RECLAMATION
Managing Water in the West

Biological Assessment for Bull Trout Critical Habitat in the Upper Snake River Basin

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Regional Office
Snake River Area Office
Boise, Idaho

December 2013

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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.

Photograph on front cover: Aerial view of Mason Dam and Phillips Lake, Oregon, Upper Division, Baker Project, Oregon.

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Acronyms and Abbreviations

°C	degrees Celsius
2004 Operations	*Operation Description of Bureau of Reclamation Projects in the Snake River Above Brownlee Reservoir*
2004 Upper Snake BA	*Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin above Brownlee Reservoir*
2004/2007 Upper Snake BA	2004 Upper Snake Biological Assessment as amended by the 2007 Upper Snake Biological Assessment
2005 USFWS BiOp	U.S. Fish and Wildlife Service *Biological Opinion for Bureau of Reclamation Operations and Maintenance in the Snake River Basin above Brownlee Reservoir*
2007 Upper Snake BA	*Biological Assessment for Bureau of Reclamation Operation and Maintenance in the Upper Snake River Basin above Brownlee Reservoir*
2008 NOAA Fisheries BiOp	NOAA Fisheries Service *Biological Opinion Consultation for the Operation and Maintenance of 10 U.S. Bureau of Reclamation Projects and 2 Related Action in the Upper Snake River Basin above Brownlee Reservoir*
BA	biological assessment
BiOp	biological opinion
cfs	cubic feet per second
CHSU	critical habitat subunit
CHU	critical habitat unit
Corps of Engineers	U.S. Army Corps of Engineers
Draft Recovery Plan	*Bull Trout Draft Recovery Plan* (2002)
EOM	end of month
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FMO	foraging, migrating, and over-wintering habitat
FY	fiscal year

HD	Hybrid-Delta scenarios
HD 2020s	Hybrid-Delta scenario covering time period 2010 to 2039
IDEQ	Idaho Department of Environmental Quality
NOAA Fisheries Service	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
O&M	operation and maintenance
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
PCE	primary constituent elements
POR	period of record
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RMJOC	River Management Joint Operating Committee
RU	recovery unit
States	States of Idaho and Oregon
T&C	terms and conditions
TMDL	Total Maximum Daily Load (planning process)
TN:TP	total nitrogen-to-total phosphorus ratio
upper Snake River projects	Reclamation projects in the Snake River basin above Brownlee Reservoir
USFS	U.S. Department of Agriculture, Forest Service
USFWS	U.S. Department of the Interior, Fish and Wildlife Service
USGS	U.S. Department of the Interior, Geological Survey
UW CIG	University of Washington Climate Impacts Group
VIC	variable infiltration capacity hydrologic model
WY	water year

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1.0 INTRODUCTION

The Bureau of Reclamation (Reclamation) is submitting this biological assessment (BA) as a companion document to the *Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin above Brownlee Reservoir* (2004 Upper Snake BA) (Reclamation 2004a). This biological assessment addresses the impacts to designated bull trout critical habitat where it intersects with the action areas described in the 2004 Upper Snake BA. Its focus is on the long-term operational effects on designated bull trout critical habitat in the Boise, Payette, Malheur, and Powder river systems above Brownlee Reservoir and the long-term hydrologic effects to designated critical habitat in the mainstems of the Snake River and Columbia River.

This biological assessment also includes consultation on the effects of the future operation and maintenance (O&M) of Reclamation facilities in the upper and lower Powder River on bull trout as a species listed under the Endangered Species Act (ESA). In 2010, two bull trout were documented in Phillips Lake on the Powder River, an area which was previously believed to be unoccupied by the species. The remaining portion of the action area is still believed to be unoccupied by the species.

Reclamation is requesting a biological opinion for the effects of O&M activities on designated bull trout critical habitat in the affected action areas and on bull trout as a species in the Powder River through 2034 which coincides with the duration of the *U.S. Fish and Wildlife Service Biological Opinion and Incidental Take Statement Consultation for the Operations and Maintenance of 12 Bureau of Reclamation Projects in the Snake River Basin above Brownlee Reservoir* (2005 USFWS BiOp). Reclamation prepared this biological assessment in compliance with Section 7 of the ESA following 50 CFR 402 and used the *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act* (USFWS and NMFS 1998).

1.1 How to Read this Document

This document is a companion to the 2004 Upper Snake BA and the 2004 *Operation Description of Bureau of Reclamation Projects in the Snake River Above Brownlee Reservoir* (2004 Operations) which are incorporated by reference and should be reviewed as needed for more details (Reclamation 2004a and Reclamation 2004b, respectively). For example, the proposed actions and the action areas for this biological assessment are the same as described in the 2004 Upper Snake BA; page numbers in the 2004 Upper Snake BA with respect to those topics are given for ease in referencing.

Section 2 presents an overview of the current hydrology and water quality in the Upper Snake River basin and future climate change modeling results. Section 3 is an overview of bull trout in the action areas and the methodology Reclamation used in the evaluations. The other sections provide features of the respective action areas, baselines, analyses, effects, and determinations for the following river systems:

- Section 4 - Boise River system (Boise Project with Anderson Ranch and Arrowrock dams and reservoirs).
- Section 5 - Deadwood River system (Payette Division of the Boise Project with Deadwood Dam and Reservoir).
- Section 6 - Malheur River system (Vale Project with Agency Valley Dam and Beulah Reservoir).
- Section 7 - Powder River system (Baker Project with Mason Dam and Phillips Lake and Thief Valley Dam and Reservoir). This section also includes information on the status of bull trout in the Powder River basin.
- Section 8 - Mainstem Snake River and Columbia River systems.

1.2 Background

In November 2004, Reclamation consulted concurrently with U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries Service) on the effects of operation and maintenance of the Reclamation projects in the Snake River basin above Brownlee Reservoir under Section 7 of the ESA. The consultation with USFWS addressed impacts to bull trout and other resident ESA-listed species present in the project areas, but did not explicitly address impacts to bull trout critical habitat because none was designated in the affected area at that time.

Reclamation received a biological opinion (BiOp) from USFWS in March 2005 (2005 USFWS BiOp) that concluded that Reclamation's proposed actions were not likely to jeopardize the continued existence of bull trout (USFWS 2005a). The 2005 USFWS BiOp contained reasonable and prudent measures with associated terms and conditions (T&Cs) aimed at reducing incidental take of bull trout at Federal facilities in the Boise, Payette, and Malheur river systems.

In 2007, Reclamation proposed refinements regarding the salmon flow augmentation actions and revised its assessment on impacts to salmon and steelhead and designated critical habitat below Brownlee Dam in the *Biological Assessment for Bureau of Reclamation Operations* *and Maintenance in the Snake River Basin above Brownlee Reservoir* (2007 Upper Snake BA) to satisfy the direction given by a September 2006 U.S. District Court Opinion and Order of Remand. Reclamation concluded that the salmon flow augmentation refinements described in the 2007 Upper Snake BA would not cause new effects to ESA-listed resident species that were not previously considered in the 2005 USFWS BiOp and provided this conclusion in a letter to USFWS dated September 6, 2007.

Reclamation also received a biological opinion from NOAA Fisheries Service in March 2005. The NOAA Fisheries Service 2005 BiOp was superseded by their *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Consultation for the Operation and Maintenance of 10 U.S. Bureau of Reclamation Projects and 2 Related Actions in the Upper Snake River Basin above Brownlee Reservoir*, (revised and reissued pursuant to court order, *American Rivers v. NOAA Fisheries*, CV 04-0061-RE [D. Oregon]) (2008 NOAA Fisheries BiOp) issued in May 2008.

In October 2010, "Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States: Final Rule" was posted in the *Federal Register* by USFWS, designating bull trout critical habitat in portions of the Boise, Payette, Malheur, and Powder rivers and the mainstems of the Snake and Columbia rivers, all of which are hydrologically influenced in varying degrees by operation of the Reclamation projects in the Snake River above Brownlee Reservoir (hereafter referred to as the upper Snake River projects) (75 FR 63898).

1.3 Proposed Actions

The proposed actions at the Reclamation facilities in the upper Snake River above Brownlee Dam are the same as the O&M activities described in the 2004 Operations (Reclamation 2004b) and the 2004 Upper Snake BA (Reclamation 2004a, pages 11-12) as refined by the 2007 Upper Snake BA (Reclamation 2007, pages 13-17). In general, activities associated with the proposed actions include water storage and release; diversion and pumping; power generation; routine maintenance activities; and the provision of salmon flow augmentation for salmon. The proposed actions are consistent with the terms of the 2004 Nez Perce Water Rights Settlement in the upper Snake River basin adjudication (USFWS 2005a, pages 1-13). T&Cs of the incidental take statements issued with the 2005 USFWS BiOp and the 2008 NOAA Fisheries BiOp are included as part of the proposed action and incorporated by reference.

1.4 Action Areas

The action areas associated with the proposed actions are the same as described in the 2004 Upper Snake BA (pages 15-27). Action areas discussed in the 2004 Upper Snake BA that have designated bull trout critical habitat within the action area are:

- Boise River system (Reclamation 2004a, page 20).
- Payette River system (Reclamation 2004a, page 21).
- Malheur River system (Reclamation 2004a, page 22).
- Powder River system (Reclamation 2004a, pages 25-26).

For this biological assessment, each proposed action is defined as a distinct action area that begins at the proposed action's furthest upstream effect (i.e., the uppermost extent of the storage reservoir or point of diversion) and ends at the location of its farthest downstream effect (the Columbia estuary). The effects analysis focuses on where designated bull trout critical habitat intersects with the action areas.

The action areas for the proposed actions share the Snake River corridor to its confluence with the Columbia River and then downstream in the Columbia River corridor to its estuary and plume (Figure 1). The combined hydrologic impacts are evaluated for their effects on bull trout critical habitat in the Snake River below the Hell Canyon Dam complex and the mainstem Columbia River to the Columbia estuary.

Not all of the action areas discussed in the 2004 Upper Snake BA have designated bull trout critical habitat. The following project areas included in that document have no designated bull trout critical habitat:

- Milner Dam (Michaud Flats, Minidoka, Palisades, and Ririe projects)
- Little Wood River system (Little Wood River Project)
- Owyhee River system (Owyhee Project)
- Mann Creek system (Mann Creek Project)
- Burnt River system (Burnt River Project)

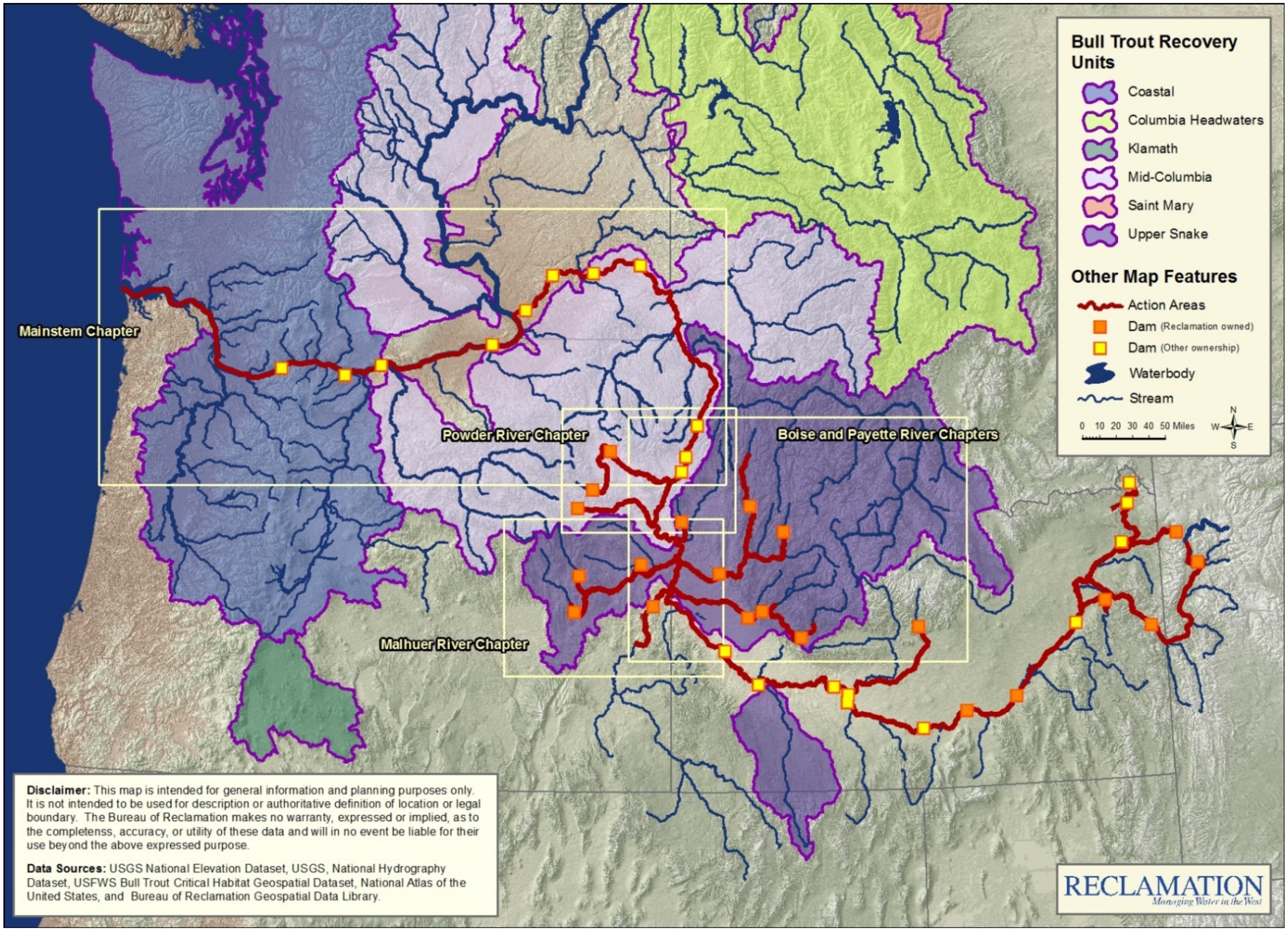

Figure 1. Consolidated action areas for Reclamation's proposed actions. The four action areas described in each section are outlined with a yellow box. The action area discussed in Section 8 covers the mainstem Snake and Columbia Rivers below Brownlee Dam.

1.5 Duration of Proposed Actions

This consultation evaluates the effects of the upper Snake River proposed actions on designated bull trout critical habitat in the upper Snake River basin and on bull trout in the Powder River basin through the year 2034. This time frame corresponds to the provisions for the Snake River flow component of the Nez Perce Water Rights Settlement in the 2005 USFWS BiOp (USFWS 2005a, pages 1-13).

1.6 Summary of Determinations of Effects

Section 1.4 of the 2004 Upper Snake BA (Reclamation, 2004a, pages 5-7) discusses Reclamation's understanding of the basis for the "may affect" determination. Reclamation, in making the "may affect" determinations submitted in this biological assessment, draws no conclusions as to whether the proposed actions are or are not likely to jeopardize the continued existence of a species or result in the destruction or adverse modification of designated critical habitat. Rather, the sole purpose of the "may affect" determination is to determine whether or not a formal consultation is required.

In determining whether the proposed actions may affect listed species or critical habitat, Reclamation considered the range of effects resulting from its proposed actions in accordance with the regulatory definition of "effects of the action" (50 CFR 402.02). The combined effects of the O&M activities of the upper Snake River project facilities was determined by assessing the hydrologic analysis, species analysis for Phillips Lake, and critical habitat analyses for each action area.

