual natural spawners (Lohn 2002). The 1996-to-2003 8-year geometric mean for wild fall Chinook salmon is 1,273 fish, which is below Lohn’s (2002) interim abundance target of 2,500 fish. Based on counts of adult fall Chinook salmon at Lower Granite Dam in 2004 (14,960 fish), 2005 (11,194 fish), and 2006 (8,048 fish) (see Table 5-3) and the proportion of wild fish in the total adult fall Chinook salmon count in previous years (between approximately 21 and 79 percent annually during the period 1996 through 2006 – see Table 5-5), the 1999-to-2006 8-year geometric mean would be expected to be closer to meeting or exceeding the interim abundance target than in previous years.

Based on numbers of wild fall Chinook listed in Table 5-5, the 1999-to-2006 8-year geometric mean is 2,790 fish.

Table 5-3. Fall Chinook salmon counts at Ice Harbor and Lower Granite Dams from 1977 to 2006.

Year	Ice Harbor Dam		Lower Granite Dam	
	Adult	Jack	Adult	Jack
1977	1,220	536	609	1,284
1978	1,089	504	641	843
1979	1,243	813	497	941
1980	1,140	579	453	328
1981	770	1,332	337	1,414
1982	1,627	1,892	724	1,478
1983	1,771	964	536	977
1984	1,650	795	637	731
1985	1,784	7,421	668	1,446
1986	3,119	2,679	782	1,802
1987	6,755	1,620	944	390
1988	3,847	2,035	629	327
1989	4,638	1,352	707	276
1990	3,470	1,847	383	189
1991	4,489	1,560	633	399
1992	4,636	894	855	102
1993	2,805	332	1,170	39
1994	2,073	1,033	791	255
1995	2,750	2,452	1,067	308
1996	3,851	811	1,308	424
1997	2,767	1,854	1,451	504
1998	4,220	3,491	1,909	2,002
1999	6,532	3,489	3,384	1,863
2000	6,485	9,864	3,696	7,131
2001	13,516	10,170	8,915	8,834
2002	15,248	6,079	12,351	5,727
2003	20,998	10,666	11,732	8,481
2004	21,109	11,167	14,960	7,600
2005	14,677	4,561	11,194	3,236
2006	10,272	6,835	8,048	6,721

Source: FPC 2007

Table 5-4. Number of fall Chinook salmon redds counted in the Snake River and tributaries between Lower Granite and Hells Canyon Dam from 1986 to 2005.

Location	Redds Counted by Year																			
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Snake River (aerial) [1]	7	66	64	58	37	41	47	60	53	41	71	49	135	273	255	535	878	1,118	1,218	1,042
Snake River (underwater)						5	0	67	14	24	33	9	50	100	91	174	235	394	491	400
Subtotal	7	66	64	58	37	46	47	127	67	65	104	58	185	373	346	703	1,113	1,512	1,709	1,442
Lower Clearwater River (RM-410			21	10	4	4	25	36	30	20	66	58	78	179	164	290	520	544	592	433
Potlatch River														7	0	24	3	1	1	0
North Fork Clearwater River [2]			0	0	0	0	0	0	7	0	2	14	0	1	0	1	0	8	2	0
Upper Clearwater River (RM 42-74)							1	0	0	0	0	0	0	2	8	16	4	19	36	54
South Fork Clearwater River							0	0	0	0	1	0	0	2	1	5	0	0	0	0
Middle Fork Clearwater River (RM 75-98)									0	0	0	0	0	0	0	0	0	0	0	0
Selway River									0	0	0	0	0	0	0	0	0	0	0	0
Asotin Creek				0	0	0	0											3	4	6
Grande Ronde	0	7	1	0	1	0	5	49	15	18	20	55	24	13	8	197	111	93	162	129
Salmon River							1	3	1	2	1	1	3	0	0	22	31	18	21	27
Imnaha River		0	1	1	3	4	3	4	0	4	3	3	13	9	9	38	72	43	35	36
Basin Totals	7	73	87	69	45	54	82	219	120	109	197	189	303	586	536	1,302	1,854	2,241	2,562	2,127

1 The targeted search area was the entire Reach from the head of Lower Granite Reservoir to Hells Canyon Dam

2 Searches covered from the mouth to the Ahsanka boat ramp in 2002. Searches covered from the mouth to Dworshak Dam in previous years.

Note: Empty cells indicate no data collected. Some data are broken down into collection method or river mile sections. Data collected by Washington Department of Fish and Wildlife, Nez Perce Tribe, Idaho Power Company, and USFWS.

Source: Garcia et al. 2006

Table 5-5. Fall Chinook salmon escapement and stock composition at Lower Granite Dam from 1975 to 2006.

Year	Lower Granite Dam Escapement	Wild
1975	1,000	1,000
1976	470	470
1977	600	600
1978	640	640
1979	500	500
1980	450	450
1981	340	340
1982	720	720
1983	540	428
1984	640	324
1985	691	438
1986	784	449
1987	951	253
1988	627	368
1989	706	295
1990	335	78
1991	590	318
1992	668	549
1993	952	742
1994	606	406
1995	637	350
1996	919	639
1997	1,007	797
1998	962	306
1999	1,862	905
2000	2,664	1,148
2001	9,875	5,163
2002	9,891	2,116
2003	13,505	3,856
2004	13,146	2,983
2005	10,194	2,602
2006	7,784	2,483

Source: NMFS 2005b and Yuen 2007

Downstream migration proceeds mostly from late May through June, with a small proportion moving past Lower Granite Dam in July and August (see Figure 4-3). As discussed in *Section 4.3.3.2, Snake River Fall Chinook Salmon,* Connor (2004) indicated that subyearling Chinook salmon in the Snake River migrate rapidly in the free-flowing river above Lewiston and may spend a substantial amount of time in Lower Granite Reservoir. In recent years, new information has revealed that many of the later emerging juveniles do not migrate out as subyearlings, but rather over-winter in the lower Snake River reservoirs (and perhaps downstream) and then outmigrate the following spring. Although the proportion of the fall Chinook salmon population that exhibits this life history strategy is unknown, it has been estimated that approximately half of the adult returns to Lower Granite Dam are from this life history strategy (Connor et al. 2005). In addition to the establishment of this "reservoir-type" life history strategy, data have shown that the juvenile migration timing of the subyearling life history has advanced by approximately 1 month since the 1990s (see Figure 4-3), perhaps simply reflecting that more of the late emerging juveniles cease migrating and adopt the reservoir-type life history. The documentation of a second life history strategy has initiated a re-assessment of Snake River flow management and operations of the downstream FCRPS dams.

5.4.1.2 Effects

Based on a comparison of modeled flows, Reclamation's past and ongoing O&M actions combined with proposed flow augmentation will continue to alter Snake River streamflows into Brownlee Reservoir (see Table 3-1). These alterations in streamflow contribute to present conditions of EFH within the action area downstream from Hells Canyon Dam, and these flow alterations are expected to continue into the future as part of the proposed actions. On an annual average basis Reclamation's proposed actions deplete approximately 2.3 million acre-feet of water, which is 6.0 percent of the average flow at Lower Granite Dam and 1.8 percent at McNary Dam on the Columbia River (see Figure 3-1).

Flow alterations affect EFH for fall Chinook salmon in 4th field HUCs in the lower Snake River. Although Reclamation's continuing operations reduces winter inflows to Brownlee Reservoir in average and dry years, the flow reduction does not limit Idaho Power Company's ability to maintain the fisheries-protection flow target of between about 8,500 and 13,500 cfs in October and November for spawning fall Chinook salmon (see Table 3-1). Fall Chinook salmon fry begin migrating downriver and through the lower Snake River reservoirs in the late spring. As discussed in *Section 4.3.1, Streamflows and Fish Survival,* the relationship between flow and smolt survival for inriver migrants during the spring is most evident in dry years.

The shifting of some of Reclamation's proposed action flow augmentation from summer to spring, especially in dry years, will benefit subyearling fall Chinook salmon migrants in dry years and should benefit the reservoir-type juveniles in all years by helping to maintain cooler water temperatures in the lower Snake River reservoirs.

Reclamation concludes that the proposed actions may adversely affect fall Chinook salmon EFH but the effects will be negligible in the lower Snake River and will diminish progressively downstream. Therefore, effects on EFH are expected to be indiscernible and insignificant in the lower Columbia River migratory corridor.

5.4.2 Snake River Spring/Summer Chinook Salmon

5.4.2.1 Species Information

Chapter 5 of the *Comprehensive Analysis* (USACE et al. 2007b) contains information about the life history and population status of the Snake River spring/summer Chinook salmon ESU and is incorporated here by reference. This ESU is currently listed as threatened under the ESA (70 FR 37160).

The Snake River spring/summer Chinook salmon ESU consists of 30 demographically independent populations (NMFS 2005b). One population inhabits the Imnaha River basin in the Hells Canyon HUC (17060101), while the majority occupies other major tributaries such as the Salmon River, Grande Ronde River, and Clearwater River that flow into the Lower Snake – Asotin Creek HUC (17060103).

Some spawning occurs in tributaries downstream from Hells Canyon Dam in the Hells Canyon HUC (17060101), such as the Imnaha River, but most of the production occurs in tributaries of the Salmon, Grande Ronde, and Clearwater Rivers that flow into but are not part of the Lower Snake – Asotin Creek HUC (17060103). Table 5-6 shows the number of adult wild spring and summer Chinook salmon counted at Lower Granite Dam from 1979 to 2006. Most of these fish are destined for the tributaries in the two uppermost HUCs. Outmigrating juveniles enter the action area from the tributaries, and as they migrate farther downstream, they are subjected to greater river flows from numerous tributary inflows, as well as other physical conditions in the river, including passage at the several hydropower projects.

Adult returns, as counted at Lower Granite Dam, have increased recently, although the 1999-to-2006 8-year geometric mean of 13,462 wild fish is below Lohn’s (2002) annual natural spawner interim abundance target of 41,900 fish.

Table 5-6. Estimated adult wild spring/summer Chinook salmon escapement to Lower Granite Dam (includes total counts at Bonneville and Lower Granite Dams for comparison).

Year	Bonneville Dam (Total Fish Count)		Lower Granite Dam (Total Fish Count)		Wild Snake River Fish Count		
	Spring Chinook	Summer Chinook	Spring Chinook	Summer Chinook	Spring Chinook	Summer Chinook	Total
1979	48,600	27,742	6,839	2,714	2,573	2,714	5,287
1980	53,100	26,952	5,460	2,688	3,478	2,404	5,882
1981	62,827	22,363	13,115	3,306	7,941	2,739	10,680
1982	70,011	20,129	12,367	4,210	7,117	3,531	10,648
1983	54,898	18,046	9,517	3,895	6,181	3,219	9,400
1984	46,866	22,421	6,511	5,429	3,199	4,229	7,428
1985	83,182	24,236	25,207	5,062	5,245	2,696	7,941
1986	118,082	26,221	31,722	6,154	6,895	2,684	9,579
1987	98,573	33,033	28,835	5,891	7,883	1,855	9,738
1988	90,532	31,315	29,495	6,145	8,581	1,807	10,388
1989	81,267	28,789	12,955	3,169	3,029	2,299	5,328
1990	94,158	24,983	17,315	5,093	3,216	3,342	6,558
1991	57,339	18,897	6,623	3,809	2,206	2,967	5,173
1992	88,425	15,063	21,391	3,014	11,134	441	11,575
1993	110,820	22,045	21,035	7,889	5,871	4,082	9,953
1994	20,169	17,631	3,120	795	1,416	183	1,599
1995	10,194	15,030	1,105	692	745	343	1,088
1996	51,493	16,034	4,215	2,607	1,358	1,916	3,274
1997	114,071	27,939	33,855	10,709	2,126	5,137	7,263
1998	38,342	21,433	9,854	4,355	5,089	2,913	8,002
1999	38,669	26,169	3,296	3,260	1,335	1,584	2,919
2000	178,302	30,616	33,822	3,933	8,049	846	8,895
2001	391,367	76,156	171,958	13,735	NA[1]	NA[1]	16,477
2002	268,813	127,436	75,025	22,159	NA[1]	NA[1]	33,784
2003	192,010	114,808	70,609	16,422	NA[1]	NA[1]	38,636
2004	107,152	92,413	70,742	8,767	NA[1]	NA[1]	20,967
2005	74,038	79,208	26,028	6,736	NA[1]	NA[1]	9,862
2006	96,456	22,530	22,530	7,058	NA[1]	NA[1]	9,340

1 Not available

Source: Yuen 2007; FPC 2004 and 2007.

5.4.2.2 Effects

Based on a comparison of modeled flows, Reclamation's past and ongoing O&M actions combined with proposed flow augmentation will continue to alter Snake River streamflows into Brownlee Reservoir (see Table 3-1). These alterations in streamflow contribute to present conditions of EFH within the action area downstream from Hells Canyon Dam, and these flow alterations are expected to continue into the future as part of the proposed actions. On an annual average basis Reclamation's proposed actions deplete approximately 2.3 million acre-feet of water, which is 6.0 percent of the average flow at Lower Granite Dam and 1.8 percent at McNary Dam on the Columbia River (see Figure 3-1).

The proposed actions predominantly affect migration for both juvenile fish and adults in the four Snake River HUCs and the five Columbia River HUCs . Snake River spring/summer Chinook salmon outmigrate in the spring as yearlings, when the proposed actions contribute to reduced flows during the spring under most conditions. Flow augmentation, which in the past was delivered in the summer months, now is proposed to be shifted more to the spring months. This shift is expected to reduce some of the effects associated with spring flow reductions and will benefit the spring migrant smolts.

Flow alterations affect EFH for spring/summer Chinook salmon in 4th field HUCs in the lower Snake River to the extent that such alterations affect flow conditions for migration. Flow augmentation will reduce deletion effects in the migration corridor for spring/summer Chinook salmon below Hells Canyon Dam from April through June during drier water years (see Table 3-1). As discussed in *Section 4.3.1, Streamflows and Fish Survival*, the value of flow augmentation for improving smolt survival for inriver migrants is most evident in dry years.

Reclamation concludes that the proposed actions may adversely affect spring/summer Chinook salmon EFH but the effects will be negligible in the lower Snake River and will diminish progressively downstream based on the small percentage of depletions compared to flow at McNary Dam. Therefore, effects on EFH are expected to be indiscernible and insignificant in the lower Columbia River migratory corridor.

5.4.3 Upper Columbia River Spring Chinook Salmon

5.4.3.1 Species Information

Chapter 8 of the *Comprehensive Analysis* (USACE et al. 2007b) contains information about the life history and population status of the Upper Columbia River spring Chinook salmon ESU and is incorporated here by reference. This ESU is currently listed as endangered under the ESA (70 FR 37160).

Outmigrating juvenile fish from this ESU enter the action area when they pass the mouth of the Snake River and enter the Mid Columbia – Lake Wallula HUC (17070101) on their downstream migration. This is approximately 247 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects. These stream-type fish outmigrate actively in the spring.

Returning adults are in the action area up to the time they pass the mouth of the Snake River. Adults are counted at Rock Island Dam. A substantial number of returning adults are from artificial propagation programs in the basin. Up to 80 percent of adults returning to the Methow River in 2001 and an estimated 70 percent returning to the Wenatchee River were of hatchery origin. The peak of the adult return is around the middle of May, based on 10-year average returns at Rock Island Dam (FPC 2007, www.fpc.org/adultqueries/Adult_Query_Graph_Results.asp). In 2007, a pronounced peak occurred in early May about 1 week earlier than the 10-year average peak.

The combined hatchery and wild adult returns were used to calculate the 1999-to-2006 8-year geometric mean, which was then reduced by 80 percent based on the observation that approximately 80 percent of the 2001 return to the Methow River was estimated to be from supplementation adults. This resulted in a geometric mean of 2,665 adults, far below the 6,250 adults listed as Lohn's (2002) interim abundance target.

5.4.3.2 Effects

This ESU spawns and rears upstream from the action area and uses the action area for juvenile and adult migration. Therefore, the proposed action would only potentially effect juvenile and adult migration for the Columbia River EFH for the Upper Columbia River spring Chinook salmon. Reclamation's proposed actions, including flow augmentation delivery, will be attenuated considerably by the time the Snake River enters the Columbia River in the Mid Columbia – Lake Wallula HUC (17070101) because of substantial tributary inflows between Hells Canyon Dam and the mouth of the Snake River. Therefore, the effect of the relatively minor flow changes in the Columbia River on upper Columbia River spring Chinook at this point and downstream is most likely negligible. As discussed in *Section 4.3.1, Streamflows and Fish Survival*, the value of flow augmentation for improving smolt survival for inriver migrants is most evident in dry years. Any beneficial value of augmenting flows on wetter-than-average years is uncertain, but not likely adverse.