1.6.1 Summary of Designated Critical Habitat Effects in the Action Areas

Reclamation has determined that the proposed actions for the Boise and Vale projects **may affect and are likely to adversely affect** designated critical habitat in the action areas of the Boise, Payette, and Malheur river systems.

Reclamation has determined that the proposed actions for the Powder Division of the Baker project **may affect and are likely to adversely affect** designated bull trout critical habitat in the Powder River system.

Reclamation has determined that the hydrologic effects to designated bull trout critical habitat downstream from Brownlee Reservoir in the mainstem Snake and Columbia rivers **may affect, but are not likely to adversely** affect designated bull trout critical habitat.

1.6.2 Summary of Bull Trout Effects in the Powder River System

Reclamation has determined that species effects of the proposed actions for the Powder Division of the Baker project **may affect and are likely to adversely affect** bull trout in Phillips Lake.

2.0 OVERVIEW OF HYDROLOGY AND WATER QUALITY IN THE UPPER SNAKE RIVER BASIN

2.1 Hydrology

Hydrology affects every physical or biological feature essential to the conservation of the species. Throughout this document, the physical and biological features of habitat essential to bull trout conservation are referred to as primary constituent elements (PCEs).[1] For this biological assessment, analyses of hydrologic effects included flow rates (PCE 7) or storage volumes, including sources of water (PCE 1); water quality and water temperatures (PCEs 2, 5, and 8); food sources (PCE 3); and migration, spawning, or rearing behavior (PCEs 2, 4, 6, and 9). While the systems in the upper Snake River basin are all heavily regulated, naturalized flows are discussed in this biological assessment as appropriate. Flow rates such as minimum flows or irrigation demand interactions are also discussed. Storage volume and changes in reservoir elevation are described in both the historical (observed record) and future climate change record (simulated record).

The hydrologic information used in this biological assessment comes primarily from current data generated from observed records, which are usually in a daily time step. Other information provided include modeled data that are in a monthly time step. For facilities that have a surface water model available (e.g., Anderson Ranch and Arrowrock reservoirs), both observed and modeled information are available and have been reported in this document. Modeled data is from the 2010 version of MODSIM, a general purpose river and reservoir operation computer simulations model that includes the river system features of storage, irrigation demand, operational flow objectives, and reservoir content. The MODSIM model was updated in 2010 to simulate current hydrologic conditions and future hydrologic conditions and analyze both the naturalized and the modified flows on the mainstem Snake River to Brownlee Reservoir as well as the Boise and Payette River systems. The historical results reported using the Modified Flows model range from 1928 to 2008. Future simulations were provided for the time period of 2010 to 2039, referred to as the "2020s" because the period of record analyzed is generally centered on that future window.

The modified flows calculated in the 2010 MODSIM version are different than the 2000 modified flows dataset used in the 2004 Upper Snake BA. Differences are described in a technical memorandum titled "Modified and Naturalized Flow of the Snake River Basin above Brownlee Reservoir" (Reclamation 2010a). The 2010 modified flows incorporate the

[1] See http://library.fws.gov/Pubs9/critical_habitat00.pdf for more details.

current level of irrigation development, which reflects the effects of groundwater pumping in the system and the dataset is considered a more accurate estimation of 2010 conditions because all years reflect the same current level of groundwater impacts. The annual volumes for the 2000 dataset are 6 percent larger than the 2010 dataset on average. The difference between these datasets was the assumption of groundwater pumping depletions above King Hill; therefore, the results between the two datasets are not directly comparable. The total effect to the Snake River as a result of the additional pumping is still less than the 2.0 million acre-feet representing steady state conditions. The methodologies used in the data infill process, definition of irrigation demand patterns, and calibration efforts were more consistent between basins for the 2010 Modified Flow model than for the 2000 model development. The variations in procedures between the datasets account for some of the differences; however, the majority of the differences are a result of accounting or additional groundwater pumping.

In 2010 and 2011, the MODSIM model was again updated (now version 8.1) and used to generate results for the River Management Joint Operating Committee (RMJOC) Climate Change Study. In addition to the previously mentioned revisions, the historical record used in the RMJOC Climate Change Study for studying the effects of the 2010 level operations (the "modified flow model") was generated by the Climate Impacts Group at the University of Washington (UW CIG) instead of Reclamation as was done in the 2004 Upper Snake BA and the 2007 Upper Snake BA. The UW CIG historical flow record was used because the same procedure used to model that flow was used to model future flows and using these data maintains consistency in reporting the results between future and historical changes. A comparison of Reclamation's historical record and UW CIG's historical record using the naturalized model showed that UW CIG flows were less than 0.2 percent higher than Reclamation flow over the entire period of record (Reclamation 2011a, Table 10, page 130).

So that a direct comparison between future flows and historical flows could be made in this biological assessment, when modeled data are reported, Reclamation used results from the RMJOC Climate Change Study model. Historical, current, and future hydrologic sections in the Boise and Payette Rivers and their facilities were evaluated using that study’s results.

2.1.1 Current Flow Conditions

Current flow conditions are consistent with those modeled for the 2007 Upper Snake BA and are extensively discussed in Chapter 3 of that document (Reclamation 2007, pages 25-47).

As in the 2007 analyses, the model output data for this biological assessment were sorted and categorized into wet (10 percent exceedence), average (50 percent exceedence), and dry (90 percent exceedence) 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 for use in the analyses for each river basin considered in this biological assessment.

2.1.2 Historical Flow Conditions

An extensive discussion of the historical flow conditions as it relates to the upper Snake River project facilities and action area can be found in the 2004 Upper Snake BA (Reclamation 2004a, Sections 3.1, pages 29-30).

2.2 Future Hydrologic Conditions/Climate Change

2.2.1 Analysis from the RMJOC Climate Change Study

The MODSIM model used to generate results for the RMJOC Climate Change Study (Reclamation 2011a) was used in this biological assessment to analyze potential impacts of climate change on bull trout critical habitat in the upper Snake River basin above Brownlee Reservoir and the two major tributaries including the Boise and Payette rivers. No constructed models or future climate change flow data were available for the Malheur or Powder rivers so other data were used to provide an analogous comparison of potential impacts of climate change in these basins. More information on the analogous datasets is provided in Sections 6.0 and 7.0.

This section reports on results from the RMJOC Climate Change Study for the upper Snake River primarily at Brownlee Reservoir. For analysis of specific reservoirs (e.g., Arrowrock or Anderson Ranch), specific analyses were conducted on and reported in the appropriate chapter of this biological assessment.

RMJOC Climate Change Study Overview

In 2011, Reclamation completed the RMJOC Climate Change Study in which the hydrology in the upper Snake River Basin above Brownlee Reservoir was analyzed. Reclamation, the U.S. Army Corps of Engineers (Corps of Engineers), and the Bonneville Power Administration completed a four-part series of reports:

1. *Climate and Hydrology Datasets for Use in the River Management Joint Operating Committee (RMJOC) Climate Agencies' Longer-Term Planning Studies: Part I - Future Climate and Hydrology Datasets* (December 2010)

2. *Climate and Hydrology Datasets for Use in the RMJOC Climate Agencies' Longer-Term Planning Studies: Part II - Reservoir Operations Assessments for Reclamation Tributary Basins* (January 2011)

3. *Climate and Hydrology Datasets for Use in the RMJOC Climate Agencies' Longer-Term Planning Studies: Part III - Reservoir Operations Assessment: Columbia Basin Flood Control and Hydropower* (May 2011)

4. *Climate and Hydrology Datasets for Use in the RMJOC Climate Agencies' Longer-Term Planning Studies: Part IV - Summary* (May 2011)

These reports should be referenced for more specific information, but a summary of the results are provided on the following pages as they relate to the action areas.[2]

In the RMJOC Climate Change Study, output (e.g., temperatures, precipitation) from Global Climate Models was spatially downscaled (coarse spatial data downscaled to finer spatial data) and bias corrected (adjustments made to the Global Climate Models output to better represent more local conditions), then used in a hydrologic model using the Hybrid Delta (HD) and Transient scenarios to generate supply or flow values at various locations in the Columbia River Basin. The HD climate change scenarios reflected a step-change in climate from a historical period to a future period, which can be useful for studies on system operational sensitivity to a shift in climate. Two future time periods of the HD scenarios were defined as the 30-year period surrounding the 2020s (2010 to 2039) called HD 2020 (used for reporting projected future flow conditions in this biological assessment) and the 30-year period surrounding the 2040s (2030 to 2059) called HD 2040. The Transient climate change scenarios reflected time-developing climate conditions continuously through historical and future periods (i.e., climate projections), which are useful for studies about the onset of potential impacts (e.g., adaptation planning where there is interest in scheduling risk management interventions through time). Transient time periods evolved from 1950 to 2099 and were not used in this biological assessment (refer to the RMJOC Climate Change Reports for more information on those results).

In all of the projections for both the HD scenarios, a warmer future climate was predicted in the Snake River subbasin. Mean annual temperatures increased from 0.5 percent to about 2 percent in the HD 2020 scenario and from a little more than 1 percent to more than 3 percent increase in the HD 2040 scenario when compared to the historical record.

The process to select which climate change projections to use in the RMJOC Climate Change Study was extensive and will not be described in this document (see the RMJOC studies, particularly Reclamation 2011a, for more information). In general, however, of the 57 future climate change scenarios that were available for analysis, Reclamation selected 12 HD climate projections centered on the 2020s and the 2040s to represent the range of future climates over the entire Columbia River system. The process of selecting the future climates were based on a range of temperature and precipitation change (10 percent, 50 percent, and 90

[2] All four reports can be accessed at http://www.usbr.gov/pn/programs/climatechange/reports/index.html.

percent changes when compared to historical conditions centered on the 1980s) spatially averaged over the Columbia River Basin. The approach resulted in the selection of primarily wet climate change projections in the Snake River subbasin when compared to historical temperature and precipitation (Reclamation et al. 2010, Section 4.5.1) for that subbasin. Had the future climates been selected by spatially averaging the changes in temperature and precipitation over the Snake River subbasin, different future climate change projections would have been selected so that the range of changing temperature and precipitation (10 percent, 50 percent, and 90 percent) were actually represented. Rather, because the changes were over the Columbia River Basin, the selected future climates resulted in wetter ranges over the Snake River subbasin when compared to historical conditions. The HD 2020 climate change in mean annual precipitation from historical precipitation varied between a 5 percent decrease and more than 10 percent increase in precipitation. In the HD 2040 climates, the range was even larger, from between a 5 percent decrease to a 15 percent increase when compared to the historical window centered around the 1980s (1970-1999).

The potential impact of climate change on operations in the Snake River subbasin was evaluated using two models including one that evaluated naturalized flow and one that evaluated “modified” flows or those that have 2010 level operations and demands incorporated. Both models were developed by Reclamation. Inflow into the models, generated by the UW CIG variable infiltration capacity (VIC) hydrologic model, was evaluated for the HD future climates using both "perfect" and "imperfect" forecasting. "Perfect" forecasting used a look-ahead sum of inflows in future months, and "imperfect" forecasting simulates the real world use of the prior season's precipitation and snowfall at the time of forecasting to predict seasonal runoff volumes during coming months. It was initially believed that the choice of forecasting mode would affect the results, but this was not the case; so, only the perfect forecasting method was reported on.

The VIC simulated flows total volume for the period of record calibrated well with the naturalized flows developed by Reclamation. Differences on an average monthly basis between the two datasets varied between a 0.3 percent decrease in VIC simulated flows (from Reclamation naturalized values) to no more than a 1.6 percent increase (in the month of July); however, fluctuations in annual average volumes between VIC simulated flows and Reclamation naturalized flow were found to be higher. Annual average volumes varied between roughly 32 percent more flow in the VIC dataset to almost 40 percent less flow in 2008 (that was the largest volume change in the period of record). When viewed at a monthly average basis, most of the increased volume occurred earlier in the year while summer and fall volumes tended to be less than historical volumes.

Five metrics were evaluated in the Snake River subbasin, including inflow to reservoirs, storage, flow in the Snake River at several locations (including the Boise River and in the Payette River), surface water delivery, and ESA objectives for both anadromous and resident fish species. The following subsections summarize the results of the metrics that were evaluated in the RMJOC Climate Change Study. Methods for analysis were slightly different than those used in this biological assessment and are documented as appropriate.

2.2.2 RMJOC Climate Change Study Modeled Climate Change Effects on Inflows

For the RMJOC Climate Change Study, inflow volumes to major reservoirs were summed in the upper Snake River above Brownlee Reservoir, Boise River, and Payette River. The upper Snake River reservoirs included Jackson, Palisades, Island Park, Grassy Lake, Ririe, American Falls, and Minidoka reservoirs. Major reservoirs on the Boise River included Anderson, Arrowrock, and Lucky Peak, and on the Payette River, included Payette Lake, Cascade Reservoir, and Deadwood Reservoir.

Inflow hydrology showed a shift in either peak flow timing or volume or both in all of the major reservoir groups. In all of the future climates, inflow volume to all of the reservoirs above Brownlee Reservoir increased from January to April or May and decreased in the summer to fall seasons. A shift of one month in the timing of the peak inflow of the wettest climate was observed in the inflow to reservoirs. An increase in the volume to earlier in the year than in historical conditions was observed in the Boise River, but there was no shift in the timing of the peak of the inflow at a monthly time step. It is likely that the volume change would also result in a peak flow timing shift, but that shift could not be ascertained from the monthly time step of the model used. The Payette River reservoirs had moderate increases in inflow early in the calendar year and the greatest decrease in inflow volume occurred in June in all climate scenarios when compared to the historical volumes. No shift in the timing of the peak inflow in the monthly model was evident.

2.2.3 RMJOC Modeled Climate Change Effects on End-of-Month Storage

In the RMJOC Climate Change Study, the end-of-month storage values are presented as a cumulative value of the reservoirs above the reporting point (i.e., Boise River, Payette River, Snake River above Minidoka, Snake River above Milner, and Snake River above Brownlee). The resultant value presented in the following paragraph is a cumulative amount of storage volume for the reservoirs in that system, not an individual reservoir. For this biological assessment, individual projects in each study area were evaluated and reported for each relevant facility, not cumulatively.

The increase in inflow volume that was observed in the HD 2020 and 2040 scenarios for most of the 12 climate change projections indicated a shift in the timing of the peak end-of-month storage to earlier in the year at most reporting points. When compared to historical end-of-month storage volume, end-of-month storage volume in reservoirs above Brownlee Reservoir reflected an increase in storage through May or June and then a decrease in the end-of-month storage during the irrigation season through September. In the driest climate projection in either the HD 2020 or HD 2040 scenarios, end-of-month storage volume was less than historical storage at the end of the water year and did not fully reach refill until January or February of the following year. This pattern is indicative of a greater need for stored water during the high demand summer season.

On the Boise River, end-of-month storage volumes followed similar patterns as on the upper Snake River. During dry years, a 10- to 15-percent decrease in volume was observed for late summer and fall. The drafts required to meet demands during irrigation season made refill the following year a challenge in the driest projections. The timing of the monthly peak did not appear to shift to earlier in the year, but it should be noted that with a monthly time-step model, a shift in timing by days or weeks would not be evident. While the peak flow timing does not significantly change on the Boise River, the increased magnitude of the winter and spring flow volumes result in more stored water earlier in the year when compared to the VIC historical flows. The modeled hydrology from lesser tributaries to the Snake (e.g., Owyhee, Malheur, and Powder rivers) was not presented in the report, but the data suggests that runoff from these lower elevation subbasins will generally peak in March. The shift in timing of peak inflow seen at Brownlee Reservoir was a culmination of a shift in Snake River flows at Minidoka coupled with increased earlier runoff volumes in the Owyhee and eastern Oregon subbasins that ultimately demonstrate the shift seen in the model output.

The timing of flow on the upper Snake River at Heise does not appear to significantly shift to earlier in the year. By the time the flow reaches Minidoka Dam, however, the peak appears to shift roughly a month earlier. This location includes flow from other watersheds such as the Henrys Fork River, Blackfoot River, and Willow Creek. The Snake River between Minidoka and King Hill is influenced by spring flow. The modeled hydrology illustrates that the influence of this spring flow creates a peak during the month of March. Similarly, the modeled hydrology on the Owyhee River also peaks in March and when combined, the inflow peak to Brownlee occurs earlier, in March, when compared to historical conditions.

2.2.4 RMJOC Climate Change Study Modeled Climate Change Effects on Flow

Several flow locations were chosen for climate change evaluation because they are used in operational decisions or considered important in other studies on the Snake River. These sites include Heise and Minidoka on the Snake River; at the confluence of the Snake and Boise rivers on the Boise River; and at the confluence of the Snake and Payette rivers on the Payette River.

The Snake River above Brownlee Reservoir annual flow volumes increased above VIC simulated historical flow during the winter and spring in the HD scenarios. At the Snake River at the Heise flow location, which is farther upstream in the watershed, flow was shown to increase during winter and spring in all but the driest projections in both HD 2020 and HD 2040 scenarios, except the climate projection with more warming and drier conditions.

Only in the more-warming-and-wetter climate projection of the HD 2040 scenario was peak flow timing observed to shift to earlier in the year by one month. Flow on the Snake River at Minidoka Reservoir would likely have larger volumes of flow in the winter and spring with a shift in the timing of that peak flow. Spring flows would peak in March, influencing the Snake River between King Hill and Brownlee Reservoir. The Boise River at the confluence with the Snake River was shown to have increased flows in winter and spring, but no change in the timing of the peak. Peak flow on the Payette River at the confluence with the Snake River, was generally shown to both shift in timing and increase in volume in both HD scenarios and most climate change projections.

2.2.5 RMJOC Climate Change Study Modeled Climate Change Effects on Flow Augmentation for ESA-listed Species and Resident Fish

The likelihood of delivering salmon flow augmentation water for ESA-listed salmonids was evaluated in both HD scenarios and compared to the VIC simulated historical deliveries. While achieving the full 487,000 acre-feet of salmon flow augmentation may become more difficult (particularly under the HD 2040 scenario), the likelihood of providing at least 427,000 acre-feet is projected to improve.

Other environmental objectives such as pools, minimum flows for resident fish, and ESA objectives for ESA-listed snails and bull trout are a high priority for Reclamation which is reflected in the modeling constraints. The release of storage water from an upstream reservoir may be necessary to satisfy bull trout or snail objectives. The frequency of meeting environmental objections and subsequent impact to other parts of the river system was evaluated. Palisades Reservoir's minimum flows of 900 cubic feet per second (cfs) are met between October and March for all of the climate change projections. The early fall appears to be drier in most instances, resulting in a longer duration of lower flows; however, the wetter winter months maintain higher flows than VIC simulated historical conditions. This study suggests that meeting minimum reservoir levels at Cascade, Arrowrock, and American Falls dams will be more difficult in the driest future climate projections.

2.2.6 RMJOC Climate Change Study Modeled Climate Change Effects on Critical Habitat

Climate change has the potential to profoundly alter the aquatic habitat through both direct and indirect effects. Direct effects would be evident in alterations of water yield, peak flows, and stream temperature. Future projections suggest that the Pacific Northwest may gradually become wetter than historical conditions. This is significantly different from projections in the southern United States. Warming trends may lead to a shift in cool season precipitation, resulting in more rain and less snow which would cause increased rainfall-runoff volume during the cool season accompanied by less snowpack accumulation (Reclamation 2011d). Future climate projections based on hydrologic analyses suggest that warming and associated loss of snowpack will persist over much of the western United States.

Warming is expected to diminish the accumulation of snow during the cool season (i.e., late autumn through early spring) and the availability of snowmelt to sustain runoff during the warm season (i.e., late spring through early autumn). Decreased snowpack volume also could result in decreased groundwater infiltration, runoff, and ultimately decreased contribution to summer base flow in rivers.

Warming is expected to lead to more rainfall-runoff during the cool season than snowpack accumulation. This would lead to increases in the December-March runoff and decrease the April-July runoff. For cold-water associated salmonids in mountainous regions, where the upper distribution is often limited by impassable barriers, an upward thermal shift in suitable habitat can result in a reduction in size of suitable habitat patches and loss of connectivity among patches, which in turn can lead to a population decline (USFWS 2011, pages 39-41).

USFWS (2011, pages 40-41) stated that “bull trout rely on cold water throughout their various life stages and increasing air temperatures likely will cause a reduction in the availability of suitable cold water habitat.” Migratory bull trout can be found in lakes and large rivers. Effects of climate change on lakes are likely to impact migratory bull trout that seasonally rely upon lakes for their greater availability of prey and access to tributaries. Climate-related warming of lakes will likely lead to longer periods of thermal stratification, forcing cold-water fish such as bull trout to be restricted to the bottom layers for greater periods of time (USFWS 2011, page 41).

As climate change progresses and stream temperatures warm, thermal refugia will be critical to ensure the persistence of bull trout and other species dependent on cold water. Thermal refugia are important for providing bull trout with patches of suitable habitat while allowing them to migrate through or to make foraging forays into, areas with above optimal temperatures. Populations that are currently connected may become thermally isolated, which could accelerate the rate of local extinction (USFWS 2011, page 41).

2.2.7 RMJOC Climate Change Study 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. Reclamation's reservoirs are operated with a high level of flexibility to respond to a wide variety of hydrological and meteorological conditions. Reservoir operators respond to changing conditions, whether natural or anthropogenic. This will continue to occur as new hydrologic information becomes available. Because the range of variability that is expected due to climate change is projected to remain within the historical range of variability at least through 2040 or 2050, major changes to current operations are not anticipated.

2.3 Water Quality

Reclamation's 2004 Upper Snake BA provided 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 (Reclamation 2004a, pages 248-252). Results of Reclamation's current water quality monitoring are found in Appendix B of this document.

Plans for achieving State water quality standards in water-quality-limited stream reaches in the action areas have been formulated through the Total Maximum Daily Load (TMDL) planning process specified under Section 303(d) of the Clean Water Act. Table 9-3 in Reclamation's 2004 Upper Snake BA provides the Section 303(d) listings and TMDL schedule at that time for achieving State water quality standards in the upper Snake River basin reaches and major tributaries in areas affected by Reclamation project operation (Reclamation 2004a, pages 248-249). Since the States of Idaho and Oregon (States) have not adhered to the schedule for a variety of reasons, the 2007 Upper Snake BA provides the most recent information on TMDLs and related activities and on water temperature monitoring in the upper Snake River basin.

2.3.1 Total Maximum Daily Load (TMDL)

Upper Snake River Basin TMDLs above Brownlee Reservoir

Reclamation has participated in, is currently participating in, or plans to participate in the development and implementation of many TMDLs in the action areas (Table 1). Reclamation has consistently provided technical and financial assistance to the States to help ensure that the water quality aspect of river and reservoir operation is fully understood. Data collected as part of Reclamation's Idaho and Oregon Investigation Programs (partners with the States and local water users to identify solutions to water and related natural resource problems), regional reservoir monitoring efforts, and river and reservoir monitoring for project operations have been consistently used by the States during TMDL development and implementation.

Table 1. Idaho and Oregon Subbasin TMDL status.

Subbasin	TMDL Status*	Pollutants Addressed/Listed
Snake River - Brownlee	completed 2003 (IDEQ and ODEQ 2003)	temperature, sediment, nutrients, dissolved gas, and mercury
Little Wood River	completed 2005 (IDEQ 2005)	temperature
South Fork Boise River	completed 2009 (IDEQ 2008)	temperature
Payette River	completed 1996, 1999, 2007, and 2010 (IDEQ 2011)	nutrients, bacteria, ammonia, sediment, temperature, dissolved oxygen, pH
Malheur River	completed 2010 (ODEQ 2010)	bacteria, temperature, nutrients, chlorophyll *a*
Owyhee River	TMDL not started, minimal or no activity.	arsenic, mercury, temperature
Mann Creek	completed 2006 (IDEQ 2006)	temperature
Burnt River	TMDL Initiated scoping and data collection underway.	temperature, chlorophyll a, dissolved oxygen, bacteria, sediment
Powder River	TMDL Initiated scoping and data collection underway.	temperature, turbidity, bacteria
Lower Snake to Columbia River	TMDL not started, minimal or no activity.	temperature, mercury
Columbia River Snake to mouth	TMDL initiated in 2001, not completed	temperature

* Some areas have a developed status, but a report has not been completed for citation in this table.

Reclamation's Snake River Area Office and Pacific Northwest Regional Office staffs also participate in watershed advisory groups 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.

3.0 OVERVIEW OF BULL TROUT IN THE UPPER SNAKE RIVER BASIN

Bull trout (*Salvelinus confluentus*, family *Salmonidae*) are members of the char subgroup that is native to the Pacific Northwest and western Canada and range throughout the Columbia River and Snake River basins (75 FR 63898, page 63898). Although bull trout are presently widespread in their historical range, they have declined in overall distribution and abundance during the last century (USFWS 2002a, page 6).

On June 10, 1998, USFWS issued a final rule listing the Columbia River and Klamath River populations of bull trout as threatened under the authority of the ESA (63 FR 31647). This decision conferred full protection of the ESA on bull trout occurring in the Pacific Northwest. In the rules listing bull trout as threatened, USFWS identified subpopulations (i.e., isolated groups of bull trout thought to lack two-way exchange of individuals) for which status, distribution, and threats to bull trout were evaluated. Because habitat fragmentation and barriers have isolated bull trout throughout their current range, a subpopulation is considered a reproductively isolated group of bull trout that spawns in a particular river or area of a river system (USFWS 2002a, page 7). The 2004 Upper Snake BA and 2005 USFWS BiOp provide information on the status, historic distributions, current distribution, life history, habitat requirements, and factors that contributed to the species decline and current conditions and recovery efforts in the action area.

USFWS completed a 5-year status review for bull trout in 2008. The review considered information that had become available since the original listing of bull trout such as population and demographic trend data, genetics, species composition, habitat condition, adequacy of existing regulatory mechanisms, and management and conservation planning. With completion of the 2008 review, USFWS concluded that it was appropriate to maintain the threatened status for bull trout as currently listed and evaluated whether distinct population segments exist and merit protections of the ESA.

3.1 Critical Habitat Designations

The ESA defines critical habitat as "the specific areas in the geographical area occupied by the species, at the time it is listed…, on which are found those physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and specific areas outside the geographical area occupied by the species at the time it is listed…upon a determination by the Secretary that such areas are essential for the conservation of the species."

Critical habitat designations for the Klamath River and Columbia River bull trout populations were originally designated in 2005 (69 FR 59995). Critical habitat was originally proposed for areas in the Snake River upstream from Brownlee Reservoir, but USFWS determined that the protection at the time afforded bull trout on Federal lands in the Snake River drainage by INFISH,[3] the Interior Columbia Basin Ecosystem Management Project strategy, the Northwest Forest Plan, and the Aquatic Conservation Strategy provided a level of conservation comparable to or greater than that achieved by designating critical habitat. At that time, no critical habitat was designated in the action areas.

In 2010, USFWS revised critical habitat for bull trout, adding several new areas in the Snake River basin (75 FR 63898). In the final critical habitat justification (USFWS 2010a), the USFWS identified six draft recovery units (RU). The upper Snake River projects action areas fall within the Upper Snake River RU (USFWS 2010a, page 4) and the Mid-Columbia River RU. The mainstem Columbia River and Snake River action areas span portions of three RUs: the Upper Snake RU, Mid-Columbia RU, and the Coastal RU.

3.1.1 Locations of Critical Habitats in this Assessment

3.1.2 Upper Snake Recovery Unit

The Upper Snake RU is essential to the conservation of bull trout because populations are detectably different at the mitochondrial DNA level from the two RUs west of the Cascade Range and at the microsatellite DNA level from the three RUs east of the Cascade Range. The Upper Snake RU bull trout are mostly isolated from other RUs in the headwaters of the Snake River basin due to distance in the lower Salmon River and a partial dispersal barrier in Hells Canyon. They co-occur with anadromous Columbia River Basin salmonids similar to the Mid-Columbia RU, but different from the other RUs in that they occur inland in a lower elevation climate and different vegetative condition than the two RUs west of the Cascade Range and three RUs upstream closer to the Continental Divide. The loss of this RU would result in a significant gap in the range of bull trout. The entire RU has or could have a shared evolutionary future by migrating among populations over long periods of time.

The Upper Snake River RU includes five critical habitat units (CHUs). Of those five, the action areas intersect only two CHUs: the Malheur River basin CHU, where the Vale Project is located on the Malheur River, and the Southwestern Idaho River Basins CHU, where the Arrowrock and Payette divisions of the Boise Project are located (Appendix A). The Jarbidge CHU, Salmon River CHU, and Little Lost River CHU lie outside of the action areas.

[3] INFISH refers to the The PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program which was initiated in 1998 to provide a consistent framework for monitoring aquatic and riparian resources on most U.S. Forest Service and Bureau of Land Management lands in the upper Columbia River Basin.

3.1.3 Mid-Columbia Recovery Unit

The Mid-Columbia RU is essential to the conservation of bull trout because populations are detectibly different at the mitochondrial DNA level from the two RUs west of the Cascade Range and at the microsatellite DNA level from the three other RUs east of the Cascade Range. Bull trout in the Mid-Columbia RU are mostly isolated from other RUs due to distance and partial dispersal barriers, including the Columbia Gorge downstream and Hells Canyon, and ancient waterfalls in the upper Columbia River basin upstream. These bull trout co-occur with anadromous Columbia River basin salmonids similar to the upper Snake RU, but are different from the other RUs. They occur inland in a lower elevation climate and different vegetative conditions than the two RUs west of the Cascade Range and three RUs upstream closer to the Continental Divide. The loss of this RU would result in a significant gap in the range of bull trout. The entire RU has or could have a shared evolutionary future by migrating among populations over long periods of time.

The Mid-Columbia RU has 12 CHUs. The Baker Project intersects in the Powder River CHU (Appendix A). The other 11 CHUs lie outside the action areas.

3.1.4 Coastal Recovery Unit

The Coastal RU is essential to the conservation of bull trout because populations are significantly different at the mitochondrial DNA level from the four RUs east of the Cascade Range and at the microsatellite DNA level from the Klamath RU. In the Olympic Peninsula and Puget Sound areas, they are almost completely isolated from other RUs and are partially isolated from other RUs in the lower Columbia River. Some populations within this RU exhibit amphidromous (move to and from salt water from fresh water) life history form. They co-occur with Dolly Varden (*Salvelinus malma*) in the northern portion of the RU and coastal populations of anadromous salmonids elsewhere. They occur in a coastal climate and vegetative condition west of the Cascade Range, different from the four RUs to the east. The loss of this RU would result in a significant gap in the range of bull trout and the entire RU has or could have a shared evolutionary future by migrating among populations over long periods of time (USFWS 2010a).