Based on the distance downstream from Reclamation's upper Snake River projects where this ESU enters the action area in the Mid Columbia – Lake Wallula HUC (17070101), and the much greater flows in the Columbia River compared to the depletion from Reclamation's proposed actions at this point in the action area, representing less than 2 percent of total Columbia River flow at McNary Dam (see Figure 3-1). Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Upper Columbia River spring Chinook salmon.

5.4.4 Middle Columbia River Spring Chinook Salmon

5.4.4.1 Species Information

NMFS concluded that this ESU was not warranted for listing under the ESA (NMFS 2004). It includes stream-type Chinook salmon spawning in the Klickitat, Deschutes, John Day, and Yakima Rivers, excluding the Snake River basin (Myers et al. 1998). Juveniles from this ESU emigrate to the ocean as yearlings. Some artificial propagation programs have been implemented for this ESU. An early attempt at artificial propagation in 1899 was eventually unsuccessful, while programs established in the late 1940s and 1950s were more successful. Substantial artificial propagation occurs in the Deschutes River basin.

A rough estimate of the total inriver returns of this ESU can be made by subtracting hatchery returns and Zone 6 fishery landings from the difference between Bonneville Dam counts and the sum of Priest Rapids and Ice Harbor Dams counts. A 1997 estimate of abundance calculated as described above resulted in a 5-year geometric mean (1992 to 1996) of about 25,000 adults, but this is probably an upper bound of escapement (Myers et al. 1998). From 1998 through 2006, numbers of adult spring Chinook salmon annually counted passing Bonneville, Priest Rapids, and Ice Harbor Dams were approximately one to five times, two to seven times, and one to three times, respectively, greater than in 1997 (FPC 2007). Downstream migrants from the Yakima River population of this ESU enter the action area in the Mid Columbia – Lake Wallula HUC (17070101) when they pass the mouth of the Snake River. This is about 247 miles downstream from Hells Canyon Dam and even farther from Reclamation’s upper Snake River projects. Other populations enter the action area farther downstream. The ESU primarily uses the action area for juvenile and adult migration. Spawning and rearing occur in the major tributaries listed above.

5.4.4.2 Effects

The effects of Reclamation’s proposed actions diminish substantially with distance downstream from Hells Canyon Dam; effects to EFH for this ESU will likely be minimal. Because of the distance downstream from Reclamation’s upper Snake River projects, and the much larger volume of water in the Columbia River compared to the volume of Snake River inflows (see Figure 3-1), the effects of the proposed actions on EFH for this ESU are unquantifiable but likely negligible. Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Middle Columbia River spring Chinook salmon.

5.4.5 Upper Columbia River Summer/Fall Chinook Salmon

5.4.5.1 Species Information

NMFS concluded that this ESU was not warranted for listing under the ESA (NMFS 2004). It was formerly referred to as Middle Columbia River summer/fall Chinook salmon ESU (Myers et al. 1998) and includes all ocean-type Chinook salmon spawning in areas between McNary and Chief Joseph Dams. A large portion of this ESU consists of the "upriver brights" from the Hanford Reach of the Columbia River that enter the action area as outmigrants once they pass the mouth of the Snake River and enter the Mid Columbia – Lake Wallula HUC (17070101). This is about 247 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects.

The Hanford Reach fall run is the predominant population; the 1990-to-1994 geometric mean was about 58,000 fish (Myers et al. 1998). Long-term trends for the three largest populations are positive, but they are mixed for smaller populations. The summer run is heavily influenced by hatchery releases (Wells Dam stock). Freshwater spawning and rearing habitat has experienced degradation, with hydropower project-related inundation of mainstem spawning grounds and degradation of the migration corridor. However, these conditions exist for the most part on the Columbia River upstream from the action area. A number of improvements have been made to correct degraded conditions for fish passage. The action area downstream from the mouth of the Snake River in the Mid Columbia – Lake Wallula HUC (17070101) and other Columbia River 4th field HUCs is used primarily for rearing and migration.

Typically, summer/fall Chinook salmon in the mid-Columbia region begin spawning in late September, peak in mid-October, and complete spawning in late November (Chapman et al. 1994, cited in Myers et al. 1998). Developing eggs incubate in the gravel for an extended period (5 to 7 months) until they emerge as fry from the gravel in late winter or spring (mid-February to April).

5.4.5.2 Effects

Adults from this ESU spawn outside the action area, but the subyearlings outmigrate and rear throughout the mid- to late summer. As the fry migrate downstream, they enter the action area in the Mid Columbia – Lake Wallula HUC (17070101). Because of the distance downstream from the Hells Canyon Complex where the flow effects of Reclamation's upper Snake River projects would be most significant, and the much larger volume of water in the Columbia River compared to the volume of Snake River inflows (see Figure 3-1), the effects of the proposed actions on EFH for this ESU are unquantifiable but likely negligible. Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Upper Columbia River summer/fall Chinook salmon.

5.4.6 Deschutes River Summer/Fall Chinook Salmon

5.4.6.1 Species Information

The ESU includes all naturally spawned populations of Chinook salmon from the Deschutes River. NMFS determined it did not warrant listing under the ESA (NMFS 2004). Spawning and rearing habitat for this ESU comprise approximately 2,687 square miles in the Deschutes River basin of Oregon. Outmigrating juvenile Deschutes River summer/fall Chinook salmon enter the action area when they exit the Deschutes River and enter the Mid Columbia – Hood HUC (17070105) at RM 328.5. This is about 366.9 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River projects. Fish in this ESU use this HUC and three additional HUCs downstream primarily as a migration corridor.

5.4.6.2 Effects

Adults from this ESU spawn outside the action area, but the subyearlings outmigrate and rear throughout the mid- to late summer. The subyearlings migrate down the Deschutes River and enter the action area when they enter the Columbia River in the Mid Columbia – Hood HUC (17070105). Because of the distance downstream from Reclamation's upper Snake River projects, and the much larger volume of water in the Columbia River compared to the volume of Snake River inflows (see Figure 3-1), the effects of the proposed actions on EFH for this ESU are unquantifiable but likely negligible. Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Deschutes River summer/fall Chinook salmon.

5.4.7 Lower Columbia River Chinook Salmon

5.4.7.1 Species Information

Chapter 12 of the *Comprehensive Analysis* (USACE et al. 2007b) contains information about life history and population status of the Lower Columbia River Chinook salmon ESU and is incorporated here by reference. This ESU is currently listed as threatened (70 FR 37160). This ESU contains populations downstream from the Klickitat River that enters the action area. This is approximately 391 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River basin projects. This ESU includes both spring-run and fall-run populations.

The BRT (2003) found moderately high risk for the four Viable Salmonid Population (VSP) categories, and that the majority of these fish appear to be hatchery produced. The artificial propagation programs in the ESU may provide slight benefits to ESU abundance, spatial structure, and diversity, but may have uncertain effects in productivity. Population abundance has increased recently, but the long-term trends in productivity are below replacement for the majority of populations in the ESU (69 FR 33101). Literally millions of hatchery-produced Chinook salmon juveniles are released into the lower Columbia River each year (BRT 2003).

5.4.7.2 Effects

The effects of Reclamation's proposed actions are likely to affect less the EFH of those ESUs farther downstream or farther removed from the action area. Because of the distance downstream from Reclamation's upper Snake River projects, and the much larger volume of water in the Columbia River compared to the volume of Snake River inflows (see Figure 3-1), the effects of the proposed actions on EFH for this ESU are unquantifiable but likely negligible. Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Lower Columbia River Chinook salmon.

5.4.8 Upper Willamette River Chinook Salmon

5.4.8.1 Species Information

Chapter 15 of the *Comprehensive Analysis* (USACE et al. 2007b) contains information about life history and population status of the Upper Willamette River Chinook salmon ESU and is incorporated here by reference. This ESU is currently listed as threatened (70 FR 37160).

The Willamette/Lower Columbia Technical Recovery Team (WLCTRT 2003) reported that this ESU has a spring run-timing and estimated that seven populations existed historically. All Upper Willamette River spring Chinook salmon, except those migrating to the Clackamas River, must pass Willamette Falls. The 2004 run size at Willamette Falls was the largest in recent years, with 143,700 adult Chinook salmon counted (ODFW 2007). In 2005, 61,000 adults were counted, while 59,700 adults were counted in 2006, and 52,000 adults are projected for 2007. While there is no assessment of the ratio of hatchery-origin to natural-origin fish at Willamette Falls, the BRT (2003) states that the majority are likely hatchery-origin spring Chinook salmon. The Molalla and Calapooia river populations have little to no natural production. The Clackamas, North and South Santiam, and Middle Fork Willamette Rivers populations have some natural production, but hatchery percentages of naturally produced fish are between 64 and 97 percent in these four populations (Good et al. 2005; Cooney et al. 2003).

Despite the substantial hatchery component to the run, adult returns have increased substantially since the mid-1990s when the adult return was around 20,000 fish (estimated from Figure A.2.6.2, BRT 2003). Because of the heavy reliance on artificial propagation in this ESU, the BRT (2003) concluded that most natural spring Chinook salmon populations were extirpated or nearly so, and that the only potentially self-sustaining population is in the McKenzie River. The BRT (2003) noted that productivity of this ESU would be below replacement if it were not for artificial propagation. The BRT (2003) found moderately high risks for all VSP categories.

5.4.8.2 Effects

This ESU spawns, incubates, and rears outside of the action area, only occurring in the action area when juveniles exit the Willamette River and enter the Lower Columbia – Clatskanie River HUC (17080003) or when upstream migrating adults exit the Lower Columbia – Clatskanie River HUC (17080003) and enter the Willamette River. This is 469.4 miles downstream from Hells Canyon Dam and even farther from Reclamation's upper Snake River basin projects. Adults and juveniles use the lower 101 miles of the Columbia River for migration. The effects of Reclamation's proposed actions are likely to have minimal if any effect on the EFH of this ESU. Because of the distance downstream from Reclamation's upper Snake River projects, and the much larger volume of water in the Columbia River compared to the volume of Snake River inflows (see Figure 3-1), the effects of the proposed actions on EFH for this ESU are unquantifiable but likely negligible. Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Upper Willamette River Chinook salmon.

5.4.9 Lower Columbia River Coho Salmon

5.4.9.1 Species Information

Chapter 13 of the Comprehensive Analysis (USACE et al. 2007b) contains information about life history and population status of the Lower Columbia River coho salmon ESU and is incorporated here by reference. This ESU is currently listed as threatened under the ESA (70 FR 37160). The BRT (NMFS 1991) was initially unable to identify whether an historical coho salmon ESU existed in the Lower Columbia River. Additional information obtained in the mid-1990s indicated that it might be part of a larger coho salmon ESU, and it was combined with the Southwest Washington/Lower Columbia River ESU. In 2001, the BRT (NMFS 2001) concluded that the Lower Columbia River coho salmon ESU is separate from the Southwest Washington coho salmon ESU, based on tagging studies, differing marine distributions, and genetics. It thus warranted designation as a separate ESU.

This ESU is altered from historical conditions and natural production is limited to two Oregon populations in the Sandy and Clackamas Rivers (69 FR 33101). Because the BRT concluded that the hatchery-produced fish contain a significant portion of the historical diversity of Lower Columbia River coho salmon, the progeny of 21 artificial propagation programs are considered, along with the two naturally spawning populations, part of the ESU.

5.4.9.2 Effects

This ESU spawns, incubates, and rears far downstream from Hells Canyon Dam and Reclamation's upper Snake River projects; juvenile outmigrants encounter EFH when they enter the Mid Columbia – Hood HUC (17070105). Because of the distance downstream from Reclamation's upper Snake River projects, and the much larger volume of water in the Columbia River compared to the volume of Snake River inflows (see Figure 3-1), the effects of the proposed actions on EFH for this ESU are unquantifiable but likely negligible. Reclamation concludes that its proposed actions will not adversely affect EFH in the Columbia River for Lower Columbia River coho salmon.

5.5 Summary of Effects Analysis

Reclamation concludes that its proposed actions involving continued operations and routine maintenance at its upper Snake projects may adversely affect EFH for Snake River fall Chinook salmon and Snake River spring/summer Chinook salmon but the effect is expected to be negligible. Upper Snake River flow augmentation provided during the spring migration season will reduce some of the adverse effects and benefit the EFH for these species by providing some additional flow in the Snake River in the drier-than-average years

Reclamation concludes that the proposed actions will not adversely affect EFH for Upper Columbia River spring Chinook salmon, Middle Columbia River spring Chinook salmon, Upper Columbia River summer/fall Chinook salmon, Deschutes River summer/fall Chinook salmon, Lower Columbia River Chinook salmon, Upper Willamette River Chinook salmon, and Lower Columbia River coho salmon.

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APPENDICES

Appendix A NEZ PERCE SETTLEMENT COMPONENTS

A.1 Introduction

The Nez Perce Water Rights Settlement (Nez Perce Tribe et al. 2004) consists of three components, including the Snake River Flow, the Salmon/Clearwater, and the Nez Perce Tribal. Details of the Snake River Flow component are described in Section 1.4 and Appendix C of the 2007 Upper Snake BA and Chapters 2 and Appendix B of the 2004 Upper Snake BA. Its elements are incorporated into the proposed actions that Reclamation is consulting on in this Remand. Information about elements of the other two components that provide potential benefits to ESA-listed anadromous fish are described below.

A.2 Salmon/Clearwater Component

A.2.1 Salmon and Clearwater Habitat Trust Fund

As part of the Settlement, the United States will contribute $38 million (in 2004 dollars) over the course of five years, beginning in 2007, for fish and habitat protection projects. The purpose of the fund is to supplement monies otherwise available for habitat protection and restoration in the Salmon and Clearwater River basins. Congress has appropriated the 2007 dollars; the out-year funding is anticipated to be appropriated on an annual basis.

The fund will be divided into two accounts: (1) one-third of the United States' contribution to the fund will be placed into an account for which the Nez Perce Tribe will develop a process for administration, and (2) the remainder will be placed into an account for the State of Idaho (State) to implement the Section 6 Cooperative Agreements. The Section 6 Cooperative Agreements are intended to satisfy the requirements of section 7(a) (2) of the ESA. The State will collaborate with the Nez Perce Tribe and the United States to determine how to direct use of the Section 6 account.

The Nez Perce Tribe has not formally dedicated any portion of this funding towards any specific fish or habitat improvement project at this time. The agreement anticipates the State's portion will be used for activities such as riparian fencing, riparian plantings, restoration of large woody debris, improving or protecting flow conditions to augment stream flows, stabilizing sediment sources, and correcting man-made passage barriers such as unscreened diversions, stream crossings, or culverts.

A.2.2 Salmon/Clearwater Minimum Streamflows

As part of the Settlement, implemented in part through the Snake River Water Rights Act of 2004 (Public Law 108-447), the State of Idaho agreed to adopt minimum streamflows in the Salmon and Clearwater River basins. These basins contain critical spawning and rearing habitat for ESA-listed spring Chinook, steelhead ("A" and "B" run), and fall Chinook salmon. The Idaho Water Resource Board (IWRB) now holds in trust for the public, minimum streamflow rights on over 200 rivers, streams, and creeks in the Salmon and Clearwater River basins that the Tribe identified (Tribal Priority Streams) as having important salmon and steelhead spawning and rearing habitat. The intent of establishing minimum streamflows is to ensure these streams are not dewatered to a level that impairs spawning and rearing or other ecological functions that support salmon, steelhead, and the aquatic environment.

The minimum streamflows are subordinated to water rights existing prior to April 1, 2005, and to future domestic, commercial, municipal, and industrial (DCMI) water rights. In issuing any new water rights for future uses that may affect the instream flows, the Idaho Department of Water Resources will consider the local public interest under Idaho Code Section 42-203(A)5, including but not limited to the protection of fish and wildlife habitat, aquatic life, recreation, aesthetic beauty, transportation and navigation values, and water quality.

The Tribal Priority Streams have been divided into "A" and "B" list groups based on the level of existing use; streams on the "A" list are considered non-developed and streams on the "B" list are considered developed. Tribal Priority Streams have minimum stream flows and future non-DCMI use levels assigned based on land classification, except for streams identified as "Special Areas." Special Area streams address certain special resource value areas or areas of special concern relative to local uses as agreed to by parties to the Settlement. Land classification was established based on the predominant land ownership and, where appropriate, Federal land classification existing in a particular stream's basin.

A.2.2.1 "A" List Tribal Priority Streams

Minimum streamflows were determined based on categories determined by ownership of the lands within the basin. Four ownership categories were identified: (1) State and private, (2) Federal non-wilderness, (3) wilderness/Wild and Scenic, and (4) Special Areas.

For each category, minimum streamflows have been set by month based on estimated hydrology of unimpaired flows, and a reservation for future non-DCMI use equal to a percentage of the minimum monthly median flow value from the estimated hydrology. Minimum streamflows, future allocations, and the floor flow are based on exceedance values. The individual minimum streamflows have been decreed as quantities in cubic feet per second as will the future allocation for non-DCMI uses and floor flows. Because these flows are based on estimated flow, the IWRB can, after government to government consultation with the Nez Perce Tribe, change these decreed flows based upon actual flows, if such data become available.

For State and private basins, minimum streamflows have been established for each month of the year at the 50 percent exceedance level of the estimated unimpaired flow, subordinated to a future non-DCMI use in the amount of 25 percent of the lowest median monthly unimpaired flow value.

For Federal, non-wilderness basins, minimum streamflows have been decreed for each month of the year at 40 percent exceedance level of the estimated unimpaired flow, subordinated to a future non-DCMI use in the amount of 10 percent of the lowest median monthly unimpaired flow value.

For Federal wilderness and Wild and Scenic basins, minimum streamflows have been decreed for each month of the year at the 30 percent exceedance level of the estimated unimpaired flow, subordinated to a future non-DCMI use in the amount of 5 percent of the lowest median monthly unimpaired flow value.

The Special Areas include watersheds that hold special values including high value habitat for fish resources, other special values, and areas where future development opportunities would be preserved. The minimum streamflows and reservations for future non-DCMI use for the special areas differ from the land-based formula described above. Special Areas include:

- **Lower Salmon River below Long Tom Bar to the mouth**: Minimum streamflows for the lower Salmon River downstream of the Wild and Scenic reach are consistent with the existing State application filed for the lower Salmon River below Hammer Creek. The State application for the minimum streamflow in the lower Salmon River addresses the reach from the mouth to Hammer Creek. The minimum streamflows reach in the application will be extended to include the reach of the Salmon below the Little Salmon River. The minimum streamflows in the reach between the Little Salmon and designated Wild and Scenic River reach are based on the downstream reach and adjusted for the inflow from the Little Salmon River. The State minimum streamflow is consistent with the Wild and Scenic instream flow for the main Salmon River.

- **South Fork Salmon River and tributaries contained within the Tribal Priority Stream List**: Minimum streamflows are decreed for each month of the year at the 40 percent exceedance level of the estimated unimpaired hydrology, subordinated to a future non-DCMI use in the amount of 5 percent of the lowest median monthly unimpaired flow value.
- **Upper Salmon River basin**: The upper Salmon River basin includes a number of tributaries that meet the criteria for "B" list streams. Minimum streamflows established for the tributaries or the mainstem Salmon River are in accord with Wild and Scenic River instream flows and future allocations.
- **Lolo Creek**: Minimum streamflows are decreed for each month of the year at the 40 percent exceedance level of the estimated unimpaired hydrology, subordinated to a future non-DCMI use in the amount of 10 percent of the lowest median monthly unimpaired flow value.
- **Bedrock Creek**: Minimum streamflows are decreed for each month of the year at the 40 percent exceedance level of the estimated unimpaired hydrology, subordinated to a future non-DCMI use in the amount of 10 percent of the lowest median monthly unimpaired flow value.
- **Upper North Fork Clearwater River, Breakfast Creek**: Minimum streamflows are decreed for each month of the year at the 40 percent exceedance level of the estimated unimpaired hydrology, subordinated to a future non-DCMI use in the amount of 10 percent of the lowest median monthly unimpaired flow value.

Future Uses for "A" List streams

The future use allocations will provide water for non-DCMI uses. The parties will study the overlap of existing uses and future use to determine if additional criteria will assist the parties in allocating future use. The goal is to avoid reducing streamflows to a level where the unimpaired 80 percent exceedance value is the flow that normally occurs in the stream due to the combination of existing and future use.

A.2.2.2 "B" List Tribal Priority Streams

Minimum streamflows and other non-flow-related actions were developed by the parties, in conjunction with local stakeholders and communities.

A.2.3 Idaho Forestry Program

The State, NMFS, and the USFWS will enter into a Section 6 cooperative agreement to implement a forest practices program that provides specific stream protection measures, including establishment of riparian no-harvest and restricted-harvest zones, road management measures to reduce delivery of sediment to streams, and culvert replacement requirements to eliminate fish passage barriers. Adaptive management measures, coupled with effectiveness monitoring, will allow for program changes as necessary to achieve the program's objectives. All State forest lands in the Salmon and Clearwater River basins are currently implementing the program terms; the program will be opened to private enrollment once the cooperative agreement is finalized.

A.2.4. Lemhi River Habitat Improvement Agreements

The State, NMFS, and USFWS are currently developing a Section 6 cooperative agreement in conjunction with local water users to establish minimum flows, reconnect tributary streams, and undertake other habitat improvement measures in the Lemhi River basin. An interim agreement provides for minimum flows on the mainstem of the Lemhi River to address fish passage requirements. Once completed, a similar program will be established on the Pahsimeroi River.

A.3 Nez Perce Tribal Component

As part of the Settlement, the Nez Perce Tribe, in conjunction with an intergovernmental board consisting of the Tribe, Army Corps of Engineers, BPA, NMFS, and the State, controls the use of 200,000 acre-feet of stored water in Dworshak Reservoir, located on the North Fork Clearwater River on the Reservation. This water can be used for flow augmentation and temperature control (cooling) in the lower Snake River in August and September. This water is part of the 1.2 million acre-feet that is drafted annually for flow augmentation and temperature control. Prior to the Settlement, 1.2 million acre-feet was drafted by August 31 of each year. This measure is intended to benefit juvenile and adult fall Chinook and adult steelhead by shaping cool flows into September.

Appendix B THE UPPER SNAKE MODSIM MODEL - 2007 VERSION

B.1 Modifications Made to 2004 Version of the MODSIM Model

The MODSIM model network of the Snake River basin was developed to replicate historical data and system operations over a defined period of record. After the model had been calibrated to observed data, it was then configured to represent proposed operational conditions for analyses performed in the Upper Snake BA. Reclamation has continually updated and improved this Upper Snake River Basin MODSIM model since its initial development in 1992. These enhancements to the model are designed to incorporate new information and logic as a means of best representing the physical system or potential operational changes. For example, in 2004, additional years were added to the observed data set to create a 1928 to 2000 period of record, the current level of irrigation diversions were incorporated, and groundwater influences were integrated into the model configuration. This 2004 MODSIM version was used to conduct analyses in the 2004 Upper Snake BA (USBR 2004b). Appendix E of the 2004 Upper Snake BA and Larson (2003) describe these model improvements.

In 2007, Reclamation revised the Upper Snake River MODSIM model to capture current groundwater irrigation practices above King Hill and within the Payette River basin in the model configuration. These revisions do not reflect a material change in Upper Snake project operations as described in the 2004 Upper Snake BA and supporting documents, but rather a better model representation of ground water and surface water interactions based on the current conditions. Therefore, the 2007 MODSIM results are not directly comparable to the 2004 MODSIM results because of the model refinements. The following text provides some general information about the improvements incorporated into the 2007 version of MODSIM.

B.1.1 Snake River – Above King Hill

The 2004 MODSIM model presented in the 2004 Upper Snake BA assumed that 1.5 million acre-feet of total groundwater pumping occurred on the Eastern Snake River Plain above King Hill. A recent study conducted by the Idaho Water Resources Research Institute (Contor et al. 2004) determined that roughly 2.0 million acre-feet of groundwater pumping currently occurs above King Hill. Therefore, the 2007 MODSIM model incorporated a total of 2.0 million acre-feet of groundwater pumping, to represent these current irrigation practices above King Hill. However, the modeled increase of 0.5 million acre-feet of groundwater pumping does not equate to a modeled decreased flow in the Snake River of 0.5 million acre-feet by 2000. The influence of this additional pumping, assuming that it is held constant in the future, will not be realized for many years due to the aquifer influence and interaction.

In order to accommodate the 2 million acre-feet of groundwater pumping as reported by Contor et al. (2004), acreages assumed to be irrigated by ground water were linearly increased between the years 1980 and 2000. The total acreage was increased such that the average volume of groundwater pumped between the years 1996 and 2000, equaled approximately 2 million acre-feet.

B.1.2 Payette River Basin

The 2007 Upper Snake MODSIM model also reflects revisions to incorporate irrigation influences in the Payette River basin. Historical return flows were estimated by taking estimated historical diversions and using rule of thumb infiltration and lag parameters. These estimated historical return flows were subtracted from the local gains data set to separate base flow from return flows as a result of historical surface water irrigation diversion. These same return flow assumptions are used in the model to estimate return flows from future irrigation diversion in the modeled scenarios.

B.1.3 Summary

The 2007 Upper Snake MODSIM model was used to analyze the proposed action flow regime into Brownlee Reservoir. Its configuration and assumptions were developed based on the current available information. Reclamation's proposed action scenario model network can be described as the calibrated model network under current surface water diversion development, current level of groundwater pumping, and proposed reservoir operation protocol.

For each of the numerous basins comprising the Snake River drainage, various methods and techniques were used to develop the unique scenario configurations presented in the 2007 Upper Snake BA. Differing levels of data availability, study development, and current system knowledge dictated the assumptions used. Sophisticated techniques were used for the Snake River above King Hill to account for aquifer influences and less refined methodologies were used in other reaches to define model configurations.

Monthly output for the modeled scenarios used in the hydrologic analyses described in this document are presented in Table B-1 on the following pages.

Table B-1. MODSIM model output of monthly flows into Brownlee Reservoir under the Proposed Action scenario (in acre-feet) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	TOTAL
1928	801,417	1,073,837	1,089,560	1,268,371	882,581	1,941,625	1,700,483	2,914,897	1,396,898	823,690	759,308	726,944	15,379,611
1929	790,130	994,306	826,890	955,787	583,845	1,163,930	1,152,144	1,248,292	1,145,000	742,868	725,803	616,165	10,945,160
1930	742,595	884,464	893,615	624,940	868,268	823,970	890,598	895,424	727,358	716,703	683,945	588,169	9,340,049
1931	750,764	764,424	734,266	721,495	603,932	866,912	787,927	660,917	500,508	524,473	453,549	493,492	7,862,659
1932	630,584	757,324	717,788	703,631	465,029	1,237,628	1,642,107	1,685,044	1,515,227	795,315	639,615	642,268	11,431,560
1933	781,464	951,826	861,221	720,458	636,761	842,944	997,252	1,176,099	1,712,055	730,698	634,492	650,189	10,695,459
1934	758,441	925,756	922,271	886,718	725,333	782,634	801,433	614,652	561,969	465,279	424,033	475,579	8,344,098
1935	625,553	727,716	695,945	709,425	632,167	730,504	1,138,897	1,011,343	951,141	630,571	603,803	601,598	9,058,663
1936	748,327	883,082	814,527	767,601	782,350	656,891	2,036,526	1,677,743	1,252,958	713,961	686,428	680,633	11,701,027
1937	753,089	894,793	848,083	651,416	618,575	654,592	1,061,465	924,578	752,410	519,333	500,176	575,214	8,753,724
1938	788,205	879,282	1,036,051	1,039,009	948,699	1,384,077	2,263,442	2,519,403	1,720,933	1,072,998	772,351	739,700	15,164,150
1939	893,208	975,777	912,082	848,349	701,772	1,303,963	1,690,119	1,226,703	739,945	639,722	508,302	589,507	11,029,449
1940	813,074	779,211	748,926	927,766	1,117,859	1,431,221	1,645,610	1,308,503	923,231	676,169	577,651	678,898	11,628,119
1941	911,527	900,055	849,881	847,850	903,701	1,121,211	1,075,786	1,202,618	1,267,812	732,855	718,407	711,022	11,242,725
1942	828,092	943,080	1,016,190	854,285	885,554	722,355	1,871,565	1,328,454	1,573,796	775,130	653,540	705,968	12,158,009
1943	880,553	1,022,448	1,080,088	1,647,672	1,651,958	2,410,664	4,202,696	2,157,093	1,926,121	1,470,631	835,866	854,129	20,139,919
1944	1,064,911	1,223,540	1,216,252	1,076,379	912,030	928,636	930,176	896,564	1,046,233	730,904	677,835	650,579	11,354,039
1945	807,826	883,698	772,597	792,230	945,079	856,064	895,709	1,712,114	1,612,405	807,006	709,937	741,933	11,536,598
1946	872,915	988,476	1,082,715	1,233,286	940,518	2,127,757	3,223,844	2,433,054	1,329,859	846,282	789,119	772,556	16,640,381
1947	904,804	971,323	1,072,390	1,031,086	1,129,184	1,428,265	1,404,147	1,899,597	1,431,098	779,420	751,618	721,590	13,524,522
1948	873,067	967,485	945,302	1,042,938	971,037	963,506	1,319,140	2,063,486	2,199,902	852,439	752,376	706,134	13,656,812
1949	876,280	921,679	862,503	715,005	822,533	1,337,443	1,706,394	2,521,256	1,376,864	736,471	725,161	665,706	13,267,295
1950	825,573	860,698	770,632	1,011,842	1,048,605	1,634,227	1,965,906	1,686,848	1,788,789	1,050,651	711,783	752,495	14,108,049
1951	967,907	1,224,762	1,333,572	1,578,427	1,502,553	1,682,395	2,677,976	2,216,304	1,483,098	849,488	786,221	739,629	17,042,332
1952	1,005,809	1,192,986	1,283,348	1,495,996	1,287,158	1,012,966	4,820,184	4,140,844	2,100,376	1,014,121	740,690	734,488	20,828,966
1953	871,569	926,262	877,906	1,265,479	1,030,401	1,050,980	1,501,133	1,829,566	2,402,509	1,018,866	735,128	769,117	14,278,916
1954	917,904	968,463	941,512	982,809	937,209	1,143,598	1,625,389	1,870,528	1,294,265	826,376	752,468	682,480	12,943,001
1955	838,210	953,375	883,403	795,403	680,094	711,109	960,933	1,099,856	1,201,772	758,456	666,078	588,162	10,136,851
1956	783,270	861,616	1,320,527	1,710,753	1,436,557	1,832,670	2,686,578	2,413,438	2,308,923	840,187	792,110	756,551	17,743,180
1957	976,790	1,023,020	996,250	1,112,707	1,357,290	1,834,521	2,132,977	3,229,883	1,955,184	796,009	741,695	757,761	16,914,087
1958	944,849	931,470	946,909	989,230	1,327,669	1,099,206	2,411,443	3,222,302	1,725,794	820,123	785,292	736,456	15,940,743
1959	810,940	854,165	813,641	820,098	752,619	745,870	1,020,915	1,026,270	1,169,462	694,161	717,600	800,810	10,226,551
1960	905,151	882,600	840,781	690,262	836,892	1,223,985	1,415,103	1,051,557	1,139,658	642,235	602,954	584,809	10,815,987
1961	776,179	847,026	734,182	675,904	857,383	834,272	738,079	811,323	816,501	535,729	449,187	512,664	8,588,429
1962	786,245	735,001	695,764	764,872	1,004,411	868,628	1,844,800	1,586,617	1,268,373	704,923	682,683	645,295	11,587,612
1963	939,312	1,032,270	1,051,923	816,975	1,190,472	768,328	1,015,996	1,384,672	1,697,615	751,850	682,968	641,650	11,974,031
1964	776,302	912,256	856,880	709,882	639,993	818,290	1,408,271	1,515,024	2,251,467	770,972	721,198	727,352	12,107,887