The Columbia River, from the mouth upstream to John Day Dam, is essential for maintaining bull trout distribution and provides essential foraging, migrating, and over-wintering (FMO) habitat for extant tributary populations of bull trout in the Lewis, Hood, Klickitat, and Deschutes Rivers and connectivity between these core areas,[4] as well as facilitates the potential reestablishment of a population within the White Salmon River. Connectivity from

[4] Core areas are defined by USFWS as an area that is considered to be a functioning, standalone population unit (USFWS 2005b). The use of the term “core areas” is frequently used by the USFWS for bull trout status reviews.

the Pacific Ocean and upriver allows for the opportunity for amphidromous and fluvial life history expressions and genetic exchange and diversity, which are essential to the recovery unit. Sections of the Columbia River within this reach of the critical habitat are either presently used by bull trout, or are unknown and have historically been used by bull trout for foraging, over-wintering, and migration. Habitat in the Lower Columbia River is presently considered to be suitable for foraging, over-wintering, and migration. At present, bull trout populations in this CHU are somewhat disconnected from each other and at low levels.

The part of the action areas including the mainstem Columbia River from John Day Dam downstream to the Pacific Ocean (CHU 8) is within the Coastal Recovery Unit.

3.1.5 Primary Constituent Elements

In accordance with the ESA and regulations at 50 CFR 424.12(b) in determining which areas occupied at the time of listing to propose as critical habitat, USFWS designated the physical or biological features (PCEs) essential to the conservation of the species and that may require special management considerations or protection and include, but are not limited to:

- PCE 1 - Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
- PCE 2 - Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including, but not limited to, permanent, partial, intermittent, or seasonal barriers.
- PCE 3 - An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- PCE 4 - Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.
- PCE 5 - Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.
- PCE 6 - In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

- PCE 7 - A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
- PCE 8 - Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
- PCE 9 - Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout (75 FR 63898, page 63931-63932).

3.2 Recovery Planning

In 2002, USFWS published a *Bull Trout Draft Recovery Plan* (*Draft Recovery Plan*) and conducted a 5-year status review in 2008 (referred to as the core area assessments). Both documents are currently being updated and will include new population and demographic trend data, genetics, species composition, habitat condition, and threats. Reclamation has participated in the recovery planning process and prepared this biological assessment using the most current information on bull trout, both published and unpublished. Reclamation anticipates this document to be compatible with the revised *Draft Recovery Plans* when they are completed.

3.3 Critical Habitat Analyses in this Assessment

The critical habitat analyses in this document focused on areas where an action area overlaps with designated critical habitat. All actions areas in this document are consistent with those in the 2004 Upper Snake BA (Reclamation 2004a, page 3).

This biological assessment describes how the proposed action may alter the function and use of the designated critical habitat in each of the action areas. All of the action areas provide for foraging, migration and over-wintering (FMO) use, but none of the action areas were designated as spawning and rearing habitat. To perform this analysis, Reclamation 1) identified the baseline function of each PCE in all areas addressed in this biological assessment; 2) evaluated how O&M influenced these PCEs; 3) evaluated the likely changes in the function of each PCE as a result of future O&M activities; and 4) determined how these changes would affect the function of the critical habitat area as FMO habitat.

In the baseline analysis for each PCE, Reclamation identified whether a PCE is present or not present in an area and how it contributes to the habitat use for which an area was designated.

In areas where a PCE is present and fully functioning for its intended use, Reclamation described the PCE as being present in and contributing to a particular use. Where baseline factors might limit the performance of a PCE, Reclamation described the PCE as present, but making a limited contribution to a particular use. Finally, where a PCE is not supported within an area or is so degraded to make no meaningful contribution to a designated use, Reclamation described a PCE as not present.

In the effect analysis for each PCE, Reclamation described how our proposed actions influences each PCE and determines how and to what extent the proposed actions affect each PCE. Where a proposed action degrades a PCE to such a degree to affect a change in the function and use of a designated critical habitat area for the use it was designated, Reclamation described the effect as “adverse.” Where a proposed action influences, but does not alter the function of a PCE, Reclamation described the effect as “insignificant.” Where a proposed action may influence, but the effects are so small that they are not detectable, Reclamation described the effect as "discountable;" meaning those effects that are extremely unlikely to occur (USFWS and NMFS 1998).

3.3.1 Analysis of PCEs in this Assessment

For the purpose of this assessment Reclamation recognizes that each PCE works in concert with others to support a designated use. Often, there is overlap between relevant factors for several PCEs. For example, PCEs 5 and 8 each consider water temperature, but in different ways. This section clarifies how Reclamation evaluated each PCE.

PCE 1

PCE 1 requires “springs, seeps, groundwater sources and subsurface connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.” PCE 1 plays different roles depending on the habitat type. In spawning and rearing habitats, groundwater influence can provide an important cue for spawning behaviors (75 FR 63898, page 63930, citing Baxter and Hauer 2000, page 1476). In FMO habitat, groundwater can provide a source of thermal refugia and water quality. The importance of this contribution to FMO habitat is relative to other sources of thermal refugia and water quality. Where groundwater influence plays a relatively small role in determining thermal refugia and water quality, the PCE was considered as present, but providing a limited contribution. For example, in deep reservoir environments, the thermal regime of the reservoir and tributary inflow renders groundwater influence a relatively insignificant factor in determining the presence of thermal refugia and adequate water quality. In these areas, Reclamation evaluated the presence of thermal refugia under PCE 5 and water quality under PCE 8.

PCE 2

PCE 2 requires "migration habitats with minimal physical, biological, or water quality impairments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including, but not limited to, permanent, partial, intermittent, or seasonal barriers." Generally, PCE 2 was considered as present in waterbodies where bull trout are able to migrate between different habitats even if some impediments exist. Where impediments exceed the minimal threshold described in the PCE and bull trout migration behaviors are significantly affected by an impediment, the PCE is described as present, but making a limited contribution to a habitat use. In evaluating the baseline condition, when effects of impediments outside of the action areas affect the function of PCE 2 inside the action area, such as upstream impediments to a reservoir, the PCE was also described as present, but making a limited contribution. Where impediments are so severe that little meaningful migration can take place, the PCE was considered as not present. To evaluate this PCE, Reclamation considered physical impediments downstream of facilities, including water temperature barriers and temporary and seasonal barriers caused by the formation of anchor ice.

A recurrent effect on PCE 2 in reservoirs is associated with the exposure of the varial zone. The varial zone is the migration corridor where a tributary flows into a reservoir which is periodically inundated or dewatered with fluctuating reservoir water surface levels (e.g., full pool levels or various drawdown levels). A varial zone is seasonally present when the reservoir is drawn down below the point where the habitat changes from lentic conditions representative of the action area. Degradation of the varial zone occurs when high amounts of fine material from upstream tributaries deposits within a reservoir, forming delta-like zones at the mouths of tributaries. While reservoir operations do relatively little to affect the formation of varial zones, reservoir drawdowns can expose greater amounts of the varial zone. Varial zones can present impediments to bull trout migration in different ways. In most instances, a lack of habitat complexity and cover in varial zones may expose migrating bull trout to an increased risk of predation. In limited cases, varial zones can expose physical barriers as well.

PCE 3

PCE 3 requires "[a]n abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish." This PCE was considered as present and contributing to FMO habitat where a sufficiently abundant and diverse prey base allows for growth of both individual and populations of bull trout. Where the prey base is present to support individual growth, but may limit the growth of a population, PCE 3 was considered present, but providing a limited contribution to FMO habitat. If the prey base was not sufficient to influence bull trout use of a particular area, PCE 3 was considered as not present.

To evaluate PCE 3, Reclamation primarily evaluated the operational influence on water quality (discussed in detail under PCE 8) on primary productivity. This process began with an evaluation of nutrient, dissolved oxygen, and temperature conditions within a reservoir. Ideally, these conditions maintain a balance of phytoplankton and zooplankton production to support a diverse food web within the reservoir and downstream. Adverse influence can occur where water quality conditions cause an imbalance in this relationship. This can reduce dissolved oxygen levels, increase algae induced turbidity, and disrupt primary productivity in ways that directly and indirectly influence the production of bull trout prey. As these processes occur within a reservoir, they may influence downstream conditions. This influence may differ, especially where reservoirs release cold water into the river below.

In evaluating PCE 3, Reclamation considered nonnative fish species as a portion of bull trout prey base. Often the presence of nonnative species can provide forage fish for adult bull trout while at the same time competing with smaller bull trout for prey at lower trophic levels. Because the interactions of nonnative species on the overall food web are complex, changing, and often unknown contributions of nonnative species to bull trout prey base are described under PCE 3, while discussing competition under PCE 9.

PCE 4

PCE 4 requires "complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes, that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure." PCE 4 was considered as present when a habitat exhibits some complex features. Some limiting factors may reduce the contribution of complexity to FMO habitat. Reclamation's analysis focused on the influence of hydrologic conditions on the interface with riparian zones. In manmade environments such as reservoirs, the complex features and the processes that maintain them differ from those in natural environments. Shoreline areas of reservoirs present a similar case. This biological assessment notes that reservoir operation influences shoreline complexity; however, reservoir complexity was evaluated with an understanding of the migratory habits of bull trout and their use of critical habitat within the context of the Critical Habitat Subunit (CHSU). The migratory life history of the bull trout population using the designated critical habitat in this analysis (adfluvial) has been documented to make frequent movements both within and between habitats. As such the function of this PCE is described, in part, using habitat outside the action area as well as habitat within the action area with access through an open migration corridor. The total habitat complexity may be less in a reservoir environment when not at full storage; however, functional complexity refers to the availability of habitats within the action area in addition to an open migration corridor (PCE 2) allowing fishes to use a variety of river and reservoir environments.

PCE 5

PCE 5 requires "water temperatures ranging from 2° to 15° C with adequate thermal refugia for temperatures that exceed the upper end of this range." Cold water temperatures are an important characteristic of bull trout FMO habitat. To evaluate this PCE, baseline seasonal temperatures were evaluated as to whether they influenced bull trout use of the habitat. PCE 5 was considered as present when water temperatures were within 2° to 15° C for those times bull trout were likely to use the habitat area. The PCE was considered present but limited, where temperatures exceeded 15° C, but thermal refugia persist. The effects of water temperature on water quality, habitat complexity, migration, and prey base are discussed within those respective PCEs.

PCE 6

PCE 6 requires "In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure the success of egg and embryo over-winter survival, fry emergence, and young of the year and juvenile survival." No spawning and rearing habitats occur within the action areas evaluated in this assessment.

PCE 7

PCE 7 requires "a natural hydrograph including peak, high, low, and base flows, or if flows are controlled, minimal flow departure from a natural hydrograph." PCE 7 addresses the timing and amount and timing of stream flow, a characteristic that is by definition not present in a reservoir environment. Where critical habitat was designated as a reservoir, the biological assessment notes that PCE 7 is not present. In the streams and rivers affected by Reclamation's projects, the presence and function of PCE 7 were evaluated.

PCE 8

PCE 8 requires "sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited" (75 FR 63898, page 63932). To evaluate this PCE, Reclamation looked to the direct effects of several water quality parameters and total water quantity on bull trout behaviors. While a thorough discussion of water quality occurs under this PCE, the effects of water quality on migration, prey base, thermal refugia, and complex habitat processes are discussed in greater detail under their respective PCEs. This PCE was considered present when water quality conditions are suitable for bull trout when bull trout are likely to inhabit the reservoir. PCE 8 was considered as present, but limited if some impairments occur while bull trout may be present. If water quality conditions are rarely suitable for bull trout, PCE 8 was considered as not present.

Evaluation of water quality in reservoir environments requires a basic understanding of two important phenomena: reservoir stratification and nutrient cycling. Especially in deeper reservoirs, water quality conditions can vary with depth in the reservoir. Generally, warmer water congregates at the top of a reservoir (epilimnion) and cooler water at the bottom (hypolimnion). Wind events, depth, surface area, tributary inflow can all affect this stratification, and at times, cause the temperature strata to break down and the water in the reservoir to mix. Like temperature, dissolved oxygen levels can also stratify.

Suitable water quality conditions for bull trout can only exist where both temperature and dissolved oxygen concentrations are both present within the same strata. The influence of reservoir operation on water temperature depends largely on when releases occur and where the water is drawn from. For example, in reservoirs that release water from the bottom of the dam, operations may deplete cold water supplies, warming the reservoir, but cooling the river below. Similarly changes in water volume and temperature can affect nutrient cycles in a reservoir. In a healthy reservoir, primary and secondary production exhibits a balance between phytoplankton and zooplankton communities. Warm-water temperatures, nutrient loads, and low dissolved oxygen can favor the development of inedible phytoplankton communities. This can increase sediment loads in the reservoir, disrupt zooplankton communities and in extreme cases, cause increased bacterial growth and lead to anoxic conditions in a reservoir.

PCE 9

PCE 9 requires “low levels of nonnative predation, interbreeding and competition.” Reclamation described this PCE as present where no self-sustaining populations of nonnative species exist within a waterbody. The PCE was described as present, but limited where self-sustaining populations compete or prey on bull trout, but not at levels that would dissuade bull trout use of a waterbody. PCE 9 was considered as not present where high levels of hybridization with brook trout occur, where competition or predation prevent bull trout use of the waterbody, or where nonnative species are actively stocked within a waterbody. In some cases, nonnative species can simultaneously constitute predators, competitors, and prey to bull trout. The effect of nonnative species on prey base is discussed under PCE 3.

4.0 BOISE RIVER SYSTEM

4.1 Proposed Action

The future O&M in the Boise River system is described in the 2004 Upper Snake BA (Reclamation 2004a, page 19) and includes continued O&M activities of the Arrowrock Division of the Boise Project and the Lucky Peak Project. Since the 2004 Upper Snake BA, a new powerplant and valves were added to Arrowrock Dam (FERC Project No. 4656-020); however, power production is subordinate to flood control and irrigation deliveries. The operations are still functioning within the range analyzed in the 2004 Upper Snake BA and all other features and O&M activities remain the same as described in the 2004 Upper Snake BA.

The proposed action also includes implementation of T&Cs from the 2005 USFWS BiOp. Table 2 lists the T&Cs, purposes of the T&Cs, and current status studies or activities designed to address the T&Cs.

Table 2. Terms and Conditions (T&Cs) from the 2005 USFWS BiOp that pertain to Arrowrock or Anderson Ranch reservoirs.