Table B-1. MODSIM model output of monthly flows into Brownlee Reservoir under the Proposed Action scenario (in acre-feet) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	TOTAL
1965	843,699	913,367	1,611,115	1,771,939	2,102,453	1,840,265	2,716,006	2,439,244	2,124,828	1,101,249	836,145	783,835	19,084,145
1966	988,258	981,903	1,050,609	1,164,781	874,117	1,041,061	1,142,197	1,033,580	762,990	605,105	475,077	550,995	10,670,673
1967	825,637	791,372	773,063	1,140,438	976,092	970,230	991,108	1,509,104	2,149,027	844,540	693,442	691,441	12,355,494
1968	859,346	926,690	865,060	1,001,572	1,169,040	1,083,857	652,189	999,254	1,219,176	669,428	829,639	639,519	10,914,770
1969	832,035	965,476	889,149	1,327,694	1,037,123	935,004	3,010,016	2,962,140	1,472,679	786,890	746,905	753,113	15,718,224
1970	850,389	810,206	751,925	1,536,106	1,062,113	1,259,345	1,035,409	2,237,880	2,219,237	1,017,639	752,846	853,932	14,387,027
1971	897,703	1,018,583	892,666	2,408,658	1,888,079	2,123,432	2,948,231	3,527,238	2,509,789	1,304,930	744,183	771,056	21,034,548
1972	1,237,556	1,414,406	1,192,140	2,152,808	1,638,923	3,951,984	2,184,443	2,648,955	2,682,145	952,454	808,498	877,002	21,741,314
1973	1,011,683	1,245,121	1,320,047	1,479,841	1,123,308	1,169,805	1,191,855	1,501,768	1,024,731	680,740	664,142	731,306	13,144,347
1974	878,061	1,179,296	1,154,286	2,143,215	1,460,684	2,586,156	3,155,834	2,473,667	2,616,665	1,086,071	770,612	772,237	20,276,784
1975	994,803	1,020,892	994,898	1,567,203	1,301,264	1,561,531	1,776,452	2,935,986	2,721,455	1,510,733	879,594	817,449	18,082,260
1976	1,142,403	1,258,953	1,459,388	1,531,547	1,300,308	1,830,603	2,779,064	2,778,834	2,023,298	811,646	937,615	884,484	18,738,143
1977	906,933	1,130,402	994,259	927,628	790,137	729,490	523,676	557,591	496,563	489,545	387,156	500,427	8,433,807
1978	669,105	721,471	917,662	965,250	1,047,021	1,342,894	1,731,476	1,974,825	1,276,087	906,100	704,571	852,214	13,108,676
1979	798,848	827,987	767,744	992,956	1,028,970	1,337,339	1,190,118	1,534,279	957,498	653,810	617,675	615,950	11,323,174
1980	749,108	742,061	683,646	1,023,639	1,027,897	1,047,439	1,773,038	2,225,167	1,847,436	809,384	657,497	835,441	13,421,753
1981	822,075	927,255	1,113,894	993,423	1,110,176	952,128	1,186,908	1,135,548	1,420,370	696,571	710,982	695,616	11,764,946
1982	829,034	858,166	1,020,498	1,288,995	2,122,170	2,235,195	2,770,158	3,110,182	2,019,578	1,421,514	782,499	890,800	19,348,789
1983	1,346,466	1,310,704	1,447,034	2,306,868	1,945,532	3,651,896	2,666,970	3,081,916	2,509,916	1,271,216	1,008,632	871,799	23,418,949
1984	1,324,959	1,584,342	1,540,899	2,082,526	1,710,227	2,917,325	3,636,203	4,119,188	3,446,588	1,246,060	1,035,301	1,042,174	25,685,792
1985	1,162,651	1,575,848	1,235,334	1,282,337	1,122,940	1,343,311	2,755,212	2,147,407	1,009,823	727,040	733,722	825,360	15,920,985
1986	896,283	825,232	672,853	1,423,844	2,671,066	3,533,047	3,181,365	2,504,867	2,102,678	898,489	748,897	868,789	20,327,410
1987	934,646	1,135,744	1,041,378	1,282,966	964,452	1,009,716	805,442	738,278	708,843	609,987	513,678	595,587	10,340,717
1988	670,560	705,215	691,025	663,724	657,650	698,775	720,797	686,468	649,870	479,919	424,558	538,442	7,587,003
1989	685,673	728,949	672,287	701,409	661,198	1,607,863	2,014,344	1,424,394	975,981	675,117	703,700	689,188	11,540,103
1990	799,736	858,286	775,575	690,572	585,137	790,328	845,923	814,861	836,316	643,543	603,318	576,988	8,820,583
1991	718,075	723,780	589,944	665,130	615,211	649,448	625,845	858,234	733,883	577,580	437,449	593,208	7,787,787
1992	683,518	823,664	763,038	616,817	726,598	682,312	601,382	525,351	463,412	401,385	339,098	405,335	7,031,910
1993	564,270	640,247	608,064	682,634	599,013	1,623,723	1,785,684	2,445,977	1,423,099	774,959	718,806	635,589	12,502,065
1994	782,975	780,225	771,241	758,420	629,462	736,920	792,536	778,167	556,682	525,599	445,504	511,670	8,069,401
1995	684,536	668,345	693,898	1,050,019	1,132,853	1,485,312	1,579,824	2,284,797	2,005,390	1,045,804	690,864	730,784	14,052,426
1996	897,195	904,848	1,345,392	1,655,219	2,035,793	2,206,480	2,966,617	2,708,836	1,707,674	923,323	784,369	795,269	18,931,015
1997	920,828	943,789	1,260,550	2,937,831	2,351,257	2,677,855	3,172,291	3,481,158	2,753,655	1,225,620	987,953	846,567	23,559,354
1998	1,348,628	1,187,337	1,071,269	1,774,641	1,279,283	1,684,532	1,698,583	3,506,352	2,537,965	1,043,366	759,140	810,154	18,701,250
1999	912,341	1,130,184	1,175,782	1,604,440	1,460,515	2,534,252	2,633,171	2,465,652	2,452,784	887,206	785,391	774,436	18,816,154
2000	883,840	871,312	853,814	1,240,080	1,344,725	1,383,505	1,808,712	1,253,951	827,098	717,242	721,041	744,713	12,650,033
Average	868,174	954,126	959,011	1,155,117	1,098,231	1,399,893	1,776,880	1,870,876	1,527,571	820,258	693,039	703,980	13,827,157

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Proposed Action Scenario (in cfs) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Average
1928	13,034	18,046	17,720	20,628	15,344	31,578	28,578	47,406	23,476	13,396	12,349	12,217	21,148
1929	12,850	16,710	13,448	15,544	10,513	18,930	19,362	20,302	19,242	12,082	11,804	10,355	15,095
1930	12,077	14,864	14,533	10,164	15,634	13,401	14,967	14,563	12,224	11,656	11,123	9,885	12,924
1931	12,210	12,847	11,942	11,734	10,874	14,099	13,242	10,749	8,411	8,530	7,376	8,293	10,859
1932	10,255	12,727	11,674	11,443	8,085	20,128	27,597	27,405	25,464	12,935	10,402	10,794	15,742
1933	12,709	15,996	14,006	11,717	11,465	13,709	16,759	19,127	28,772	11,884	10,319	10,927	14,783
1934	12,335	15,558	14,999	14,421	13,060	12,728	13,469	9,996	9,444	7,567	6,896	7,992	11,539
1935	10,174	12,230	11,318	11,538	11,383	11,881	19,140	16,448	15,984	10,255	9,820	10,110	12,523
1936	12,170	14,841	13,247	12,484	13,601	10,683	34,225	27,286	21,057	11,611	11,164	11,438	16,151
1937	12,248	15,037	13,793	10,594	11,138	10,646	17,839	15,037	12,645	8,446	8,135	9,667	12,102
1938	12,819	14,777	16,850	16,898	17,082	22,510	38,038	40,974	28,921	17,451	12,561	12,431	20,943
1939	14,527	16,398	14,834	13,797	12,636	21,207	28,403	19,950	12,435	10,404	8,267	9,907	15,230
1940	13,223	13,095	12,180	15,089	19,434	23,277	27,655	21,281	15,515	10,997	9,395	11,409	16,046
1941	14,825	15,126	13,822	13,789	16,272	18,235	18,079	19,559	21,306	11,919	11,684	11,949	15,547
1942	13,468	15,849	16,527	13,894	15,945	11,748	31,453	21,605	26,449	12,606	10,629	11,864	16,836
1943	14,321	17,183	17,566	26,797	29,745	39,206	70,629	35,082	32,370	23,918	13,594	14,354	27,897
1944	17,319	20,562	19,780	17,506	15,856	15,103	15,632	14,581	17,583	11,887	11,024	10,933	15,647
1945	13,138	14,851	12,565	12,884	17,017	13,923	15,053	27,845	27,097	13,125	11,546	12,469	15,959
1946	14,197	16,612	17,609	20,057	16,935	34,605	54,178	39,570	22,349	13,763	12,834	12,983	22,974
1947	14,715	16,324	17,441	16,769	20,332	23,229	23,597	30,894	24,050	12,676	12,224	12,127	18,698
1948	14,199	16,259	15,374	16,962	16,882	15,670	22,169	33,559	36,971	13,864	12,236	11,867	18,834
1949	14,251	15,489	14,027	11,628	14,810	21,751	28,677	41,004	23,139	11,978	11,794	11,188	18,311
1950	13,427	14,465	12,533	16,456	18,881	26,578	33,038	27,434	30,062	17,087	11,576	12,646	19,515
1951	15,741	20,583	21,688	25,671	27,055	27,362	45,005	36,045	24,924	13,816	12,787	12,430	23,592
1952	16,358	20,049	20,872	24,330	22,377	16,474	81,006	67,344	35,298	16,493	12,046	12,343	28,749
1953	14,175	15,566	14,278	20,581	18,553	17,093	25,227	29,755	40,375	16,570	11,956	12,925	19,755
1954	14,928	16,276	15,312	15,984	16,875	18,599	27,316	30,421	21,751	13,440	12,238	11,469	17,884
1955	13,632	16,022	14,367	12,936	12,246	11,565	16,149	17,887	20,196	12,335	10,833	9,884	14,004
1956	12,739	14,480	21,476	27,823	24,975	29,806	45,149	39,251	38,803	13,664	12,882	12,714	24,480
1957	15,886	17,192	16,202	18,096	24,439	29,836	35,846	52,529	32,858	12,946	12,063	12,735	23,386
1958	15,366	15,654	15,400	16,088	23,906	17,877	40,526	52,406	29,003	13,338	12,772	12,377	22,059
1959	13,189	14,355	13,233	13,338	13,552	12,130	17,157	16,691	19,653	11,289	11,671	13,458	14,143
1960	14,721	14,833	13,674	11,226	14,549	19,906	23,782	17,102	19,153	10,445	9,806	9,828	14,919
1961	12,623	14,235	11,940	10,993	15,438	13,568	12,404	13,195	13,722	8,713	7,305	8,616	11,896
1962	12,787	12,352	11,316	12,439	18,085	14,127	31,003	25,804	21,316	11,464	11,103	10,845	16,053
1963	15,276	17,348	17,108	13,287	21,436	12,496	17,074	22,520	28,529	12,228	11,107	10,783	16,599
1964	12,625	15,331	13,936	11,545	11,126	13,308	23,667	24,640	37,837	12,539	11,729	12,224	16,709

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Proposed Action Scenario (in cfs) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Average
1965	13,721	15,350	26,202	28,818	37,857	29,929	45,644	39,671	35,709	17,910	13,599	13,173	26,465
1966	16,072	16,501	17,087	18,943	15,739	16,931	19,195	16,810	12,822	9,841	7,726	9,260	14,744
1967	13,428	13,299	12,573	18,547	17,575	15,779	16,656	24,543	36,116	13,735	11,278	11,620	17,096
1968	13,976	15,574	14,069	16,289	20,324	17,627	10,960	16,251	20,489	10,887	13,493	10,747	15,057
1969	13,532	16,225	14,461	21,593	18,674	15,206	50,585	48,175	24,749	12,798	12,147	12,656	21,733
1970	13,830	13,616	12,229	24,982	19,124	20,481	17,401	36,396	37,296	16,550	12,244	14,351	19,875
1971	14,600	17,118	14,518	39,173	33,997	34,534	49,547	57,365	42,178	21,223	12,103	12,958	29,109
1972	20,127	23,770	19,388	35,012	28,493	64,273	36,711	43,081	45,075	15,490	13,149	14,739	29,942
1973	16,453	20,925	21,469	24,067	20,226	19,025	20,030	24,424	17,221	11,071	10,801	12,290	18,167
1974	14,280	19,819	18,773	34,856	26,301	42,060	53,036	40,230	43,975	17,663	12,533	12,978	28,042
1975	16,179	17,157	16,180	25,488	23,430	25,396	29,854	47,749	45,736	24,570	14,305	13,738	24,982
1976	18,579	21,157	23,735	24,908	22,606	29,772	46,704	45,193	34,003	13,200	15,249	14,864	25,831
1977	14,750	18,997	16,170	15,086	14,227	11,864	8,801	9,068	8,345	7,962	6,296	8,410	11,665
1978	10,882	12,125	14,924	15,698	18,853	21,840	29,098	32,117	21,445	14,736	11,459	14,322	18,125
1979	12,992	13,915	12,486	16,149	18,528	21,750	20,001	24,953	16,091	10,633	10,046	10,351	15,658
1980	12,183	12,471	11,118	16,648	17,870	17,035	29,797	36,189	31,047	13,163	10,693	14,040	18,521
1981	13,370	15,583	18,116	16,156	19,990	15,485	19,947	18,468	23,870	11,329	11,563	11,690	16,297
1982	13,483	14,422	16,597	20,963	38,212	36,352	46,554	50,582	33,940	23,119	12,726	14,970	26,827
1983	21,898	22,027	23,534	37,518	35,031	59,392	44,820	50,123	42,181	20,674	16,404	14,651	32,354
1984	21,548	26,626	25,060	33,869	29,732	47,446	61,108	66,992	57,922	20,265	16,838	17,514	35,410
1985	18,909	26,483	20,091	20,855	20,220	21,847	46,303	34,924	16,971	11,824	11,933	13,871	22,019
1986	14,577	13,868	10,943	23,157	48,095	57,460	53,465	40,738	35,337	14,613	12,180	14,600	28,253
1987	15,201	19,087	16,936	20,865	17,366	16,421	13,536	12,007	11,913	9,920	8,354	10,009	14,301
1988	10,906	11,852	11,238	10,794	11,433	11,364	12,113	11,164	10,921	7,805	6,905	9,049	10,462
1989	11,151	12,250	10,934	11,407	11,905	26,149	33,852	23,166	16,402	10,980	11,445	11,582	15,935
1990	13,006	14,424	12,614	11,231	10,536	12,853	14,216	13,252	14,055	10,466	9,812	9,697	12,180
1991	11,678	12,164	9,595	10,817	11,077	10,562	10,518	13,958	12,333	9,393	7,114	9,969	10,765
1992	11,116	13,842	12,410	10,032	12,632	11,097	10,107	8,544	7,788	6,528	5,515	6,812	9,702
1993	9,177	10,760	9,889	11,102	10,786	26,407	30,009	39,780	23,916	12,603	11,690	10,681	17,233
1994	12,734	13,112	12,543	12,335	11,334	11,985	13,319	12,656	9,355	8,548	7,245	8,599	11,147
1995	11,133	11,232	11,285	17,077	20,398	24,156	26,550	37,159	33,702	17,008	11,236	12,281	19,435
1996	14,591	15,206	21,881	26,920	35,392	35,885	49,856	44,055	28,698	15,016	12,757	13,365	26,135
1997	14,976	15,861	20,501	47,779	42,337	43,551	53,312	56,616	46,277	19,933	16,068	14,227	32,620
1998	21,933	19,954	17,423	28,862	23,035	27,396	28,546	57,025	42,652	16,969	12,346	13,615	25,813
1999	14,838	18,993	19,122	26,094	26,298	41,216	44,252	40,100	41,220	14,429	12,773	13,015	26,029
2000	14,374	14,643	13,886	20,168	23,378	22,501	30,396	20,394	13,900	11,665	11,727	12,515	17,462
Average	14,119	16,035	15,597	18,786	19,597	22,767	29,861	30,427	25,672	13,340	11,271	11,831	19,109