T&C	Action Area	Description	Purpose	Studies/Activities
1.a.	Arrowrock Reservoir	Within the range of proposed operation, decrease the frequency, duration, and extent of drawdowns below elevation 3100 feet in Arrowrock Reservoir during the fall migration period (September 15-October 31).	Reduce the level of take (bull trout) from habitat loss and death from predation in the varial zone.	Ongoing
1.b.	Arrowrock Reservoir	Within the range of proposed operations, decrease the rate and extent of drafting at Arrowrock Reservoir during the summer months (June through September).	Minimize harm associated with reduced reservoir productivity and reduced prey abundance that results from extreme drawdown.	Ongoing

T&C	Action Area	Description	Purpose	Studies/Activities
1.c.	Arrowrock Reservoir	Minimize conditions that increase risk of entrainment of bull trout through clamshell outlet conduits in Arrowrock Dam.	Conditions leading to entrainment may occur during three general operating seasons (USFWS 2005a, page 238).	Structural changes have occurred to eliminate each of the three conditions described.
1.d.	Arrowrock Reservoir	Implement a trap-and-haul program below Arrowrock Dam.	Capture bull trout in Lucky Peak Reservoir and release in Arrowrock Reservoir to return these individuals to the Arrowrock adfluvial population.	Implemented according to Monitoring and Implementation Plan (Reclamation 2006).
2.a.	Anderson Ranch Reservoir and South Fork Boise River	Determine and implement ramping rates (increasing and decreasing) of flows from Anderson Ranch Reservoir that reduce take of bull trout in the South Fork Boise River.	The South Fork Boise River below Anderson Ranch Reservoir provides 26 miles of habitat that is used by bull trout in the Arrowrock Reservoir metapopulation.	Ongoing
2.b.	Anderson Ranch Reservoir and South Fork Boise River	Determine the flexibility in the proposed action to manage flows from Anderson Ranch Reservoir to minimize disruption of biological processes, particularly migratory cues of bull trout in the South Fork Boise River.	To determine how discharge from Anderson Ranch Reservoir may affect the migratory and biological cues of bull trout from the Arrowrock Reservoir meta-population that use the South Fork Boise River.	Ongoing

To implement the T&Cs of the 2005 USFWS BiOp, Reclamation prepared a monitoring and implementation plan that identified operational indicators to monitor incidental take associated with the proposed action (Reclamation 2006). Operational indicators describe a set of measurable criteria, such as specific reservoir elevations, that allow Reclamation to verify compliance with the T&Cs of the 2005 Incidental Take Statement. Table 3 lists the eight operational indicators associated with the Boise River projects.

Table 3. Operational Indicators associated with Anderson Ranch and Arrowrock dams and reservoirs (Reclamation 2006). Data updated through Water Year 2012.

Facility	Anticipated Take	Operational Indicator	Critical Season	Expected Occurrence/ Recorded Occurrences
Anderson Ranch Dam and Reservoir	Up to 50 percent of the Middle and North Fork populations are affected by the spillway discharges that disrupt timing of migration and spawning and that after metabolic rates.	Water is dicharged over the spillway.	Spring	6 of 30 years; this has occurred once since 2006
Anderson Ranch Dam and Reservoir	Up to 50 percent of the Middle and North Fork populations are affected by the altered flow and temperature regime that disrupts migration and spawning and that increases metabolic rates.	Water is stored and released at Anderson Ranch Dam.	Spring through fall	30 of 30 years; this has occurred seven times since 2006
Anderson Ranch Dam and Reservoir	Up to 10 percent of bull trout in the reservoir are entrained into the South Fork Boise River	Storage and release operations at Anderson Ranch Dam alter the natural flow regime.	Spring	6 of 30 years, this has not occurred since 2006
Anderson Ranch Dam and Reservoir	Up to 4 percent of bull trout in the reservoir experience degraded water quality.	Reservoir storage volume falls below 62,000 acre-feet.	Summer	2 of 30 years; this has not occurred since 2006.
Arrowrock Dam and Reservoir	Up to 50 percent of the Middle and North Fork populations are affect by low reservoir productivity and decreased prey.	Reservoir volume of less than 200,000 acre-feet at the end of June.	June 30	3 of 30 years; this has occurred once since 2006
Arrowrock Dam and Reservoir	Up to 8 percent of bull trout in the reservoir are entrained into Lucky Peak Reservoir, as averaged over any consecutive 5-year period.	Water is discharged over the spillway.	March through June	15 of 30 years this has occurred once since 2006
Arrowrock Dam and Reservoir	Up to 2 percent of bull trout in the reservoir are entrained into Lucky Peak Reservoir.	Discharge exceeds 695 cfs while the reservoir water surface elevation is less than 3111 feet.	July through September	30 of 30 years this has occurred 5 times since 2006

Facility	Anticipated Take	Operational Indicator	Critical Season	Expected Occurrence/ Recorded Occurrences
Arrowrock Dam and Reservoir	Up to 20 percent of bull trout in the reservoir, as averaged over any 5 consecutive years, experience habitat degradation and predation.	Mean daily reservoir elevation falls below 3100.	September 15 through October 31	18 of 30 years: this has not occurred since 2006.
Arrowrock Dam and Reservoir	Up to 5 percent of bull trout in the reservoir are entrained into Lucky Peak Reservoir, as averaged over any consecutive 5-year period.	Discharge exceeds 695 cfs while the reservoir water surface elevation is less than 3111 feet.	Winter	20 of 30 years; this has not occurred since 2006.

4.2 Action Area

A detailed description of the Boise Project in the Boise River system action area appears in the 2004 Upper Snake BA (Reclamation 2004a, page 19) and the 2004 Operations for Reclamation projects in the Snake River above Brownlee Dam (Reclamation 2004b, page 79-115). The analysis in this chapter focuses on three locations where the Boise Project in the Boise River system action area overlaps with the Anderson Ranch and Arrowrock Reservoir CHSUs:

- **Anderson Ranch Reservoir** (4,601.1 acres [1,862.0 hectares]) is part of the Anderson Ranch CHSU and contains FMO habitat.

- **South Fork Boise River** (22.7 miles [36.5 kilometers]) from approximately Anderson Ranch Dam to Arrowrock Reservoir contains parts of the Anderson Ranch and Arrowrock CHSUs and contains FMO habitat.

- **Arrowrock Reservoir** (3,093.7 acres [1,252.0 hectares]) is part of the Arrowrock Reservoir CHSU and contains FMO habitat.

Bull trout critical habitat in the Boise River basin is part of the Southwest Idaho River Basins CHU (CHU 26) (75 FR 63898, USFWS and IDFW 2010). The Southwest Idaho River Basins CHU is part of the larger Upper Snake River RU. The Southwest Idaho River Basin CHU includes approximately 1,336.0 miles (2,149.6 kilometers) of streams and 10,652.5 acres (4,311.0 hectares) of lake and reservoirs designated as critical habitat. The Southwest Idaho

River Basins CHU includes eight CHSUs: Anderson Ranch Reservoir, Arrowrock Reservoir, South Fork Payette River, Deadwood River, Middle Fork Payette River, North Fork Payette River, Squaw Creek, and Weiser River (Table 4; Appendix A).

Table 4. Critical habitat stream miles, surface area, and storage volumes within the Southwest Idaho River Basin Critical Habitat Unit (CHU) and Critical Habitat Subunits (CHSUs). Subunits described in this chapter are highlighted. Designated critical habitat within the action area is totaled.

Critical Habitat Unit	Critical Habitat Stream Miles (kilometers)	Critical Habitat Surface Area - Acres (hectares)	Critical Habitat Storage - Acre-feet
Southwest Idaho River Basins 26 - 4,158.3 total stream miles (6,692.2 kilometers)	**1,335.2 (2149.0)**	**10,652.5 (4,311.0)**	**901,100**
Southwest Idaho River Basins CHU Subunits (CHSUs)			
Weiser River	70.4 (113.3)	0	0
Squaw Creek	44.9 (72.3)	0	0
NF Payette River	19.3 (31.1)	0	0
MF Payette River	122.7 (197.6)	0	0
Upper South Fork Payette River	278.0 (447.4)	0	0
Deadwood River	77.0 (123.9)	2,957.8 (1,197.0)	154,000
Arrowrock Reservoir	447.4 (720.0)	3,093.7 (1,252.0)	272,200
Anderson Ranch Reservoir	275.5 (443.4)	4,601.0 (1,862.0)	474,900

These subunits are considered essential to bull trout conservation because of the presence of populations exhibiting rare adfluvial life history expressions, a moderate number of local populations, moderate to large numbers of individuals, a moderate amount of habitat, and few threats (USFWS and IDFW 2010).

Figure 2 shows the Boise River basin bull trout core areas coincident with the CHSUs, CHU boundaries, designated critical habitat streams and reservoirs, and the proposed action project boundaries for the Boise River basin projects. Effects where the proposed action influences the hydrology in designated critical habitat are analyzed in this section (bold red lines show the area of overlap between the 2004 Upper Snake BA action area and designated critical habitat). Operation of the Boise River system also contributes to the aggregate effect of upper Snake River projects on designated critical habitat located on the mainstem Snake and Columbia rivers. Designated critical habitat on the mainstem Snake and Columbia rivers are part of Mainstem Snake River CHU (CHU 23), Mainstem Columbia River CHU (CHU 22), and Lower Columbia CHU (CHU 8) and these effects are analyzed in Section 8.

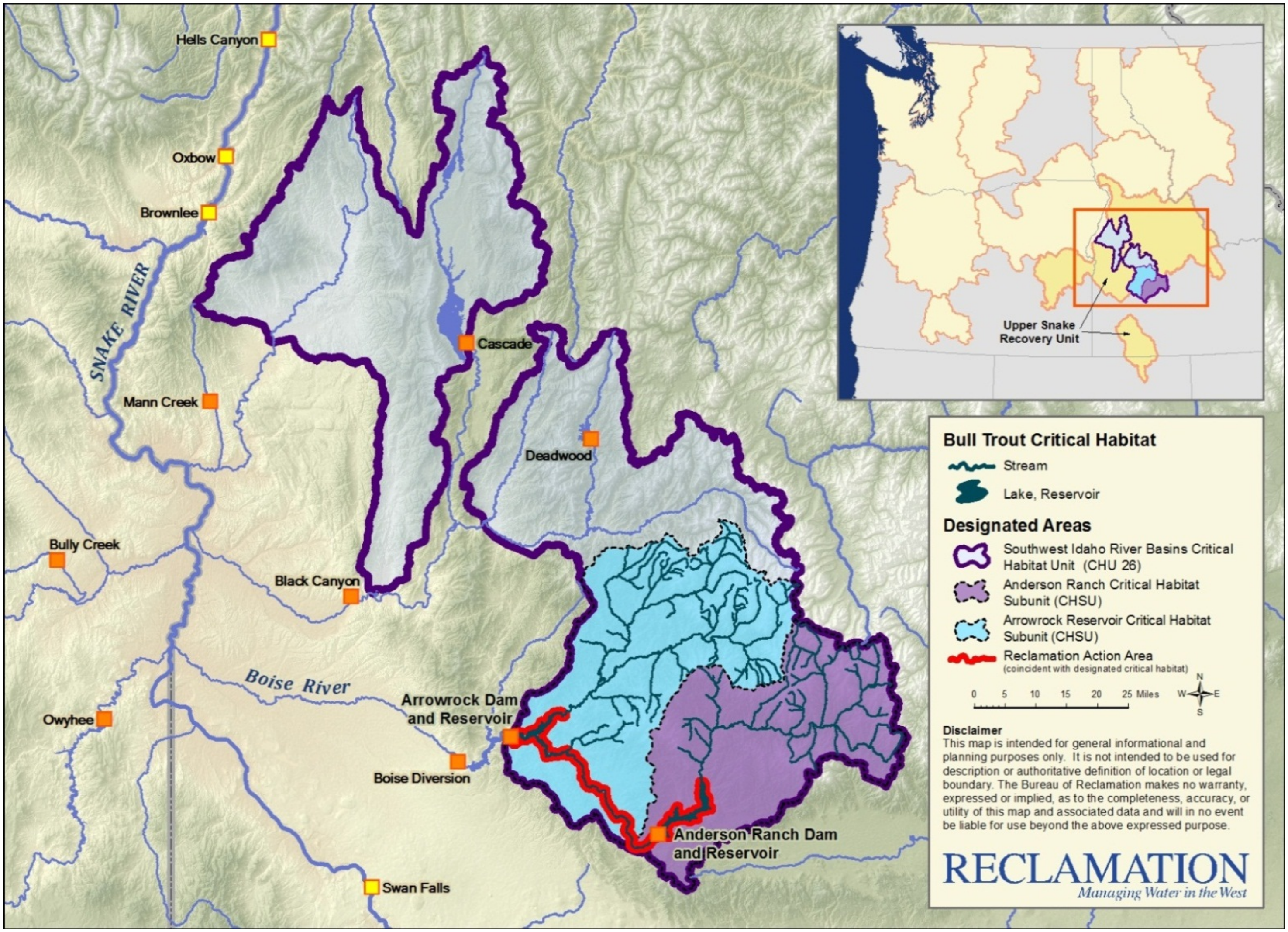

Figure 2. Southwest Idaho River Basin Critical Habitat Unit 26 boundary. The action area described in Section 4.0 only includes Anderson Ranch, Arrowrock, and Deadwood reservoirs and the South Fork Boise River between Anderson Ranch and Arrowrock reservoirs.

4.3 Environmental Baseline

4.3.1 Baseline Hydrology

Anderson Ranch Dam is located on the South Fork Boise River. At full pool, Anderson Ranch Reservoir stores nearly 475,000 acre-feet of water with a surface elevation of 4196 feet and a surface area of 4,743 acres (4,601 acres are designated as critical habitat; 75 FR 63898, USFWS and IDFW 2010). Slightly more than 413,000 acre-feet of the full volume is active storage.

Arrowrock Dam is located downstream of Anderson Ranch Dam on the Boise River. At full pool, Arrowrock Reservoir stores 271,700 acre-feet of water with a surface elevation of 3216 feet and a surface area of 3,141 acres. Arrowrock Reservoir has a small amount of inactive space of 514 acre-feet that occurs at reservoir water surface elevation 3015 feet. The inactive space was created in 2004 when the clamshell gates were installed and the sluice gates were retired.

Reclamation operates the Boise River system as a unified storage system for joint irrigation and flood control. To the extent possible, water is stored in the uppermost reservoir (Anderson Ranch) to maximize refill capabilities of the system. Flood control operations generally run from November 1 through May 31 and the attempt to fill reservoirs occurs in May or early June. From April to October, Reclamation drafts Arrowrock Reservoir for irrigation. The lowest reservoir volumes occur October through March. In wet years, volumes may drop in early spring to meet flood control criteria (see Reclamation 2004b, pages 79-117, for more detailed description of the operations). The 2005 USFWS BiOp identified operational indicators for both reservoirs to minimize take of bull trout. For Anderson Ranch Dam, the 2005 USFWS BiOp identified a reservoir storage volume below 62,000 acre-feet (this volume includes powerhead and dead space) by the end of September as an operational indicator to minimize impacts to water quality in dry water years.

For Arrowrock Dam, the 2005 USFWS BiOp identified the mean daily reservoir operation below a surface water elevation of 3100 feet (37,912 acre-feet storage volume) from September 15 to October 31 as an operational indicator to minimize impact to the migration corridor and predation. There is also a reservoir volume target of 200,000 acre-feet by June 30 to minimize impacts on reservoir productivity.

The figures provided in this section for both Anderson Ranch and Arrowrock reservoirs were developed using the MODSIM model results from the RMJOC Climate Change Study. While gaged data are available, modeled results from the RMJOC Climate Change Study were used to allow a direct comparison to modeled future climate change results that are provided in this section. More details on the use of modeled versus observed records are provided in Section

2.0. Monthly summary hydrographs representing the 10 percent (wet), 50 percent (average), and 90 percent (dry) exceedances are provided. In addition, active storage volume is provided on the figures where appropriate.

The end-of-month storage volumes shown on the graphs for Anderson Ranch Reservoir (Figure 3) and Arrowrock Reservoir (Figure 4) reflect active storage volume only. Dead storage volumes are not part of the storage volume values plotted. Dead storage cannot be released downstream for inflow use, but may be available for in-reservoir fish use.