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Without Reclamation Scenario (in acre-feet) (Upper Snake MODSIM –May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	TOTAL
1928	1,231,615	1,720,548	1,578,118	1,550,994	1,091,520	2,410,327	2,038,960	4,319,005	1,874,794	573,372	386,867	524,625	19,300,745
1929	865,401	1,283,891	1,045,790	1,093,123	719,095	1,634,459	1,608,860	1,973,965	1,465,386	422,515	318,028	404,796	12,835,309
1930	718,564	1,104,708	1,216,103	904,904	1,261,306	1,306,207	1,438,586	1,528,856	844,066	395,106	361,865	450,681	11,530,952
1931	890,517	1,108,080	1,051,833	995,486	891,785	1,253,482	883,912	804,043	469,152	328,014	306,551	395,345	9,378,200
1932	791,224	1,000,272	1,007,104	936,461	682,317	1,862,048	2,347,026	3,144,175	2,413,054	549,748	304,482	434,959	15,472,870
1933	641,184	1,174,757	1,039,961	1,043,348	871,734	1,201,114	1,588,375	1,789,447	2,483,538	458,704	319,553	438,494	13,050,209
1934	612,602	1,082,894	1,172,515	1,251,726	1,061,836	1,279,038	1,041,043	757,286	502,749	325,497	286,101	364,118	9,737,405
1935	785,425	1,010,808	986,592	945,080	876,870	1,089,145	1,900,545	1,790,822	1,524,212	384,186	292,652	376,893	11,963,230
1936	577,996	1,057,501	980,921	1,065,556	1,096,751	1,178,895	3,174,103	3,591,442	1,883,021	403,379	345,871	461,475	15,816,911
1937	602,899	1,064,028	1,058,687	886,279	870,577	1,081,340	1,377,859	1,401,187	848,291	378,972	325,132	429,534	10,324,785
1938	925,512	1,198,710	1,543,996	1,211,318	1,069,796	1,855,474	3,007,761	3,754,619	2,848,352	863,560	409,949	497,902	19,186,949
1939	896,623	1,288,495	1,211,047	1,069,873	863,738	1,930,112	2,174,336	1,858,744	599,822	371,906	312,110	439,265	13,016,071
1940	974,909	1,067,692	1,096,904	1,106,422	1,356,338	2,063,083	1,990,155	1,607,956	886,152	383,706	316,113	533,952	13,383,382
1941	1,088,190	1,271,206	1,213,152	1,165,306	1,338,587	1,668,363	1,332,607	1,523,351	1,326,161	486,839	397,290	526,594	13,337,646
1942	809,690	1,316,948	1,524,921	1,182,339	1,197,341	1,170,241	2,918,489	2,252,978	2,042,175	547,847	335,794	494,333	15,793,096
1943	753,952	1,427,186	1,541,633	1,796,762	1,572,039	2,405,914	4,722,667	3,280,383	3,281,304	1,669,002	494,452	597,762	23,543,056
1944	887,404	1,565,700	1,239,587	1,080,166	1,074,187	1,176,556	1,180,803	1,177,103	1,515,276	446,774	325,015	441,995	12,110,566
1945	673,367	1,234,888	1,115,609	1,163,237	1,410,314	1,333,928	1,479,662	2,833,352	2,320,302	612,342	354,834	503,170	15,035,005
1946	889,236	1,328,379	1,441,810	1,350,662	990,425	2,255,758	3,641,839	3,396,962	1,887,844	551,668	380,820	583,104	18,698,507
1947	1,037,021	1,472,325	1,596,215	1,135,774	1,339,872	1,555,871	1,649,572	2,846,129	1,919,156	515,302	361,738	519,100	15,948,075
1948	903,402	1,297,076	1,290,276	1,294,502	1,172,917	1,222,011	1,741,155	2,799,933	2,611,857	542,397	351,255	493,781	15,720,562
1949	862,202	1,221,709	1,149,974	1,013,997	1,108,641	1,893,332	2,458,385	3,379,009	1,616,536	401,054	328,085	451,907	15,884,831
1950	896,846	1,255,653	1,143,754	1,161,873	1,244,420	1,768,671	2,262,428	2,521,139	2,978,035	1,006,680	372,543	499,545	17,111,587
1951	1,070,523	1,458,518	1,477,018	1,238,411	1,742,571	1,563,334	3,116,452	3,460,338	2,170,452	600,799	426,747	518,181	18,843,344
1952	1,117,048	1,391,250	1,531,134	1,280,514	1,143,566	1,049,934	5,308,948	5,544,499	2,662,405	760,283	358,591	532,167	22,680,339
1953	799,639	1,161,871	1,203,622	1,667,095	1,286,882	1,338,825	1,826,830	2,093,850	3,394,845	809,984	365,976	494,811	16,444,230
1954	755,071	1,254,864	1,227,684	1,257,113	1,260,596	1,440,392	1,852,775	2,756,640	1,724,061	587,628	370,630	476,749	14,964,203
1955	813,211	1,205,779	1,126,280	1,074,730	909,791	1,061,116	1,307,211	1,741,152	1,636,333	510,722	327,683	420,859	12,134,867
1956	735,897	1,268,477	2,014,768	1,856,028	1,233,730	1,905,922	2,881,782	4,005,066	3,329,000	567,754	407,311	503,914	20,709,649
1957	951,220	1,360,211	1,366,642	1,102,328	1,530,139	2,159,227	2,119,396	4,296,277	2,923,278	506,485	367,204	501,696	19,184,103
1958	914,289	1,202,425	1,308,206	1,183,246	1,705,012	1,371,348	2,622,167	4,335,925	2,109,278	484,036	403,037	519,781	18,158,750
1959	689,460	1,226,723	1,276,191	1,234,956	1,107,301	1,129,663	1,464,684	1,644,911	1,735,276	403,406	337,406	624,702	12,874,679
1960	1,025,501	1,159,223	1,112,114	1,022,252	1,172,632	1,892,231	1,765,173	1,424,716	1,156,820	328,096	326,878	426,579	12,812,215
1961	918,084	1,223,385	1,039,950	922,514	1,214,382	1,263,232	887,593	1,115,805	884,022	288,915	245,239	399,129	10,402,250
1962	1,055,693	1,117,180	1,046,977	940,283	1,519,636	1,323,807	2,474,926	2,651,795	1,973,443	434,149	331,259	433,504	15,302,652
1963	939,067	1,273,703	1,305,232	1,005,360	1,787,680	1,090,163	1,327,998	2,080,195	2,218,056	468,296	302,283	457,937	14,255,970
1964	673,821	1,204,296	1,090,248	1,051,020	914,738	1,191,681	1,964,392	2,372,946	3,056,285	560,495	346,079	491,832	14,917,833

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Without Reclamation Scenario (in acre-feet) (Upper Snake MODSIM –May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	TOTAL
1965	688,631	1,202,446	2,312,170	1,716,533	1,976,445	1,576,915	2,946,493	3,637,764	3,587,000	1,094,613	529,895	546,666	21,815,571
1966	829,189	1,224,436	1,129,630	1,201,419	971,198	1,318,221	1,452,858	1,658,176	646,996	316,902	298,096	405,535	11,452,656
1967	915,836	1,149,359	1,149,309	1,261,730	1,068,456	1,194,045	1,107,433	2,295,683	3,198,093	626,779	319,795	443,426	14,729,944
1968	846,379	1,210,311	1,112,759	1,064,744	1,405,648	1,351,473	921,341	1,436,668	1,808,888	346,443	492,865	458,427	12,455,946
1969	847,055	1,302,897	1,196,326	1,735,402	1,209,119	1,253,993	3,877,839	3,825,576	1,776,378	482,713	364,303	551,164	18,422,765
1970	873,047	1,146,443	1,133,757	2,002,531	1,300,760	1,410,807	1,086,720	2,927,788	3,313,135	784,772	394,587	618,096	16,992,443
1971	857,304	1,462,136	1,276,114	2,170,384	1,441,145	1,754,222	2,862,443	4,826,143	4,363,061	1,416,648	386,020	522,961	23,338,581
1972	1,086,975	1,490,465	1,413,705	1,665,307	1,253,510	3,855,147	2,408,535	3,779,690	4,130,041	680,873	457,620	630,220	22,852,088
1973	1,189,413	1,422,381	1,470,753	1,560,017	1,223,127	1,496,016	1,598,309	2,212,929	1,199,016	391,435	360,150	559,228	14,682,774
1974	957,266	1,716,087	1,633,359	1,964,121	1,092,145	2,429,492	3,057,247	3,574,555	4,430,345	928,444	440,735	511,323	22,735,119
1975	988,897	1,243,582	1,245,501	1,235,596	1,288,097	1,736,737	1,835,699	3,630,985	4,181,914	1,687,911	494,178	562,786	20,131,883
1976	1,174,322	1,348,154	1,590,962	1,399,306	1,241,708	1,606,070	2,903,016	4,147,081	2,614,946	579,802	616,930	700,472	19,922,769
1977	1,010,019	1,159,102	1,166,430	1,085,091	978,117	979,493	504,052	517,892	399,234	246,311	216,969	374,947	8,637,657
1978	860,448	1,048,231	1,472,429	1,347,262	1,311,403	1,968,331	2,443,079	3,067,734	2,544,281	766,280	365,729	610,901	17,806,108
1979	744,747	1,058,220	1,018,717	1,096,688	1,223,771	1,724,860	1,517,124	2,372,014	1,270,034	333,079	324,498	435,247	13,118,999
1980	738,094	984,189	1,041,711	1,435,341	1,493,422	1,360,481	2,029,728	3,185,183	2,390,760	603,933	324,550	677,410	16,264,802
1981	790,621	1,202,012	1,447,792	1,271,002	1,412,654	1,360,799	1,553,381	1,779,848	1,591,043	389,679	331,535	505,221	13,635,587
1982	821,674	1,245,031	1,597,636	1,211,144	2,446,614	2,145,307	2,644,906	4,272,277	3,706,339	1,789,414	451,284	667,385	22,999,011
1983	1,216,910	1,385,950	1,659,060	1,698,351	1,517,724	3,562,038	2,728,198	4,324,952	4,146,597	1,419,725	614,219	632,437	24,906,161
1984	1,259,506	1,722,275	1,707,498	1,659,478	1,363,304	2,701,500	3,802,871	5,367,175	4,712,394	1,346,740	492,269	704,347	26,839,357
1985	1,181,187	1,578,719	1,438,646	1,318,975	1,187,558	1,576,319	3,168,834	2,856,166	1,167,535	397,845	347,677	667,070	16,886,531
1986	1,045,292	1,252,568	1,151,334	1,062,853	2,775,288	3,736,584	3,416,575	3,227,633	3,663,159	622,136	391,640	651,337	22,996,399
1987	1,132,887	1,325,433	1,237,976	1,219,254	1,186,017	1,450,303	1,044,092	888,377	504,412	381,475	342,305	450,503	11,163,034
1988	808,399	1,083,036	1,075,010	1,034,461	1,001,612	1,121,358	1,173,009	915,659	637,011	285,804	256,745	403,944	9,796,048
1989	758,096	1,075,450	1,032,622	987,238	948,127	2,675,772	2,808,795	2,464,032	1,497,512	353,223	364,347	494,572	15,459,786
1990	852,785	1,099,684	1,037,936	1,074,245	903,190	1,316,248	1,348,779	1,007,071	949,802	320,816	300,308	414,690	10,625,554
1991	752,891	1,031,636	876,037	1,006,138	936,246	1,093,141	888,007	1,874,252	1,216,938	357,768	271,610	439,835	10,744,499
1992	562,447	1,100,153	1,029,884	934,731	1,093,766	1,094,507	694,268	614,748	308,976	289,754	236,720	338,065	8,298,019
1993	671,854	904,617	952,608	983,314	858,682	2,886,175	2,556,638	3,938,183	2,388,074	548,571	427,832	453,504	17,570,052
1994	812,659	951,367	1,051,580	1,074,642	946,348	1,158,013	966,684	1,004,963	408,018	282,417	259,354	357,323	9,273,368
1995	891,173	978,419	1,091,389	1,381,881	1,650,709	2,131,387	1,980,842	3,283,083	3,259,532	978,427	372,395	509,063	18,508,300
1996	896,719	1,234,726	1,577,142	1,295,499	1,833,300	1,987,176	2,872,384	3,791,169	3,400,387	671,483	424,197	552,725	20,536,907
1997	876,246	1,359,136	1,743,634	2,846,850	1,733,376	2,306,599	3,114,568	5,225,324	4,224,679	1,177,506	489,772	629,801	25,727,491
1998	1,205,994	1,279,804	1,238,981	1,467,174	1,212,733	1,936,210	1,938,974	4,581,868	3,221,414	822,656	391,971	603,860	19,901,639
1999	1,081,302	1,270,017	1,312,770	1,418,784	1,307,826	2,392,934	2,525,560	3,495,563	3,793,140	649,762	448,700	518,173	20,214,531
2000	852,431	1,215,443	1,237,898	1,319,533	1,588,964	1,679,889	2,223,327	1,920,449	807,435	378,871	336,299	562,530	14,123,069
Average	888,397	1,240,072	1,277,173	1,280,110	1,261,276	1,694,586	2,121,672	2,709,379	2,172,237	612,063	367,692	504,526	16,129,185

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Without Reclamation Scenario (in cfs) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Average
1928	20,030	28,915	25,666	25,225	18,976	39,200	34,266	70,242	31,507	9,325	6,292	8,817	26,538
1929	14,074	21,577	17,008	17,778	12,948	26,582	27,038	32,103	24,627	6,872	5,172	6,803	17,715
1930	11,686	18,565	19,778	14,717	22,711	21,243	24,176	24,864	14,185	6,426	5,885	7,574	15,984
1931	14,483	18,622	17,106	16,190	16,057	20,386	14,855	13,077	7,884	5,335	4,986	6,644	12,969
1932	12,868	16,810	16,379	15,230	11,862	30,283	39,443	51,135	40,553	8,941	4,952	7,310	21,314
1933	10,428	19,742	16,913	16,968	15,696	19,534	26,694	29,103	41,737	7,460	5,197	7,369	18,070
1934	9,963	18,199	19,069	20,357	19,119	20,802	17,495	12,316	8,449	5,294	4,653	6,119	13,486
1935	12,774	16,987	16,045	15,370	15,789	17,713	31,940	29,125	25,615	6,248	4,760	6,334	16,558
1936	9,400	17,772	15,953	17,330	19,067	19,173	53,343	58,409	31,645	6,560	5,625	7,755	21,836
1937	9,805	17,882	17,218	14,414	15,676	17,586	23,156	22,788	14,256	6,163	5,288	7,219	14,288
1938	15,052	20,145	25,111	19,700	19,263	30,176	50,547	61,063	47,868	14,044	6,667	8,368	26,500
1939	14,582	21,654	19,696	17,400	15,552	31,390	36,541	30,230	10,080	6,048	5,076	7,382	17,969
1940	15,855	17,943	17,839	17,994	23,580	33,553	33,446	26,151	14,892	6,240	5,141	8,973	18,467
1941	17,698	21,363	19,730	18,952	24,103	27,133	22,395	24,775	22,287	7,918	6,461	8,850	18,472
1942	13,168	22,132	24,800	19,229	21,559	19,032	49,047	36,641	34,320	8,910	5,461	8,308	21,884
1943	12,262	23,985	25,072	29,222	28,306	39,128	79,367	53,350	55,144	27,144	8,041	10,046	32,589
1944	14,432	26,312	20,160	17,567	18,675	19,135	19,844	19,144	25,465	7,266	5,286	7,428	16,726
1945	10,951	20,753	18,144	18,918	25,394	21,694	24,867	46,080	38,994	9,959	5,771	8,456	20,832
1946	14,462	22,324	23,449	21,966	17,834	36,686	61,203	55,246	31,726	8,972	6,193	9,799	25,822
1947	16,866	24,743	25,960	18,472	24,126	25,304	27,722	46,288	32,253	8,381	5,883	8,724	22,060
1948	14,692	21,798	20,984	21,053	20,391	19,874	29,261	45,537	43,894	8,821	5,713	8,298	21,693
1949	14,022	20,532	18,703	16,491	19,962	30,792	41,315	54,954	27,167	6,523	5,336	7,595	21,949
1950	14,586	21,102	18,601	18,896	22,407	28,765	38,021	41,002	50,048	16,372	6,059	8,395	23,688
1951	17,410	24,511	24,021	20,141	31,377	25,425	52,374	56,277	36,476	9,771	6,940	8,708	26,119
1952	18,167	23,381	24,902	20,826	19,881	17,076	89,220	90,173	44,743	12,365	5,832	8,943	31,292
1953	13,005	19,526	19,575	27,113	23,172	21,774	30,701	34,053	57,052	13,173	5,952	8,316	22,784
1954	12,280	21,089	19,966	20,445	22,698	23,426	31,137	44,832	28,974	9,557	6,028	8,012	20,704
1955	13,226	20,264	18,317	17,479	16,382	17,257	21,968	28,317	27,500	8,306	5,329	7,073	16,785
1956	11,968	21,317	32,767	30,185	21,448	30,997	48,430	65,136	55,946	9,234	6,624	8,469	28,543
1957	15,470	22,859	22,226	17,928	27,552	35,116	35,618	69,872	49,127	8,237	5,972	8,431	26,534
1958	14,869	20,207	21,276	19,244	30,700	22,303	44,067	70,517	35,448	7,872	6,555	8,735	25,149
1959	11,213	20,616	20,755	20,085	19,938	18,372	24,615	26,752	29,162	6,561	5,487	10,498	17,838
1960	16,678	19,481	18,087	16,625	20,386	30,774	29,665	23,171	19,441	5,336	5,316	7,169	17,677
1961	14,931	20,560	16,913	15,003	21,866	20,545	14,917	18,147	14,856	4,699	3,988	6,708	14,428
1962	17,169	18,775	17,027	15,292	27,363	21,530	41,593	43,127	33,165	7,061	5,387	7,285	21,231
1963	15,272	21,405	21,228	16,351	32,189	17,730	22,318	33,831	37,276	7,616	4,916	7,696	19,819
1964	10,959	20,239	17,731	17,093	15,903	19,381	33,013	38,592	51,363	9,116	5,628	8,266	20,607