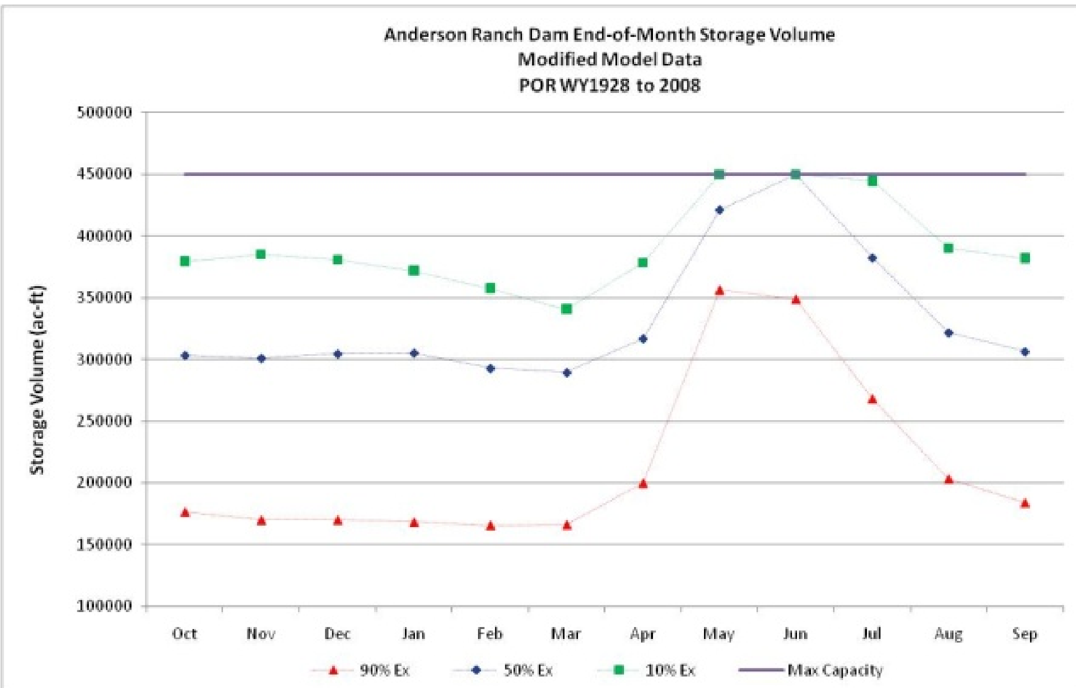

Figure 3. Anderson Ranch Reservoir end-of-month storage volume (acre-feet). Hydrographs for dry (90%), average (50%), and wet (10%) exceedances and maximum storage are shown using a period of record (POR) for water years (WY) 1928 to 2008. Storage volume represents active storage only.

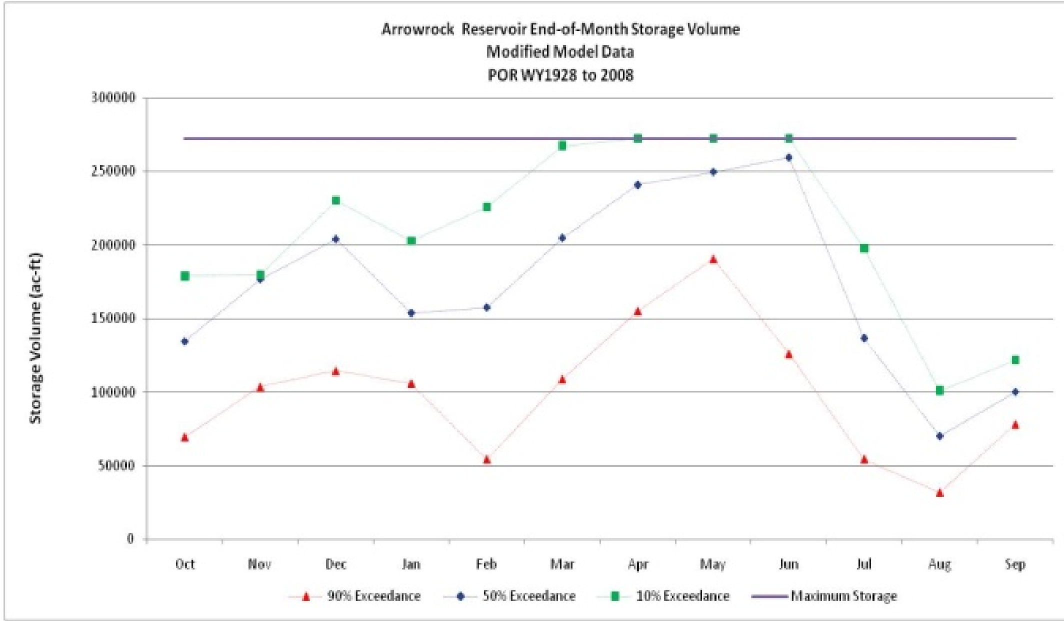

Figure 4. Arrowrock Reservoir end-of-month storage volume (acre-feet). Hydrographs for dry (90%), average (50%), and wet (10%) exceedances and maximum storage are shown using a period of record (POR) for water years (WY) 1928 to 2008. Storage volume represents active storage only.

In general, the figures indicate that during the largest exceedance events, storage volume reaches maximum capacity in May and June for Anderson Ranch Reservoir and April and May for Arrowrock Reservoir. Generally, drafting for irrigation initiates in June or July in both reservoirs. During the lowest storage exceedance levels, storage volume remains above 150,000 acre-feet in Anderson Ranch Reservoir and generally above 50,000 acre-feet in Arrowrock Reservoir, with the exception of August when the volume is slightly less than 50,000 acre-feet.

Figure 5 and Figure 6 reflect results using the full modeled period of record (1928 to 2008) compared to those from the more recent past (1980 to 2008). This comparison was made to better understand if climate change within the more recent past could be observed. The modified model was used so that effects of the 2010 level of operations could be observed between the two time periods. As these figures reflect, Anderson Ranch and Arrowrock reservoirs have experienced an increase in the large exceedance event discharges during the last 30 years.

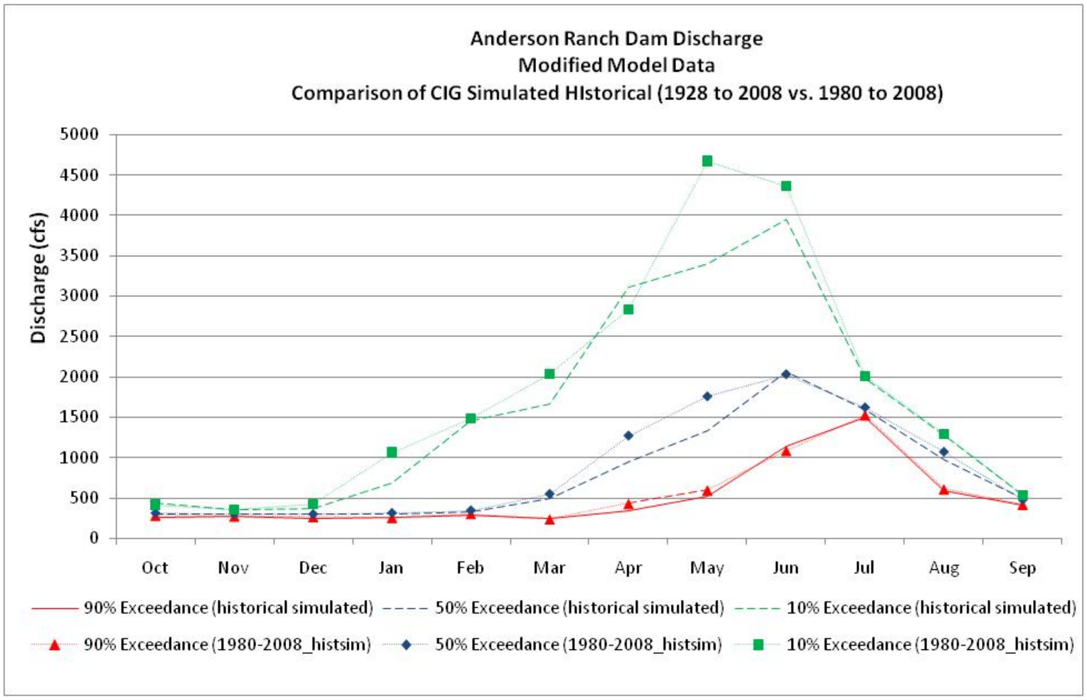

Figure 5. Anderson Ranch Dam discharge using CIG generated simulated historical comparing the period of record from 1928 through 2008 to 1980 through 2008. Hydrographs for dry (90%), average (50%), and wet (10%) exceedances are shown.

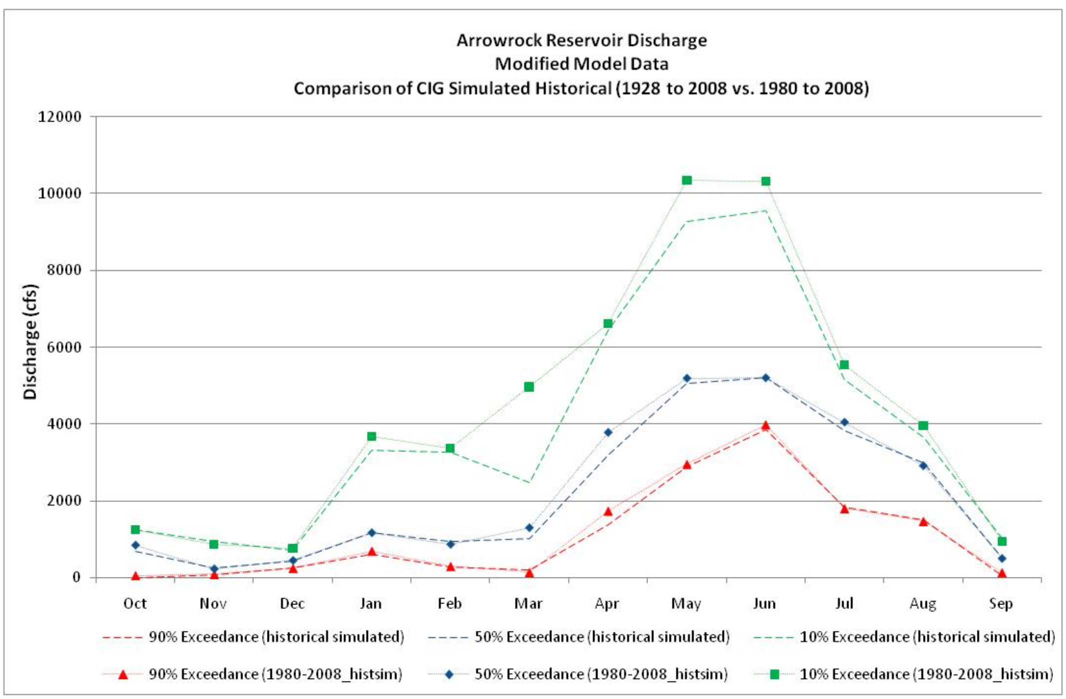

Figure 6. Arrowrock Reservoir discharge using CIG generated simulated historical comparing the period of record from 1928 through 2008 to 1980 through 2008. Hydrographs for dry (90%), average (50%), and wet (10%) exceedances are shown.

When comparing the 1980-2008 period to the 1928-2008 period, the greatest increase in modeled discharges occurs in May for both Anderson Ranch and Arrowrock dams and is most pronounced at the 10-percent exceedance level. This may suggest that there has been a slight shift of inflows to earlier in the year in the 1980 to 2008 period. This shifting of inflows would cause an earlier refill of the reservoirs, which would require greater discharges from the dams during May to prevent flooding. The 10-percent exceedance level represents wet years when the Boise River system reservoirs would refill completely.

The increase in discharges is not as great at the 50- or 90-percent exceedance levels when comparing the last 30 years to the full period of record. During these years, the conditions are drier and the reservoirs would not refill completely. There would be less of a change in discharges when comparing the two periods because there would not be the requirement to release water early for flood control. During the late summer and fall when the reservoirs are near their annual minimum elevations, Anderson Ranch Dam modeled discharges are nearly the same for all exceedance levels because the minimum discharge target of 300 cfs will almost always be met. At Arrowrock Dam, the discharges are less for the 90-percent exceedance level because the discharges would be very low to help keep Arrowrock Reservoir elevations above the minimum level. At the 50- and 10-percent exceedance levels, there would still be a small amount of water available in Arrowrock Reservoir to release to Lucky Peak Reservoir. There is very little difference when comparing the last 30 years to the full period of record.

Future Hydrology with Climate Change

Figure 7 and Figure 8 illustrate future hydrology obtained from the RMJOC Climate Change Study that was completed in 2011 (Reclamation 2011a, page 146). Figure 7 shows the end-of-month storage volume for Anderson Ranch Dam comparing the results of the UW CIG simulated historical record to the simulated future period. The Hybrid-Delta 2020 (HD 2020) future dataset was used for comparison because it best represented the period for which this biological assessment is being developed. As shown in Figure 7, both the 10- and 50-percent exceedance level storage volumes have increased from November through April likely due to increased snowmelt and liquid precipitation and higher temperatures due to climate change. The 10-percent exceedance receding limb (July through September) is projected to decrease at a faster rate than has historically occurred due to drier late summer conditions.

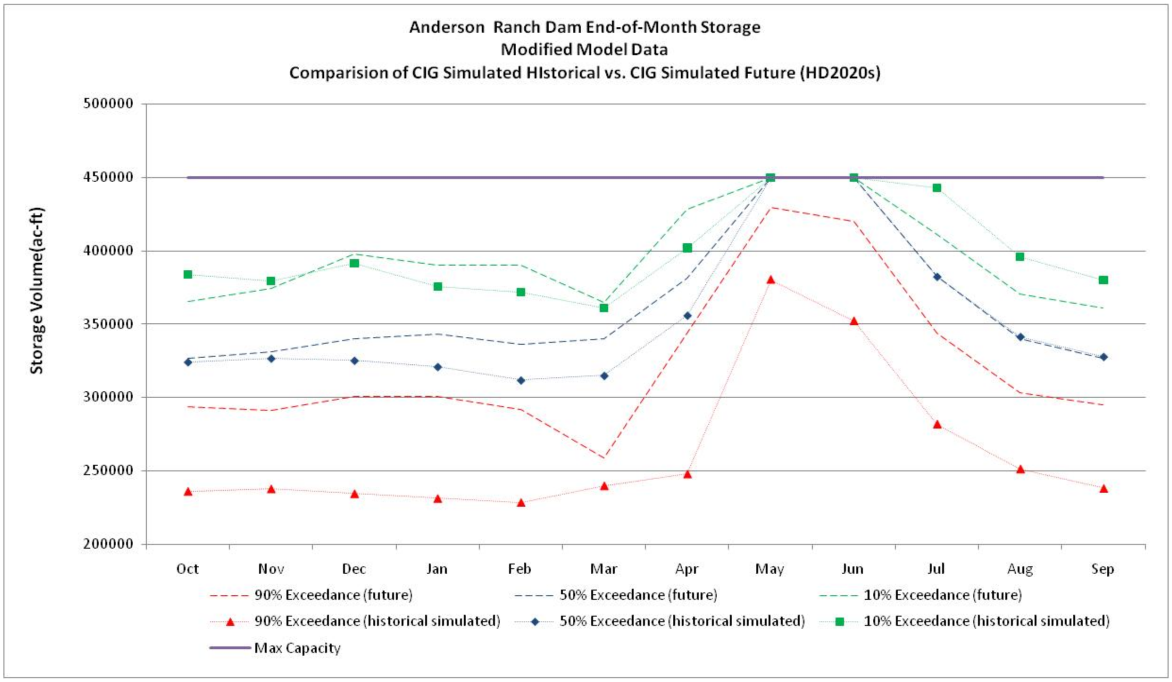

Figure 7. Anderson Ranch Dam end-of-month storage volume comparing CIG generated simulated historical (1928 to 2008) to the CIG HD 2020 simulated future climate change storage volume. Hydrographs for dry (90%), average (50%), and wet (10%) exceedances are shown. The CIG simulated storage is the average monthly discharge exceedances of the median of six future HD 2020 projections. Maximum capacity of 450,030 acre-feet is active storage volume and powerhead pool volume only.

A significant increase in available stored water is projected to occur in the 90-percent exceedance storage when the simulated future results are compared to simulated historical conditions. This projected increase in the lower exceedance level storage volume may be an artifact of selecting projections based on average changes in climate determined at the larger Columbia River Basin scale (see Reclamation 2011b, page 131) that were not retained when applied to the upper Snake River basin. Most of the climate change projections, excluding the warmer/drier future, used in the upper Snake River basin analysis generally showed wetter futures with larger inflow volumes.

Figure 8 reflects the discharge from the Anderson Ranch Dam for both the simulated historical period and the future climate change projection. In general, the discharges for all exceedence levels are generally higher during the spring when inflows are shown to be increasing. Other than higher discharges in March through June (approximately), Anderson Ranch Dam discharge patterns is anticipated to remain similar to current conditions.

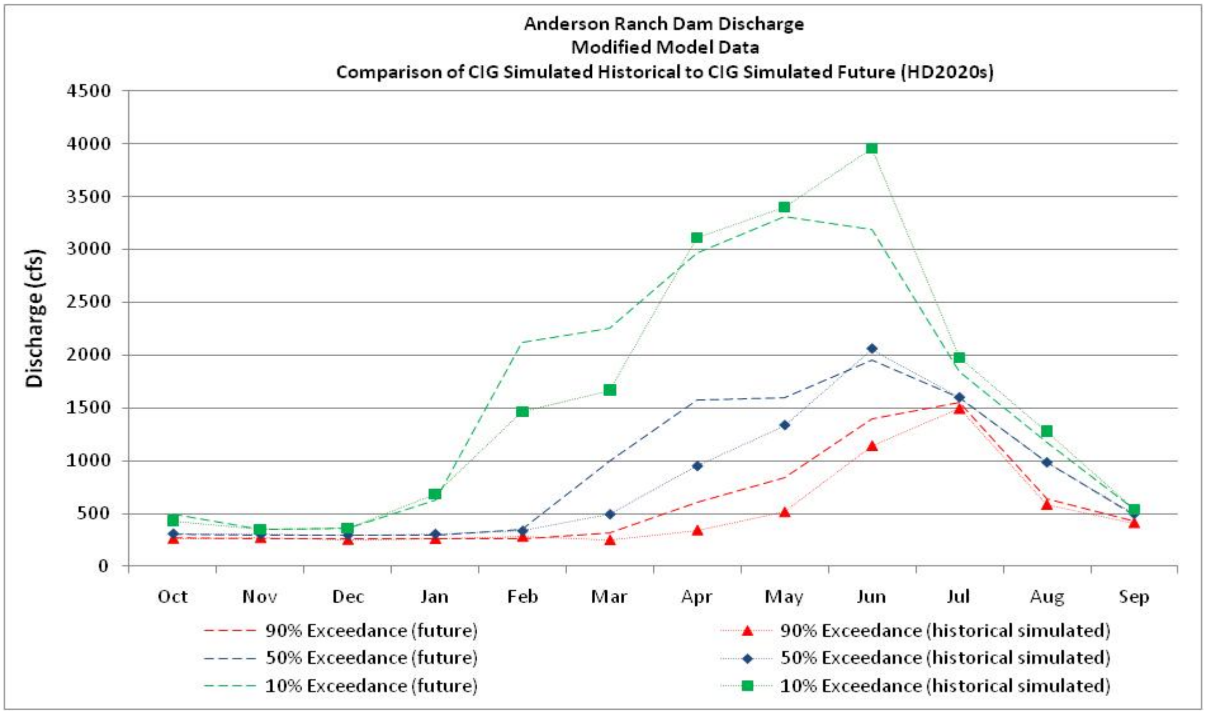

Figure 8. Anderson Reservoir discharge using CIG generated simulated historical and future datasets. Hydrographs for dry (90%), average (50%), and wet (10%) exceedances are shown. CIG simulated future flows were generated using the median of six future HD projections and then calculating the average monthly discharge exceedances.

Figure 9 and Figure 10 show Arrowrock Reservoir end-of-month storage volume and reservoir discharge, respectively, comparing water years 1928 to 2008 to the future period of 2020 to 2039 (HD 2020s). As with Anderson Ranch Dam, the end-of-month storage pattern of spring volume exceeding historical volume in Arrowrock Reservoir can be observed. In the low water (90-percent exceedance level) periods when compared to historical conditions, a significant increase in storage volume appears in the spring months and again in the early summer (June, July, and August). This again is likely attributable to the projection method and projected changes in climate change described in the Anderson Ranch Dam discussion.

Figure 10 reflects the discharge from Arrowrock Reservoir for both the simulated historical period and the future climate change projection. In general, the discharges for all exceedence levels are generally higher during the spring when inflows are expected to be greater than historical rates. Even with higher discharges projected for January through April (approximately), future Arrowrock Dam discharge patterns are anticipated to remain generally similar to current conditions.

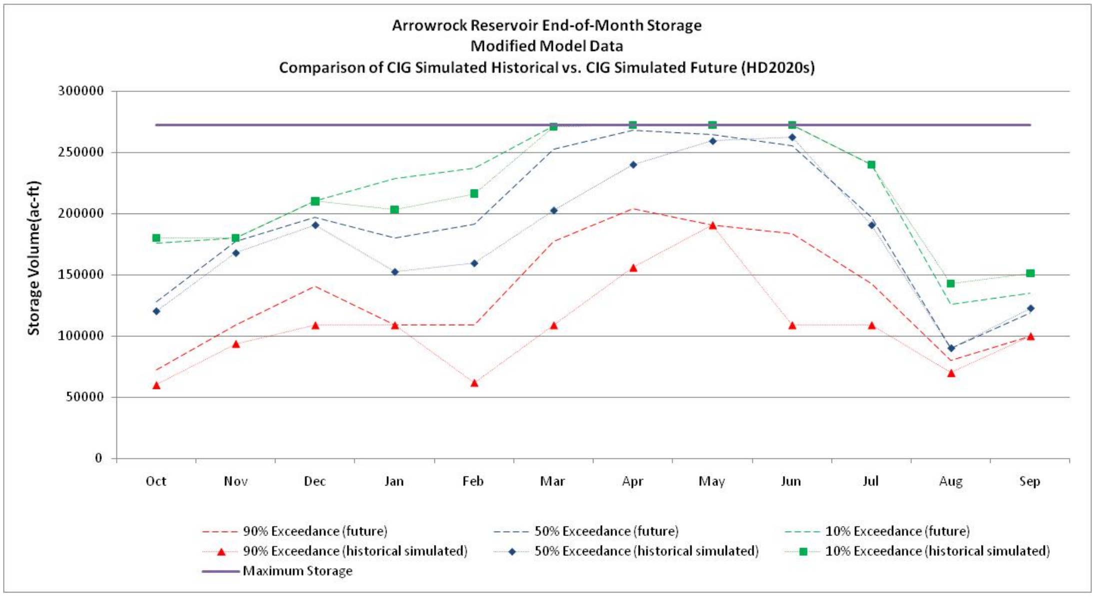

Figure 9. Arrowrock Reservoir end-of-month storage volume comparing CIG generated simulated historical (1928 to 2008) to the CIG HD 2020 simulated future climate change storage volume. Hydrographs for dry (90%), average (50%), and wet (10%) exceedances are shown. The CIG simulated storage is the average monthly discharge exceedances of the median of six future HD 2020 projections. Maximum capacity of 272,224 acre-feet is active storage volume only.

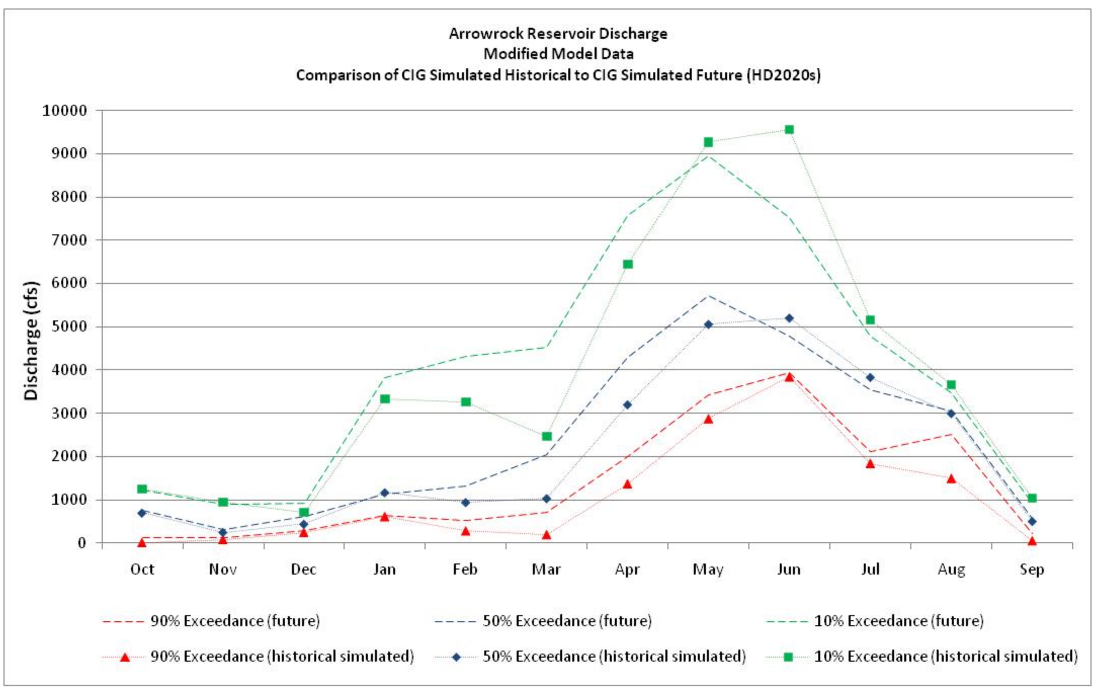

Figure 10. Arrowrock Reservoir discharge using CIG generated simulated historical and future datasets. Hydrographs for dry (90%), average (50%), and wet (10%) exceedances are shown. CIG simulated future flows were generated using the median of six future HD projections and then calculating the average monthly discharge exceedances.

4.3.2 Baseline Population Status and Trends

The 2004 Upper Snake BA and 2005 USFWS BiOp described conditions in the Boise River system action areas through 2004. Table 5 shows the studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to the Boise River system action areas. Stable or slightly increasing population trends have been documented in the South Fork Boise River basin above Anderson Ranch Reservoir (USFWS 2008c) and the adfluvial population in the Boise River Basin above Arrowrock Reservoir (Reclamation 2012).

Table 5. Pertinent studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to the Boise River system action areas.

Date	Reference	Title
2008	Monnot et al. 2008	Influences of Body Size and Environmental Factors on Autumn Downstream Migration of Bull Trout in the Boise River, Idaho
2008	USFWS 2008a	5-Year Review: Summary and Evaluation for Bull Trout
2008	USFWS 2008b and USFWS 2008c	Core Area Assessments
2007	Cannon 2007	Measure gas saturation in South Fork Boise River following drawdown from Anderson Ranch Dam
2006, 2008, 2010, 2012, ongoing every two years	Reclamation 2012	Lucky Peak Reservoir Trap-and-Haul
2010	Reclamation 2011c	Arrowrock Hydro plant begins operations.
2010	USGS/Reclamation internal data	Intragravel habitat conditions in South Fork Boise River
Start 2011-ongoing	Reclamation internal data	Habitat surveys in varial zones for Arrowrock and Anderson Ranch reservoirs
Start 2011-ongoing	Reclamation 2012	Arrowrock Reservoir fish sampling and water quality monitoring, bull trout movement
Start 2011-ongoing	Reclamation 2012	Boise River weirs
2011	Battelle 2011	Using the Sensor Fish to Assess Fish Passage Survival through Arrowrock Dam and Arrowrock Dam Hydroelectric Project, Boise, Idaho.
2011	Normandeau Associates 2011	Assessment of Direct Survival/Injury of Fish Passing Through the Arrowrock Dam and Arrowrock Dam Hydroelectric Project, Boise, Idaho

The most relevant studies, monitoring, or reports mentioned in Table 5 include results from current fish sampling in Arrowrock Reservoir and the South Fork Boise River downstream of Anderson Ranch Dam as part of efforts to address T&Cs 2.a. and 2.b. Although the summary reports are not complete, preliminary data summaries where applicable are included in the PCE descriptions.

4.3.3 Baseline Critical Habitat Conditions

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Anderson Ranch Reservoir

PCE 1 is present, but provides a limited contribution to FMO habitat in Anderson Ranch Reservoir. In reservoir environments, subsurface connectivity and thermal refugia are a function of several factors including thermal stratification within the reservoir, tributary inflow, wetland influence, and groundwater recharge. In deep reservoirs such as Anderson Ranch, the process of thermal stratification tends to be the primary driver of thermal refugia rather than seeps, springs, or groundwater influence which does not appear to provide a significant contribution to FMO habitat in the reservoir. The topography along both sides of the reservoir is steep which limits the influence of off-channel habitat; however, there are small areas of wetlands associated with the mouth of the South Fork Boise River. High to full pool levels in the reservoir result in groundwater storage (recharge) that is later released as reservoir levels drop during irrigation water withdrawals. Generally, this groundwater release does not play a significant role in contributing to cold water refugia within the reservoir.

Subsurface connectivity between cold water refugia in the reservoir and tributary habitats may be limited by the condition of tributaries that are outside the action area. Many tributaries in the South Fork Boise River basin may exceed cold water biota standards during summer months. The role of springs, seeps, or groundwater from these unmanaged tributaries on cold water refugia in the reservoir is unknown. Generally, the significance of spring seeps and groundwater sources are greater in the headwater areas where they have more contribution to the total flow than farther downstream (Wehrly et al. 2006).

South Fork Boise River

PCE 1 is present, but provides a limited contribution to FMO habitat in the South Fork Boise River. There are 24 tributaries in the South Fork Boise River between Anderson Ranch and Arrowrock reservoirs that contribute an approximate annual average of 108 cfs or 18 percent of the annual flow of the mainstem South Fork Boise River. In addition to hyporheic exchange, there are multiple areas of riparian springs and seeps that contribute to cold water refugia in the South Fork Boise River (USGS and Reclamation 2009, unpublished)

Arrowrock Reservoir

PCE 1 is present, but provides a limited contribution to FMO habitat in Arrowrock Reservoir. Like Anderson Ranch Reservoir, thermal refugia in Arrowrock Reservoir are primarily a function of thermal regimes within the reservoir. From June through September, the lower strata of the reservoir warm, limiting the function of thermal refugia. Most adult and subadult bull trout migrate to tributary habitats at these times (Salow 2005 and Maret and Schultz 2013). Groundwater influence, on the other hand, does not appear to provide a significant contribution to FMO habitat in Arrowrock Reservoir. The topography along both sides of the reservoir is steep which limits the influence of off-channel habitat. High to full pool levels in the reservoir result in groundwater storage (recharge) that is later released as reservoir levels drop during irrigation water withdrawals. Generally, this groundwater release does not play a significant role in contributing to cold water refugia within the reservoir.