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Without Reclamation Scenario (in cfs) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Average
1965	11,200	20,208	37,604	27,917	35,588	25,646	49,517	59,163	60,282	17,802	8,618	9,187	30,228
1966	13,485	20,577	18,372	19,539	17,487	21,439	24,416	26,968	10,873	5,154	4,848	6,815	15,831
1967	14,895	19,316	18,692	20,520	19,239	19,419	18,611	37,336	53,746	10,194	5,201	7,452	20,385
1968	13,765	20,340	18,097	17,316	24,437	21,980	15,484	23,365	30,399	5,634	8,016	7,704	17,211
1969	13,776	21,896	19,456	28,224	21,771	20,394	65,169	62,217	29,853	7,851	5,925	9,263	25,483
1970	14,199	19,267	18,439	32,568	23,421	22,945	18,263	47,616	55,679	12,763	6,417	10,387	23,497
1971	13,943	24,572	20,754	35,298	25,949	28,530	48,105	78,490	73,324	23,040	6,278	8,789	32,256
1972	17,678	25,048	22,992	27,084	21,792	62,698	40,477	61,471	69,408	11,073	7,442	10,591	31,480
1973	19,344	23,904	23,920	25,371	22,024	24,330	26,860	35,990	20,150	6,366	5,857	9,398	20,293
1974	15,568	28,840	26,564	31,943	19,665	39,512	51,379	58,135	74,454	15,100	7,168	8,593	31,410
1975	16,083	20,899	20,256	20,095	23,193	28,245	30,850	59,052	70,279	27,451	8,037	9,458	27,825
1976	19,099	22,656	25,875	22,758	21,587	26,120	48,787	67,446	43,946	9,430	10,033	11,772	27,459
1977	16,426	19,479	18,970	17,647	17,612	15,930	8,471	8,423	6,709	4,006	3,529	6,301	11,959
1978	13,994	17,616	23,947	21,911	23,613	32,012	41,057	49,892	42,758	12,462	5,948	10,267	24,623
1979	12,112	17,784	16,568	17,836	22,035	28,052	25,496	38,577	21,344	5,417	5,277	7,315	18,151
1980	12,004	16,540	16,942	23,344	25,963	22,126	34,111	51,802	40,178	9,822	5,278	11,384	22,458
1981	12,858	20,200	23,546	20,671	25,436	22,131	26,105	28,946	26,738	6,338	5,392	8,491	18,904
1982	13,363	20,923	25,983	19,697	44,054	34,890	44,449	69,482	62,287	29,102	7,339	11,216	31,899
1983	19,791	23,292	26,982	27,621	27,328	57,931	45,849	70,339	69,686	23,090	9,989	10,628	34,377
1984	20,484	28,944	27,770	26,989	23,701	43,936	63,909	87,289	79,194	21,903	8,006	11,837	36,997
1985	19,210	26,531	23,397	21,451	21,383	25,636	53,254	46,451	19,621	6,470	5,654	11,210	23,356
1986	17,000	21,050	18,725	17,286	49,972	60,770	57,417	52,492	61,561	10,118	6,369	10,946	31,976
1987	18,425	22,275	20,134	19,829	21,355	23,587	17,547	14,448	8,477	6,204	5,567	7,571	15,452
1988	13,147	18,201	17,483	16,824	17,413	18,237	19,713	14,892	10,705	4,648	4,176	6,789	13,519
1989	12,329	18,074	16,794	16,056	17,072	43,517	47,203	40,074	25,167	5,745	5,926	8,312	21,356
1990	13,869	18,481	16,880	17,471	16,263	21,407	22,667	16,378	15,962	5,218	4,884	6,969	14,704
1991	12,245	17,337	14,247	16,363	16,858	17,778	14,923	30,482	20,451	5,819	4,417	7,392	14,859
1992	9,147	18,489	16,749	15,202	19,015	17,800	11,668	9,998	5,193	4,712	3,850	5,681	11,459
1993	10,927	15,203	15,493	15,992	15,461	46,939	42,966	64,048	40,133	8,922	6,958	7,621	24,222
1994	13,217	15,988	17,102	17,477	17,040	18,833	16,246	16,344	6,857	4,593	4,218	6,005	12,827
1995	14,494	16,443	17,750	22,474	29,723	34,664	33,289	53,394	54,778	15,913	6,056	8,555	25,628
1996	14,584	20,750	25,650	21,069	31,872	32,318	48,272	61,657	57,145	10,921	6,899	9,289	28,369
1997	14,251	22,841	28,358	46,300	31,211	37,513	52,342	84,982	70,998	19,150	7,965	10,584	35,541
1998	19,614	21,508	20,150	23,861	21,836	31,489	32,586	74,517	54,138	13,379	6,375	10,148	27,467
1999	17,586	21,343	21,350	23,074	23,549	38,917	42,443	56,850	63,746	10,567	7,297	8,708	27,953
2000	13,863	20,426	20,132	21,460	27,624	27,321	37,364	31,233	13,569	6,162	5,469	9,454	19,507
Average	14,448	20,840	20,771	20,819	22,513	27,560	35,656	44,064	36,506	9,954	5,980	8,479	22,299

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Naturalized Flow Scenario (in acre-feet) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1928	1,318,693	1,455,711	1,332,278	1,340,683	890,779	2,343,436	2,281,379	5,314,532	3,165,951	1,696,743	936,899	928,441	23,005,525
1929	1,115,207	996,672	796,682	872,182	513,656	1,479,881	1,818,814	2,900,454	2,700,768	1,182,403	701,314	772,584	15,850,617
1930	921,814	816,231	965,823	680,147	1,061,509	1,149,374	1,664,824	2,379,825	2,069,022	972,222	877,458	797,586	14,355,835
1931	1,113,042	819,067	793,747	772,911	671,151	1,092,558	1,360,924	1,675,172	1,156,049	532,739	482,336	541,087	11,010,783
1932	781,005	690,124	749,025	712,539	464,690	1,721,508	2,651,445	4,165,893	3,781,736	1,544,255	742,060	747,565	18,751,845
1933	884,231	889,166	777,836	808,289	653,390	1,023,058	1,842,453	2,759,440	3,790,521	1,078,144	650,782	678,121	15,835,431
1934	807,891	789,119	908,932	1,021,223	841,529	1,128,031	1,535,147	1,627,859	921,203	513,744	416,986	481,562	10,993,226
1935	775,373	698,183	715,860	715,401	662,501	942,918	2,194,355	2,639,777	2,797,461	1,069,768	570,269	571,615	14,353,481
1936	786,025	771,292	721,063	844,463	861,896	1,016,832	3,566,878	4,580,462	3,162,209	1,070,976	767,790	755,220	18,905,106
1937	818,774	766,595	807,518	665,600	661,836	922,575	1,932,785	2,830,869	2,104,337	917,342	559,399	626,325	13,613,955
1938	897,574	890,760	1,318,583	999,911	883,266	1,795,801	3,564,015	4,751,901	4,090,074	2,099,134	914,358	852,707	23,058,084
1939	1,118,552	1,008,658	965,970	851,323	659,585	1,812,155	2,418,466	2,753,270	1,712,691	967,460	636,739	760,322	15,665,191
1940	947,546	751,482	837,671	893,434	1,150,882	1,974,536	2,542,635	2,954,831	1,967,496	775,393	540,896	869,002	16,205,804
1941	1,073,790	965,831	964,407	954,996	1,095,506	1,615,908	1,903,650	2,899,611	2,547,138	1,063,233	885,281	886,642	16,855,993
1942	1,060,662	1,031,600	1,266,349	943,812	970,461	1,010,573	3,175,260	3,088,144	3,353,997	1,423,167	690,757	802,199	18,816,981
1943	998,517	1,151,769	1,285,878	1,521,570	1,314,014	2,188,004	5,181,790	4,510,036	4,720,969	3,154,867	1,233,264	1,057,296	28,317,974
1944	1,150,665	1,295,163	984,174	849,052	842,282	1,006,753	1,646,399	2,230,885	2,741,567	1,281,862	665,232	743,291	15,437,325
1945	922,770	939,471	848,962	929,914	1,219,494	1,218,158	1,731,723	3,780,321	3,679,074	1,855,079	941,133	969,020	19,035,119
1946	1,109,014	1,021,498	1,169,442	1,109,834	780,681	2,112,712	4,043,532	4,389,811	3,104,073	1,372,160	903,351	1,018,703	22,134,811
1947	1,249,285	1,179,995	1,341,757	912,738	1,178,384	1,438,376	1,892,387	3,798,516	3,129,342	1,494,781	942,454	905,656	19,463,671
1948	1,116,473	991,555	1,029,658	1,071,092	983,029	1,071,776	2,014,154	3,791,726	3,979,228	1,331,820	818,938	843,867	19,043,316
1949	1,070,521	944,723	900,833	782,170	927,487	1,760,845	2,815,433	4,378,554	2,898,149	1,142,050	776,669	761,495	19,158,929
1950	1,121,681	974,434	902,375	944,160	1,087,822	1,652,560	2,560,141	3,471,706	4,388,009	2,545,535	1,068,959	997,326	21,714,708
1951	1,273,131	1,185,513	1,225,206	1,015,834	1,582,424	1,396,864	3,450,517	4,392,046	3,467,860	1,889,229	1,305,499	969,324	23,153,447
1952	1,325,273	1,096,175	1,276,720	1,050,883	898,556	961,486	5,875,044	6,564,132	3,995,391	1,796,460	975,590	936,788	26,752,498
1953	992,219	869,220	949,254	1,489,332	1,096,039	1,206,643	2,090,629	3,091,214	4,783,756	1,909,269	896,065	806,939	20,180,579
1954	981,559	973,458	976,475	1,025,017	1,054,148	1,282,672	2,103,390	3,713,434	2,942,821	1,765,122	905,247	816,696	18,540,039
1955	1,017,544	901,183	854,064	831,298	690,690	879,853	1,514,533	2,682,878	2,945,579	1,341,406	750,988	684,004	15,094,020
1956	953,879	988,023	1,790,376	1,638,864	1,024,974	1,849,680	3,369,618	5,200,762	4,646,279	1,716,553	990,482	907,158	25,076,648
1957	1,183,579	1,059,886	1,096,078	862,336	1,413,603	2,046,310	2,322,576	5,233,987	4,254,316	1,673,167	896,696	907,148	22,949,681
1958	1,114,241	898,500	1,042,983	1,048,535	1,585,806	1,284,866	2,792,960	5,373,290	3,369,854	1,123,086	811,745	847,438	21,293,305
1959	906,392	949,331	1,048,634	1,035,398	923,824	990,634	1,721,541	2,491,052	2,994,345	1,149,756	705,371	1,011,870	15,928,147
1960	1,246,943	879,037	863,478	823,134	967,579	1,756,639	2,423,469	2,604,342	2,445,326	768,443	638,255	678,571	16,095,216
1961	906,379	919,136	790,118	709,830	1,022,319	1,134,704	1,376,963	2,284,169	2,042,596	553,363	446,593	762,897	12,949,067
1962	1,051,662	811,759	794,503	726,311	1,331,166	1,143,925	2,891,372	3,626,084	3,299,589	1,455,509	836,839	760,376	18,729,097
1963	1,194,282	990,881	1,065,450	802,343	1,650,151	926,487	1,576,757	2,985,892	3,567,490	1,284,744	701,722	888,281	17,634,479
1964	788,213	932,814	847,343	834,283	693,884	1,036,975	2,263,970	3,344,197	4,462,825	1,889,131	880,604	866,319	18,840,559

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Naturalized Flow Scenario (in acre-feet) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1965	897,731	919,796	2,189,850	1,503,158	1,687,387	1,479,993	3,396,722	4,818,124	5,046,154	2,706,342	1,406,027	1,149,335	27,200,619
1966	1,053,282	952,420	833,070	936,795	755,785	1,178,376	1,690,271	2,599,129	1,844,767	757,936	590,188	754,328	13,946,347
1967	890,841	833,584	888,041	1,045,603	864,045	1,085,320	1,410,242	3,334,532	4,579,251	2,101,457	848,781	828,757	18,710,454
1968	1,076,814	913,566	844,703	824,748	1,252,077	1,242,786	1,198,439	2,335,918	3,105,198	1,226,868	1,315,609	953,331	16,290,057
1969	1,011,073	991,517	925,588	1,514,048	1,009,736	1,129,976	4,371,847	4,836,661	3,126,103	1,390,253	835,959	937,204	22,079,964
1970	1,104,905	853,170	896,814	1,886,542	1,129,412	1,325,477	1,359,147	3,947,809	4,690,406	2,132,216	933,295	1,130,132	21,389,326
1971	1,074,044	1,172,736	1,035,512	2,009,979	1,282,380	1,605,892	3,376,360	6,025,265	5,759,327	3,003,568	1,262,549	1,154,343	28,761,954
1972	1,326,693	1,216,421	1,161,674	1,457,394	1,064,658	3,812,294	2,778,562	4,940,317	5,539,370	2,108,943	1,274,594	1,237,430	27,918,351
1973	1,434,491	1,144,507	1,214,548	1,355,521	1,035,647	1,346,450	1,847,572	3,131,825	2,442,395	1,200,560	831,321	1,080,757	18,065,594
1974	1,159,105	1,449,775	1,416,507	1,832,140	909,033	2,421,216	3,546,221	4,790,278	5,870,978	2,475,564	1,209,863	974,915	28,055,593
1975	1,214,213	969,889	988,164	1,006,557	1,069,202	1,603,557	2,127,484	4,772,861	5,660,714	3,293,202	1,350,981	1,088,819	25,145,644
1976	1,409,374	1,070,915	1,319,952	1,163,507	1,047,250	1,444,205	3,212,229	5,272,371	3,918,079	1,905,292	1,466,396	1,265,754	24,495,323
1977	1,217,086	855,260	894,485	848,170	759,497	812,696	890,109	1,179,464	1,083,704	515,497	463,844	607,534	10,127,347
1978	858,498	736,159	1,213,810	1,121,863	1,121,769	1,968,822	2,941,285	4,096,151	3,945,885	2,299,409	1,042,314	1,121,973	22,467,937
1979	958,712	778,244	758,213	855,213	1,040,003	1,663,454	1,825,003	3,369,029	2,432,627	1,012,719	821,017	676,121	16,190,353
1980	973,940	691,226	777,629	1,240,418	1,355,128	1,274,785	2,388,894	4,207,249	3,738,044	1,656,263	853,421	1,117,522	20,274,518
1981	995,303	893,014	1,200,198	1,056,433	1,259,168	1,253,943	1,822,072	2,765,743	2,911,912	990,752	642,725	717,769	16,509,030
1982	1,058,214	979,540	1,398,286	1,019,022	2,379,073	2,117,966	3,168,880	5,541,419	5,161,153	3,408,784	1,324,864	1,263,555	28,820,755
1983	1,440,661	1,120,967	1,417,420	1,507,279	1,367,976	3,538,566	3,205,332	5,600,939	5,622,038	3,032,393	1,593,595	1,258,726	30,705,892
1984	1,479,743	1,462,559	1,425,025	1,428,822	1,210,556	2,750,648	4,264,940	6,589,449	6,077,690	2,913,002	1,502,418	1,373,214	32,478,066
1985	1,397,145	1,299,894	1,190,103	1,102,031	981,126	1,447,871	3,504,017	3,781,435	2,441,264	1,112,392	827,035	1,200,752	20,285,065
1986	1,262,593	974,360	900,315	850,744	2,706,611	3,763,160	3,741,645	4,361,063	5,074,789	2,047,004	1,190,423	1,297,352	28,170,059
1987	1,348,646	1,058,774	974,435	984,061	998,251	1,365,941	1,581,936	2,225,357	1,362,496	922,582	697,086	703,394	14,222,961
1988	789,201	763,334	797,675	804,547	797,474	975,260	1,636,793	2,222,359	1,760,016	600,605	470,443	598,137	12,215,844
1989	740,851	772,672	765,749	759,028	733,707	2,703,204	3,241,018	3,473,913	2,697,253	1,148,663	852,274	854,554	18,742,887
1990	1,074,829	802,665	774,981	845,754	716,732	1,212,784	1,901,522	2,004,975	2,246,320	940,810	653,274	623,846	13,798,492
1991	892,275	723,808	600,551	781,598	732,487	912,949	1,173,139	2,636,631	2,596,271	1,015,746	637,801	742,723	13,445,978
1992	812,430	786,495	779,023	719,433	909,879	964,627	1,242,595	1,542,503	856,752	661,466	487,792	556,149	10,319,144
1993	653,399	607,660	695,635	759,471	648,878	3,102,247	3,050,457	5,027,544	3,776,577	1,716,125	1,176,396	838,841	22,053,230
1994	1,059,144	688,584	821,153	863,141	736,662	1,018,321	1,374,873	2,288,741	1,141,118	539,021	508,102	506,228	11,545,088
1995	885,719	676,633	834,394	1,195,118	1,463,518	2,084,141	2,328,934	4,242,714	4,524,529	2,579,503	1,065,703	933,136	22,814,041
1996	1,144,803	973,892	1,352,721	1,010,081	1,652,402	1,976,355	3,247,855	4,974,392	4,898,356	2,119,243	1,036,719	1,043,723	25,430,542
1997	1,115,853	1,121,855	1,551,963	2,781,293	1,566,616	2,269,867	3,531,373	6,446,814	5,556,453	2,666,810	1,502,932	1,278,795	31,390,623
1998	1,324,202	1,046,494	1,015,109	1,299,629	1,049,565	1,857,964	2,204,349	5,609,026	4,412,647	2,300,794	1,009,215	1,112,866	24,241,859
1999	1,195,906	974,523	1,062,050	1,216,558	1,148,213	2,374,963	2,991,363	4,516,985	5,168,989	2,149,410	1,225,678	1,041,804	25,066,441
2000	1,082,579	911,498	977,128	1,102,959	1,430,014	1,627,615	2,799,976	3,204,426	2,142,982	1,018,682	716,713	907,400	17,921,971
Average	**1,061,763**	**951,814**	**1,026,000**	**1,065,473**	**1,070,999**	**1,590,271**	**2,499,800**	**3,753,075**	**3,430,023**	**1,576,301**	**891,676**	**892,365**	**19,809,559**

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Naturalized Flow Scenario (in cfs) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Average
1928	21,446	24,464	21,667	21,804	15,486	38,112	38,340	86,433	53,206	27,595	15,237	15,603	31,616
1929	18,137	16,750	12,957	14,185	9,249	24,068	30,566	47,171	45,388	19,230	11,406	12,984	21,841
1930	14,992	13,717	15,708	11,062	19,113	18,693	27,978	38,704	34,771	15,812	14,270	13,404	19,852
1931	18,102	13,765	12,909	12,570	12,085	17,769	22,871	27,244	19,428	8,664	7,844	9,093	15,195
1932	12,702	11,598	12,182	11,588	8,079	27,998	44,559	67,752	63,554	25,115	12,068	12,563	25,813
1933	14,381	14,943	12,650	13,146	11,765	16,638	30,963	44,878	63,702	17,534	10,584	11,396	21,882
1934	13,139	13,262	14,782	16,609	15,153	18,346	25,799	26,475	15,481	8,355	6,782	8,093	15,190
1935	12,610	11,733	11,642	11,635	11,929	15,335	36,877	42,932	47,013	17,398	9,275	9,606	19,832
1936	12,783	12,962	11,727	13,734	14,984	16,537	59,943	74,494	53,143	17,418	12,487	12,692	26,075
1937	13,316	12,883	13,133	10,825	11,917	15,004	32,482	46,040	35,365	14,919	9,098	10,526	18,792
1938	14,598	14,970	21,445	16,262	15,904	29,206	59,895	77,282	68,736	34,139	14,871	14,330	31,803
1939	18,192	16,951	15,710	13,845	11,876	29,472	40,644	44,778	28,783	15,734	10,356	12,778	21,593
1940	15,410	12,629	13,623	14,530	20,008	32,113	42,730	48,056	33,065	12,611	8,797	14,604	22,348
1941	17,464	16,231	15,685	15,532	19,726	26,280	31,992	47,158	42,806	17,292	14,398	14,901	23,289
1942	17,250	17,337	20,595	15,350	17,474	16,435	53,362	50,224	56,366	23,146	11,234	13,481	26,021
1943	16,239	19,356	20,913	24,746	23,660	35,584	87,083	73,349	79,339	51,309	20,057	17,768	39,117
1944	18,714	21,766	16,006	13,809	14,643	16,373	27,669	36,282	46,074	20,847	10,819	12,491	21,291
1945	15,007	15,788	13,807	15,124	21,958	19,811	29,103	61,481	61,829	30,170	15,306	16,285	26,306
1946	18,036	17,167	19,019	18,050	14,057	34,360	67,954	71,393	52,166	22,316	14,692	17,120	30,527
1947	20,318	19,830	21,822	14,844	21,218	23,393	31,803	61,777	52,590	24,310	15,328	15,220	26,871
1948	18,158	16,664	16,746	17,420	17,090	17,431	33,849	61,667	66,873	21,660	13,319	14,182	26,255
1949	17,410	15,877	14,651	12,721	16,700	28,637	47,315	71,210	48,705	18,574	12,631	12,797	26,436
1950	18,242	16,376	14,676	15,355	19,587	26,876	43,025	56,462	73,743	41,399	17,385	16,761	29,991
1951	20,705	19,923	19,926	16,521	28,493	22,718	57,988	71,430	58,279	30,725	21,232	16,290	32,019
1952	21,553	18,422	20,764	17,091	15,621	15,637	98,733	106,755	67,145	29,217	15,866	15,743	36,879
1953	16,137	14,608	15,438	24,222	19,735	19,624	35,134	50,274	80,394	31,051	14,573	13,561	27,896
1954	15,964	16,360	15,881	16,670	18,981	20,861	35,349	60,393	49,456	28,707	14,722	13,725	25,589
1955	16,549	15,145	13,890	13,520	12,437	14,309	25,453	43,633	49,502	21,816	12,214	11,495	20,830
1956	15,513	16,604	29,118	26,654	17,819	30,082	56,628	84,582	78,083	27,917	16,109	15,245	34,530
1957	19,249	17,812	17,826	14,025	25,453	33,280	39,032	85,123	71,496	27,211	14,583	15,245	31,695
1958	18,121	15,100	16,962	17,053	28,554	20,896	46,937	87,388	56,632	18,265	13,202	14,242	29,446
1959	14,741	15,954	17,054	16,839	16,634	16,111	28,931	40,513	50,322	18,699	11,472	17,005	22,023
1960	20,280	14,773	14,043	13,387	16,821	28,569	40,728	42,356	41,095	12,498	10,380	11,404	22,194
1961	14,741	15,447	12,850	11,544	18,408	18,454	23,141	37,148	34,327	9,000	7,263	12,821	17,929
1962	17,104	13,642	12,921	11,812	23,969	18,604	48,591	58,973	55,451	23,672	13,610	12,779	25,927
1963	19,423	16,652	17,328	13,049	29,713	15,068	26,498	48,561	59,954	20,894	11,412	14,928	24,457
1964	12,819	15,676	13,781	13,568	12,063	16,865	38,047	54,388	75,000	30,724	14,322	14,559	25,984

Table B-1. MODSIM Model Output of monthly flows into Brownlee Reservoir under the Naturalized Flow Scenario (in cfs) (Upper Snake MODSIM – May 2007)

Year	October	November	December	January	February	March	April	May	June	July	August	September	Average
1965	14,600	15,458	35,614	24,447	30,383	24,070	57,084	78,359	84,803	44,014	22,867	19,315	37,585
1966	17,130	16,006	13,549	15,236	13,609	19,164	28,406	42,271	31,002	12,327	9,598	12,677	19,248
1967	14,488	14,009	14,443	17,005	15,558	17,651	23,700	54,231	76,957	34,177	13,804	13,928	25,829
1968	17,513	15,353	13,738	13,413	21,767	20,212	20,140	37,990	52,185	19,953	21,396	16,021	22,473
1969	16,444	16,663	15,053	24,624	18,181	18,377	73,471	78,661	52,536	22,610	13,596	15,750	30,497
1970	17,970	14,338	14,585	30,682	20,336	21,557	22,841	64,205	78,825	34,677	15,179	18,992	29,516
1971	17,468	19,708	16,841	32,689	23,090	26,117	56,742	97,992	96,789	48,848	20,533	19,399	39,685
1972	21,577	20,443	18,893	23,702	18,509	62,001	46,695	80,347	93,092	34,299	20,729	20,796	38,424
1973	23,330	19,234	19,753	22,045	18,648	21,898	31,049	50,934	41,046	19,525	13,520	18,163	24,929
1974	18,851	24,364	23,037	29,797	16,368	39,377	59,596	77,906	98,665	40,261	19,677	16,384	38,690
1975	19,747	16,300	16,071	16,370	19,252	26,079	35,754	77,623	95,131	53,559	21,972	18,298	34,680
1976	22,921	17,997	21,467	18,923	18,207	23,488	53,983	85,747	65,845	30,987	23,849	21,272	33,724
1977	19,794	14,373	14,547	13,794	13,675	13,217	14,959	19,182	18,212	8,384	7,544	10,210	13,991
1978	13,962	12,372	19,741	18,245	20,199	32,020	49,430	66,618	66,313	37,396	16,952	18,855	31,008
1979	15,592	13,079	12,331	13,909	18,726	27,053	30,670	54,792	40,882	16,470	13,353	11,363	22,352
1980	15,840	11,616	12,647	20,173	23,559	20,732	40,147	68,424	62,820	26,937	13,880	18,781	27,963
1981	16,187	15,008	19,519	17,181	22,673	20,393	30,621	44,980	48,936	16,113	10,453	12,062	22,844
1982	17,210	16,462	22,741	16,573	42,837	34,445	53,255	90,123	86,736	55,439	21,547	21,235	39,884
1983	23,430	18,838	23,052	24,514	24,632	57,549	53,867	91,091	94,481	49,317	25,917	21,154	42,320
1984	24,066	24,579	23,176	23,238	21,046	44,735	71,675	107,167	102,139	47,375	24,434	23,078	44,726
1985	22,722	21,845	19,355	17,923	17,666	23,547	58,887	61,499	41,027	18,091	13,450	20,179	28,016
1986	20,534	16,375	14,642	13,836	48,735	61,202	62,880	70,926	85,285	33,291	19,360	21,803	39,072
1987	21,934	17,793	15,848	16,004	17,974	22,215	26,585	36,192	22,898	15,004	11,337	11,821	19,634
1988	12,835	12,828	12,973	13,085	13,864	15,861	27,507	36,143	29,578	9,768	7,651	10,052	16,845
1989	12,049	12,985	12,454	12,344	13,211	43,963	54,467	56,498	45,329	18,681	13,861	14,361	25,850
1990	17,480	13,489	12,604	13,755	12,905	19,724	31,956	32,608	37,751	15,301	10,624	10,484	19,057
1991	14,511	12,164	9,767	12,711	13,189	14,848	19,715	42,881	43,632	16,520	10,373	12,482	18,566
1992	13,213	13,217	12,670	11,700	15,818	15,688	20,883	25,086	14,398	10,758	7,933	9,346	14,226
1993	10,627	10,212	11,313	12,352	11,684	50,453	51,265	81,765	63,467	27,910	19,132	14,097	30,356
1994	17,225	11,572	13,355	14,038	13,264	16,561	23,106	37,223	19,177	8,766	8,263	8,507	15,922
1995	14,405	11,371	13,570	19,437	26,352	33,895	39,139	69,001	76,037	41,952	17,332	15,682	31,514
1996	18,618	16,367	22,000	16,427	28,727	32,142	54,582	80,901	82,320	34,466	16,861	17,540	35,079
1997	18,148	18,853	25,240	45,233	28,208	36,916	59,347	104,847	93,379	43,372	24,443	21,491	43,290
1998	21,536	17,587	16,509	21,136	18,898	30,217	37,045	91,222	74,157	37,419	16,413	18,702	33,404
1999	19,450	16,377	17,273	19,785	20,675	38,625	50,272	73,462	86,868	34,957	19,934	17,508	34,599
2000	17,606	15,318	15,891	17,938	24,861	26,471	47,055	52,115	36,014	16,567	11,656	15,249	24,729
Average	**17,268**	**15,996**	**16,686**	**17,328**	**19,119**	**25,863**	**42,011**	**61,038**	**57,643**	**25,636**	**14,502**	**14,997**	**27,341**

Appendix C BACKGROUND ON UPPER SNAKE FLOW AUGMENTATION

C.1 Introduction

Reclamation began providing additional flows from the upper Snake in 1991. Since 1992, consultations between Reclamation and NMFS under Section 7(a)(2) of the ESA have included the consideration of flow augmentation from Reclamation's upper Snake projects to augment flows in the lower Snake and Columbia Rivers through acquisitions from willing sellers and lessors. Also, as required by Section 8 of the Reclamation Act of 1902, flow augmentation must rely on state protection of augmentation flows under the provisions of State water law.

The 427,000 acre-feet from the upper Snake is one of several regional supplies of water used to help improve conditions for listed salmon and steelhead. In addition to Reclamation's upper Snake River supplies, other sources for flow augmentation within the Columbia River basin include up to 1,200,000 acre-feet from Dworshak Reservoir and up to 237,000 acre-feet from Brownlee Reservoir. Up to 2,428,000 acre-feet from reservoirs at Grand Coulee, Banks Lake, Libby, and Hungry Horse Dams, located on the upper Columbia River, are released to help meet flow objectives on the lower Columbia River at McNary Dam. Up to 1,000,000 acre-feet from Canadian storage (negotiated annually) may also be available.

The accounting for flow augmentation from the Snake River above Milner Dam takes place at the Milner gauge (RM 638.7). During the flow augmentation season, Reclamation makes releases from American Falls Reservoir, which pass through Minidoka and Milner Dams. Reclamation's releases from the Payette and Boise River systems are measured at the Letha and Middleton gauges, respectively. All of Reclamation's flow augmentation water is delivered to the lower Snake River at Brownlee Reservoir and must pass through Idaho Power Company's Hells Canyon Dam before salmon and steelhead are benefited. Reclamation's augmentation flows are most important in the Snake River reach between the toe of Hells Canyon Dam to the confluence of the Snake and Clearwater Rivers, at which point significant volumes of substantially cooler Clearwater River water from Dworshak Reservoir enter the river.

Regardless of where water is secured for flow augmentation in the upper Snake River basin, it ultimately must arrive hundreds of miles further downstream where it can benefit listed salmon and steelhead. Water is protected from intervening hostile diversion under the provisions of State water law. The active cooperation of the State water rights administrators is essential in assuring that the water Reclamation acquires reaches the targeted stream reaches. Reclamation has worked with the State and water users to develop and consummate sales and rentals of water rights and storage contract entitlements for flow augmentation. In return, a scheme to provide flow augmentation based on State law has meant that local and state water administrators assist Reclamation in determining release rates and account for water released for flow augmentation. State water administrators are also solely responsible for tracking flows downstream and for ensuring that flows are delivered to the targeted locations downstream.

Reclamation has worked diligently to secure State recognition and the concomitant protection of water provided for flow augmentation. The Idaho Legislature has enacted interim legislation since 1992, which has provided interim authority to Reclamation. This legislation has had to be renewed several times during the past decade. The Nez Perce Water Rights Settlement resulted in the amendment of Section 42-1763B, Idaho Code (House Bill 15) by the 2005 Idaho Legislature, authorizing Reclamation’s flow augmentation activities through 2034, thus adding greater certainty to Reclamation’s ability to provide flow augmentation from its upper Snake projects and protect it to the state line.

Reclamation has taken the following actions over the past several years to secure and improve delivery of water for flow augmentation:

- Permanently reacquired 60,274 acre-feet of storage space in Reclamation project reservoirs in Idaho and dedicated this water to flow augmentation.
- Acquired 17,650 acre-feet of natural flows in Oregon and secured a change in use of the 17,650 acre-feet from the Oregon Water Resources Department in order to protect the water to the state line and ensure its delivery for flow augmentation.
- Reassigned to flow augmentation a total of 98,554 acre-feet of water not contracted to water users.
- Secured (through the Nez Perce Water Rights Settlement) 30-year legislation from the State authorizing the protection of Reclamation flow augmentation releases to the state line.
- Obtained recognition under State law (through the Nez Perce Water Rights Settlement) the ability to deliver in any year water in powerhead space (up to 198,000 acre-feet) located in two reservoirs, if needed, to provide up to 427,000 acre-feet of water for flow augmentation.

- Provided (through the Nez Perce Water Rights Settlement) for the long term rental of 60,000 acre-feet of water acquired from natural flow water right holders along the Snake River. In cooperation with the State, this water has been acquired, which resulted in the permanent fallowing of 25,000 acres of irrigated land.
- Increased (through the Nez Perce Water Rights Settlement) the maximum volume of water that could be provided to 487,000 acre-feet, consisting of 427,000 acre-feet from traditional sources, plus the 60,000 acre-feet of natural flows identified above.
- Worked with the Water District 01 and Water District 65 Rental Pools to ensure the availability of water to rent for flow augmentation.
- Worked with the Water District 01 Rental Pool to develop long term certainty about the volume of water available for rental for different water year types and storage carryover conditions to reduce the uncertainty associated with the willing seller approach.

C.2 Upper Snake Flow Augmentation Sources

Since 1991, the sources used by Reclamation for flow augmentation water have been in two categories: (1) Water stored in projects (the use of uncontracted space, water rentals through the State's rental pools, and powerhead space); and (2) Natural flow water rights (lease or purchase of natural flow rights).

All flow augmentation water is administered through several rental pools located within different drainages in accordance with Idaho State law and includes releases from Reclamation storage space and leases from water users. Reclamation intends to provide salmon flow augmentation from project reservoirs in the Snake River above Milner Dam (Water District 01), the Boise River system (Water District 63), and the Payette River system (Water District 65); from lease of Idaho natural flows; and from acquired natural flows in Oregon. In addition to these long-term and permanent sources, Reclamation relies heavily each year on annual rentals from spaceholders at its projects.

C.2.1 Water Stored in Projects

C.2.1.1 Uncontracted Space (Reclamation Space)

Uncontracted space is space in the reservoir that has not been contracted to a spaceholder or was re-acquired by Reclamation for flow augmentation purposes. Uncontracted space in Reclamation's reservoirs is a reliable source of water in most years. Reclamation relies on this space as much as possible in meeting its commitment to provide flow augmentation and provides all water accrued annually in this space for flow augmentation purposes. The Boise and Payette rental pool procedures state that this space will be the last to fill (after contracted space). In drier water years when reservoirs do not refill, Reclamation may have little or no water available to provide for flow augmentation from this storage space. Water rentals reduce the carryover volume at the end of the irrigation season. This reduces the likelihood the reservoir will fill the following year in the event of below normal snowpack. Idaho's last-to-fill rule was established in the mid-1980s as a means of avoiding injury to spaceholders who rely on refill of storage the following year. Thus, the parties making water available for salmon flow augmentation have assumed any risks that the evacuated space may fail to refill.

C.2.1.2 Rental Pool

Reclamation relies heavily each year on annual rentals from water users to acquire water for its flow augmentation program. Rental water has comprised as much as 67 percent of the total volume of flow augmentation delivered in wet years but may be only 10 percent of the total volume in dry years. The two major sources of rental pool water are the water districts and the Shoshone-Bannock Tribes.

Rentals from the Districts come from three rental pools (Water District 01 above Milner Dam, Water District 63 in the Boise River system, and Water District 65 in the Payette River system). The amount available for rental varies from year to year and is dependent on runoff, reservoir carryover levels, irrigation demands, and the willingness of spaceholders to make the water available for lease subjecting it to the last-to-fill rule. Negotiation of the Nez Perce Water Rights Settlement led to the development of a chart that identifies water availability from the Water District 01 Rental Pool for flow augmentation. This chart considers total system carryover storage (above Milner Dam) on November 1 and the April 1 runoff forecast for unregulated runoff for the Snake River at Heise (for April 1 through September 30 period) to determine the amount of water available for flow augmentation from the rental pool. This chart has improved the certainty in planning for flow augmentation volumes above Milner Dam.

Rental from the Shoshone–Bannock Tribes is from contracted space in American Falls Reservoir. The Tribes are able to rent water from this space for downstream uses in accordance with the terms of the Fort Hall Water Rights Settlement of 1990. The 1990 Settlement provides that the Tribes' rental will be in accordance with a Tribal water bank; Tribal policy requires that on-reservation water needs are served first. The Tribes usually have adequate space from other sources to meet their irrigation requirements, thereby, resulting in the American Falls Reservoir space available for rental. The Shoshone–Bannock Tribes entered into one long-term lease with Reclamation to use some of this space for flow augmentation purposes. The last deliveries under that agreement are being made in 2007.

C.2.1.3 Powerhead Space

Powerhead space is part of the inactive capacity in a reservoir intended to provide adequate hydraulic head to generate hydroelectric power. Without this hydraulic head, generating units will operate inefficiently and may need to shut down in extreme conditions. Reclamation relies on powerhead space at Palisades and Anderson Ranch Reservoirs in years when it is unable to acquire sufficient water from the sources described above to obtain up to 427,000 acre-feet for flow augmentation. Reclamation uses this space as a last resort as the last-to-fill rule applies, and if the reservoir does not fill the following year, this space will not fill. Further, using this space affects the ability to generate power and can have effects to ESA-listed bull trout in Anderson Ranch Reservoir. In the past, the State has not recognized the use of powerhead space as a legal beneficial use at Palisades Reservoir under State law. The Nez Perce Water Rights Settlement resulted in the State's agreeing to allow Reclamation to amend its water right to use the powerhead space in Palisades Reservoir for flow augmentation, but not to exceed a flow augmentation total of 427,000 acre-feet when using powerhead.

C.2.2 Natural Flow Water Rights

The Nez Perce Water Rights Settlement authorized the use of up to 60,000 acre-feet of natural flow rights downstream of Milner Dam for flow augmentation. In water rich years, this will increase the volume of water available for augmentation to more than 427,000 acre-feet and up to 487,000 acre-feet. Through a complex series of negotiations, the Idaho Water Resources Board (IWRB) purchased approximately 98,000 acre-feet of water rights from the Bell Rapids Mutual Irrigation Company. Reclamation then entered into a 30-year lease with the State for 60,000 acre-feet of this water for salmon flow augmentation.

Flow augmentation from natural flow rights downstream of Milner Dam occurs during the entire irrigation season, roughly April 1 to October 31. The IWRB lease of 60,000 acre-feet is comprised of 49,500 acre-feet occurring within the April 3 to August 31 period, and 10,500 acre-feet that occurs outside the juvenile outmigration period. Even though these 10,500 acre-feet are delivered outside the April 3 to August 31 period, it nonetheless provides an instream benefit and continued flow augmentation.

Reclamation permanently acquired 17,650 acre-feet of natural flow rights on the Malheur River with supplemental Snake River rights in Oregon.

C.2.3 Summary of Sources of Upper Snake Flow Augmentation

Table C-1 summarizes the sources and potential volumes of salmon flow augmentation water available from the upper Snake River. The volume provided in any given year varies depending on the water year supply, storage carryover in reservoirs, and the willingness of spaceholders to lease water for flow augmentation. Further, State water law, and as stipulated in the Nez Perce Water Rights Settlement, limits total flow augmentation volume to 487,000 acre-feet annually, or 427,000 acre-feet if powerhead space is used.

Table C-1. Sources of salmon flow augmentation water from the upper Snake.

Source	Amount (acre-feet)	Conditions of Use
Snake River above Milner Dam		
Uncontracted space, Reclamation	22,896	Annual accrual determined by State water rights accounting.
Rentals, Water District 01	0 to 205,000	Annual amount stipulated by rental pool rules according to November 1 carryover volume and Apr-Sept runoff forecast on April 1.
Rentals, Tribes	0 to 46,931	The Shoshone-Bannock Tribes have contract space in American Falls Reservoir and can rent water from this space for downstream uses in accordance with the terms of the Fort Hall Water Rights Settlement of 1990.
Palisades Reservoir, powerhead	157,000	Pursuant to Nez Perce Water Rights Settlement, can only be used if sum of all other sources, including natural flows, is less than 427,000 acre-feet; total augmentation cannot exceed 427,000 acre-feet when used.
Boise River System		
Uncontracted space, Reclamation	40,932	Annual accrual determined by State water rights accounting.
Anderson Ranch, powerhead	36,956 [1]	Identified as "powerhead" in Nez Perce Term Sheet; conditions of use same as Palisades's powerhead.
Rentals, Water District 63	0	Rentals of 2000 acre-feet occurred in 1995 and 1997, but this is not considered a reliable source of rental water.
Payette River System		
Uncontracted space, Reclamation	95,000	Annual accrual determined by State water rights accounting.
Rentals, Water District 65	0 to 65,000	Historical range of rentals, but is not capped. Usually minimum of 50,000 acre-feet in all but the driest years.
Malheur River System		
Natural flow water right	17,650	Acquisition of Snake and Malheur River natural flow rights
Rental of Natural Flow		
Natural flow lease	60,000	30-year lease with Idaho Water Resource Board pursuant to Nez Perce Water Rights Settlement

[1] Anderson Ranch inactive space was originally 41,000 acre-feet, but a 1997 sedimentation survey has determined this space is now 36,956 acre-feet

Appendix D UPPER SNAKE RIVER BASIN TEMPERATURE MONITORING

Reclamation has developed and implemented a basin-wide temperature monitoring study for the upper Snake River basin. Data collection for a comprehensive water temperature database in the upper Snake River and major tributaries was initiated in 2004. This temperature data collection activity will provide a continuous water temperature record at points upstream and downstream of major Reclamation storage reservoirs and blocks of irrigated lands in the upper Snake River, as well as Snake River temperatures entering and leaving the Hells Canyon Complex.

A total of 52 strategically placed monitoring sites are located throughout the basin (See Table D-1 and Figure D-1). To supplement the existing stations, the USGS installed water temperature sensors at 10 currently active gaging stations. Reclamation installed real-time temperature sensors at 19 Hydromet stations and placed manual temperature sensors at 12 additional locations.

Table D-1. Upper Snake temperature monitoring locations.

BOR Code	USGS Station	Station Name
USGS Installation		
REXI	13056500	Henry's Fork near Rexburg, ID
PALI	13032500	Snake River near Irwin, ID
LORI	13038500	Snake River at Lorenzo, ID
MNNI	13057000	Snake River nr Menan, ID
BRBI	13068500	Blackfoot River nr Blackfoot, ID
SNAI	13069500	Snake River nr Blackfoot, ID
SKHI	13154500	Snake River at King Hill
HOTI	13168500	Bruneau River near Hot Springs, ID
SNYI	13213100	Snake River at Nyssa, OR
WEII	13269000	Snake River at Weiser, ID
Reclamation Installation, Hydromet		
ISLI	13042500	Henry's Fork near Island Park, ID
TEAI	13055000	Teton River nr St. Anthony, ID
FLGY	13010065	Snake River ab Jackson Lake at Flagg Ranch, WY
JCK	13011000	Snake River nr Moran, ID
ALPY	13022500	Snake River ab Reservoir nr Alpine, WY
AMFI	13077000	Snake River at Neeley, ID
MILI	13081500	Snake River at Milner, ID
ROMO	13181000	Owyhee River near Rome, OR
OWY	13183000	Lake Owyhee and Owyhee River near Nyssa, OR
WARO	13215000	Malheur River bel Warm Springs Res nr Riverside, OR
MALO	--	Malheur River at 36th St. Bridge near Ontario, OR
PARI	13213000	Boise River near Parma, ID
PAYI	13239000	NF Payette River McCall, ID
CSCI	--	NF Payette River at Cascade, ID
HRSI	13247500	Payette River near Horseshoe Bend, ID
PRPI	13251000	Payette River near Payette, ID
MCII	--	Mann Creek at Mann Creek Guard Station, ID
PHL	--	Mason Dam and Phillips Lake near Sumpter, OR
THF	--	Thief Valley Dam and Reservoir near North Powder, OR
Reclamation Installation, PN Regional Laboratory		
THSP	--	Snake River at Niagra Springs
CJST	13171500	Below CJ Strike Dam (above bridge)
BDDI	--	Boise River below Diversion Dam nr Boise, ID
PHBI	--	Payette River at Hartzel Bridge
PRMI	--	Payette River nr Montour, ID
EMM	13249500	Payette River near Plaza Bridge
WEIM	--	Weiser River near Highway 95 Bridge

Table D-1. Upper Snake temperature monitoring locations.

BOR Code	USGS Station	Station Name
GAR101	--	NF Payette River below Cascade Dam
MILI	13087995	Snake River at Murtaugh
SWAI	--	Snake River (Swan Falls) nr Murphy, ID
HCDI	13290450	Snake River at Hells Canyon Dam ID-OR State Line
PRRO	--	Powder River near Richland, OR
Existing Stations with Temperature		
BTSI	13185000	Boise River near Twin Springs, ID
BRFI	13186000	South Fork Boise River near Featherville, ID
AND	13190500	Anderson Ranch Dam and Reservoir
DEDI	13236500	Deadwood River bl Deadwood Res nr Lowman, ID
PRLI	13235000	SF Payette River at Lowman, ID
MADO	--	Malheur River near Drewsey, OR
BEUO	13217500	North Fork Malheur River at Beulah
MABO	--	NF Malheur River above Beulah Res
UNY	--	Unity Reservoir and Burnt River near Unity, OR
PRHO	--	Powder River at Hudspeth Lane near Sumpter, OR
NPDO	--	Powder River abv Thief Valley Res nr. North Powder

--: No Station

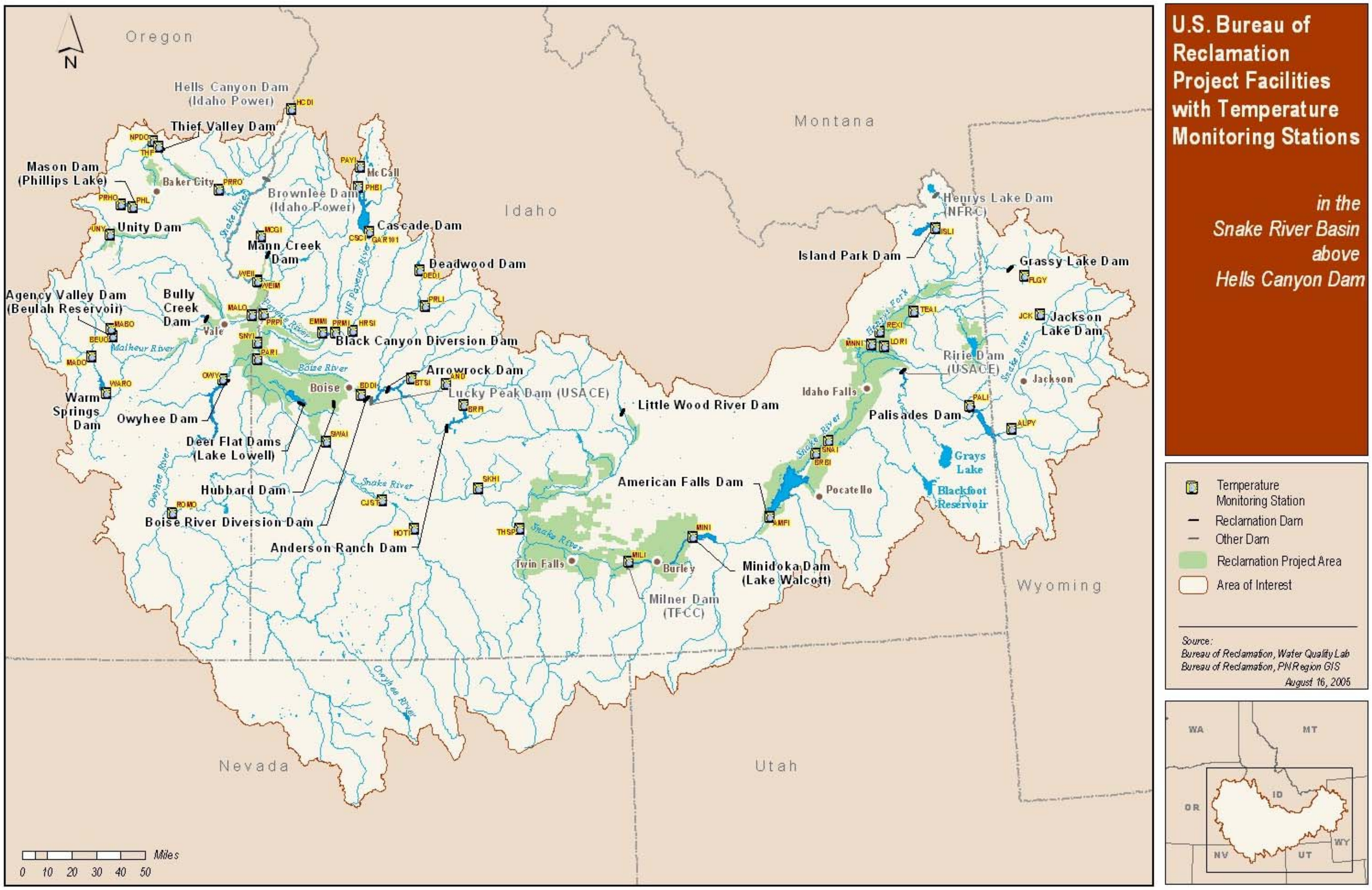

Figure D-1. Upper Snake River basin water temperature monitoring stations.