Subsurface connectivity between cold water refugia in the reservoir and tributary habitats may be limited by tributary conditions. Many tributaries in the Boise River basin may exceed cold water biota standards during summer months. The role of springs, seeps, or groundwater on cold water refugia where tributaries enter Arrowrock Reservoir is unknown. Generally, the significance of spring seeps and groundwater sources are greater in the headwater areas where they have more contribution to the total flow than farther downstream (Wehrly et al. 2006)

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including, but not limited to, permanent, partial, intermittent, or seasonal barriers.

Anderson Ranch Reservoir

PCE 2 is present and functional and contributes to FMO habitat in Anderson Ranch Reservoir. Adult and subadult bull trout are present in the reservoir year-round, although the majority leaves during May and June and return in November (Partridge et al. 2001). The South Fork Boise River is the only tributary to Anderson Ranch Reservoir that migratory bull trout are known to use. Migration habitat in the spring is in good condition with no known impediments for fish migrating out of the reservoir to upstream spawning or FMO habitats. Migration habitat in the fall experiences a reduction of diversity, but remains functional when bull trout return after spawning. In most years, the length of the varial zone during the fall migration period will vary from 0.7 to 2.9 miles (1.06 to 4.61 kilometers), depending on the pool elevation. Pool elevations are categorized by 10-, 50-, and 90-percent exceedance levels (Figure 8).

Further, the utility of PCE 2 in Anderson Ranch may be affected by upstream conditions outside of the action area. Approximately 25 percent of tributaries in the basin have barriers to migration due to culverts and land management activities (USFWS 2008c). As a result, only the South Fork Boise River is likely to be used by adfluvial bull trout from Anderson Ranch Reservoir (USFWS 2008c and Partridge et al. 2001).

South Fork Boise River

PCE 2 is present above and below Anderson Ranch Dam and contributes to FMO habitat in the South Fork Boise River; however, the dam is not equipped with fish passage facilities. Anderson Ranch Dam is a barrier, isolating populations of bull trout above and below the dam. Both populations have access to adequate spawning and rearing habitat. Downstream of Anderson Ranch and in the South Fork Boise River, the migration corridor remains functional. These populations spawn in the Middle Fork Boise River (see discussion under Arrowrock Reservoir). Above Anderson Ranch Dam, the bull trout spawn in the South Fork Boise River (see discussion in Anderson Ranch Reservoir). Outside of the Boise River system action area, seasonal impediments may exist between tributaries and the South Fork Boise River due to land management practices such as livestock grazing, road sedimentation, irrigation withdrawals on private lands, and road culverts (Burton 1999; IDEQ 2008, page 12).

Arrowrock Reservoir

PCE 2 is present in and contributes to FMO habitat in Arrowrock Reservoir. Adult and subadult bull trout over-winter in the reservoir, although the majority leaves between February and June toward their spawning locations and return to the reservoir in November (Salow 2004). An estimated 2 percent of the adfluvial population (subadult sized fish) remain in Arrowrock Reservoir during the summer months (USFWS 2005a, page 252); however, the U.S. Geological Survey (USGS) conducted an acoustic telemetry study on subadult sized bull trout in 2012 and documented that all tagged fish left the reservoir during the summer season (Maret and Schultz 2013).

The Arrowrock Reservoir adfluvial population of bull trout spawns in headwater tributaries of the North Fork and Middle Fork Boise rivers (Salow 2005), but exhibits a diversity of over-wintering behaviors. A portion of the population over-winters in the reservoir while others use the South Fork Boise River, and some fish use both habitats. Fish that over-winter in the South Fork Boise River will spawn in the North Fork and Middle Fork Boise rivers because migration is blocked by the presence of Anderson Ranch Dam.

The migration habitat in the spring is in good condition with no migration impediments occurring during the spring migration period for fish migrating out of the reservoir to spawning habitat. The migration zone experiences a reduction of structural diversity in the fall, but remains functional when bull trout return to FMO habitat after spawning. In most years, the length of the varial zone during the fall migration period will vary between 3.2 and

5.6 miles (5.11 and 9.00 kilometers) in length for the Middle Fork Boise and between 4.0 and 6.8 miles (6.47 and 10.88 kilometers) in the South Fork Boise River. Varial zone lengths are calculated using pool elevations categorized by 10-, 50-, and 90-percent exceedance level scenarios (Figure 7); however, these estimated lengths correspond to the lowest potential pool elevation for each scenario. Telemetry data confirms that bull trout migrate over the course of several months during which time the habitat complexity (PCE 4) is increasing as the reservoir is continuously refilling. While there is often physical connectivity in varial zones, these areas often lack the complexity of upstream habitats, exposing migrating bull trout to an increased risk of predation (Salow 2005). In the 2005 USFWS BiOp, USFWS identified that when reservoir elevation is below 3100 feet, migrating bull trout may be more susceptible to predation.

Arrowrock Dam isolates a population of adfluvial bull trout and is a barrier to upstream migration. For bull trout entrained out of the reservoir, the dam is not equipped with fish passage facilities. Bull trout that may be present in Lucky Peak Reservoir are believed to have been entrained from Arrowrock Reservoir. To mitigate for entrainment of bull trout from Arrowrock Reservoir (T&C 1.d.; USFWS 2005a), Reclamation traps these bull trout in Lucky Peak Reservoir and hauls them around the dam, releasing them back into the adfluvial population in Arrowrock Reservoir. Since 2005, additional studies have documented lower entrainment rates than previously suspected. The number of bull trout captured during trap-and-haul efforts since 2005 averages three fish (Reclamation 2012).

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Anderson Ranch Reservoir

PCE 3 is present in and contributes to FMO habitat in Anderson Ranch Reservoir. The species composition of Anderson Ranch Reservoir indicates a diversity of fish species and age classes including at least seven species of native fishes and five nonnative species that are commonly captured during sampling events (IDFG 2013a). In the reservoir, the nitrogen and phosphorus ratio (TN:TP) is well balanced at 15.15, indicating suitable forage zooplankton and other aquatic invertebrates as food sources (see Appendix B). Based on the most recent fish sampling conducted by IDFG and water quality conditions an abundant food base is available for migratory bull trout that use Anderson Ranch Reservoir for FMO habitat.

South Fork Boise River

PCE 3 is present in and contributes to FMO habitat the South Fork Boise River. Species composition encountered during IDFG monitoring includes a diversity of age classes of sculpins, dace, kokanee, and rainbow trout, all of which provide forage for bull trout. Young-of-year rainbow trout surveys conducted by IDFG show good recruitment and a good diversity of prey fishes within the Boise River system action area. Anderson Ranch Reservoir limits the recruitment of some nutrients into the South Fork Boise River (Appendix B); however, tributaries provide a source of nutrients at levels sufficient to support a food base for bull trout and prey fishes.

Reclamation is conducting studies in the Boise River system action area to determine effects of ramping on aquatic habitat and stranding. The general health (condition factor) of bull trout from the Arrowrock Reservoir metapopulation shows average or above average health, indicating suitable prey availability (Reclamation internal data). The Arrowrock Reservoir adfluvial population is considered a metapopulation comprised of fish from different spawning locations that mix within Arrowrock Reservoir and the South Fork Boise River action areas.

Arrowrock Reservoir

PCE 3 is present in and contributes to FMO habitat in Arrowrock Reservoir. Fish species composition encountered during IDFG monitoring indicates a diversity of fish species and age classes, including over seven species of native fishes and five nonnative species that are commonly captured during sampling events. These provide an abundance of forage fish for bull trout (Reclamation 2012). A condition factor analysis was performed for all fish species sampled in the Reservoir in 2011 and the four most abundant fish species and bull trout all showed positive growth while in the reservoir (Seo 2013 in draft). Although water quality conditions were thought to seasonally limit the prey base for bull trout in Arrowrock Reservoir (USFWS 2005a), recent data for water quality (Appendix B) and fish sampling (Reclamation internal data) suggests that the prey base for all species of fishes is sufficient to maintain an average or above condition factor for bull trout that use the reservoir for FMO habitat.

Operational indicators for Arrowrock Reservoir (Table 3) were developed to protect critical habitat by slowing the rate of drawdown during late June after the reservoir has refilled. The criteria aim to keep Arrowrock Reservoir storage at or above 200,000 acre-feet at the end of June in 90 percent of the years. This period corresponds with the longest duration of daylight and higher reservoir volumes. During this time, there are suitable conditions for zooplankton production in the shallower warmer parts of the reservoir.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes, that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths gradients velocities and structure.

Anderson Ranch Reservoir

PCE 4 is present in and contributes to FMO habitat in Anderson Ranch Reservoir. Reservoir depth and shallow shoreline habitat provides the most significant habitat complexity and contribution toward FMO habitat. Depth allows temperature (PCE 5) and water quality conditions (PCE 8) to support bull trout use when they are known to be present. Shallow shoreline habitat allows increased primary productivity (PCE 3) that supports a diversity of prey fishes.

Habitat conditions of the watersheds that enter Anderson Ranch Reservoir have been impacted by wildfire, floods, and multiple land uses (USFWS 2008c), all contributing to a decreased complexity of reservoir habitat during drawdown conditions. Drawdowns expose the varial zone of the tributaries within Anderson Ranch Reservoir. Habitat complexity is affected by changing the habitat features from a reservoir environment to a river type environment. A habitat survey was conducted in 2011 to quantify habitat variables in the varial zone within the reservoir (Prisciandaro 2012). Although the river habitats in the varial zone are different from those in the reservoir and degraded from unregulated systems, they still offer a variety of environments that could be used by bull trout. While complexity is limited when reservoirs are drawn down, depth refugia are still available.

South Fork Boise River

PCE 4 is present in and contributes to FMO habitat in the South Fork Boise River. A wide range of habitats occur in the 26.0 miles (41.8 kilometers) of the South Fork Boise River (work scheduled to occur by Reclamation from 2012 through 2014 will characterize habitat within this section). Bull trout are known to select the South Fork Boise River for over-wintering (Salow and Hostetler 2002) while some individuals reside in the river throughout the year only leaving to migrate to spawning locations. The river lacks recruitment of sediment and large woody material from sources upstream of Anderson Ranch Dam, but recruits sediment and large woody material from sources within the action area. Preliminary data being collected to address T&Cs (USFWS 2005a) suggests that diverse aquatic habitats are present within the Boise River system action area. The hydrograph is regulated, but produces a spring season high water peak that redistribute materials transported from unregulated tributaries throughout the Boise River system action area. Consistent summer flows have allowed a riparian area to become well established. The established riparian zone provides a number of benefits including, but not limited to, shading (thermal refugia), overhead cover, recruitment of large woody material, input of terrestrial prey, bank stability, and undercut banks.

Arrowrock Reservoir

PCE 4 is present in and contributes to FMO habitat in Arrowrock Reservoir. Reservoir depth and shallow shoreline habitat (maximized at higher storage volumes) provides the most significant contribution toward FMO habitat. Depth allows temperature (PCE 5) and water quality conditions (PCE 8) to support PCE criteria during all but the summer months. Shallow shoreline habitat allows increased primary productivity (PCE 3) that supports a diversity of prey fishes. Habitat conditions of the watersheds that enter Arrowrock Reservoir have been impacted by wildfire, floods, and multiple land uses (USFWS 2008c), all contributing to a decreased complexity of reservoir habitat during drawdown conditions. Drawdowns expose the varial zone of the tributaries within Arrowrock Reservoir. Habitat complexity is affected by changing the habitat features from a reservoir environment to a river type environment. A habitat survey was conducted in 2011 to quantify habitat variables in the varial zone within the reservoir (Prisciandaro 2012). Although the river habitats in the varial zone are different from those in the reservoir and degraded from unregulated systems, they still offer a variety of environments that could be used by bull trout.

Bull trout may reside in Arrowrock Reservoir throughout the year (Salow 2005), but often leave during the summer months as indicated by recent telemetry data (unpublished Reclamation records) and acoustic data (Maret and Schultz 2013).

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Anderson Ranch Reservoir

PCE 5 is present in and contributes to FMO habitat in Anderson Ranch Reservoir. Bull trout typically over-winter in Anderson Ranch Reservoir, migrating out in late spring and returning to the reservoir in November to over-winter. Water temperatures between 2° and 15° C are available throughout the year. Summer temperatures at the surface can be as high as 22° C while the temperatures near the bottom of the reservoir remain relatively constant between 4° and 5° C. As the water warms and the reservoir becomes stratified, the deeper portions of the water column become depleted of oxygen, but there is a thermal and oxygen refugia between 5 and 10 meters below the surface elevation during these months to support any bull trout that may remain in the reservoir. These are illustrated with the monthly average temperature profiles for Anderson Ranch Reservoir from April through August (Figure 11) and August through December (Figure 12).

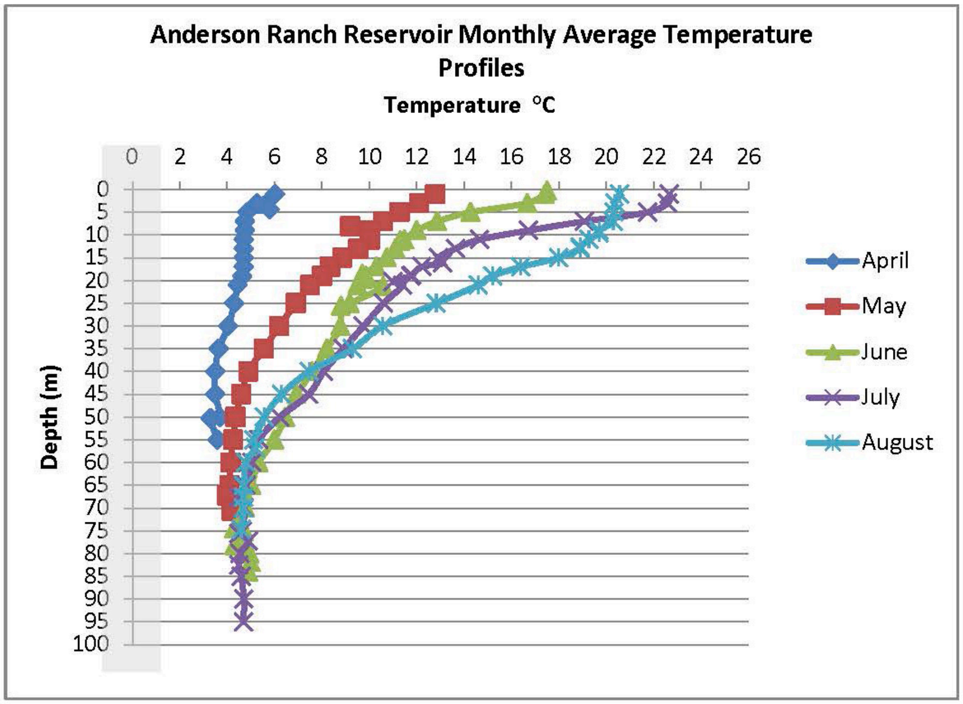

Figure 11. Monthly average temperature profiles of Anderson Ranch Reservoir, April through August.

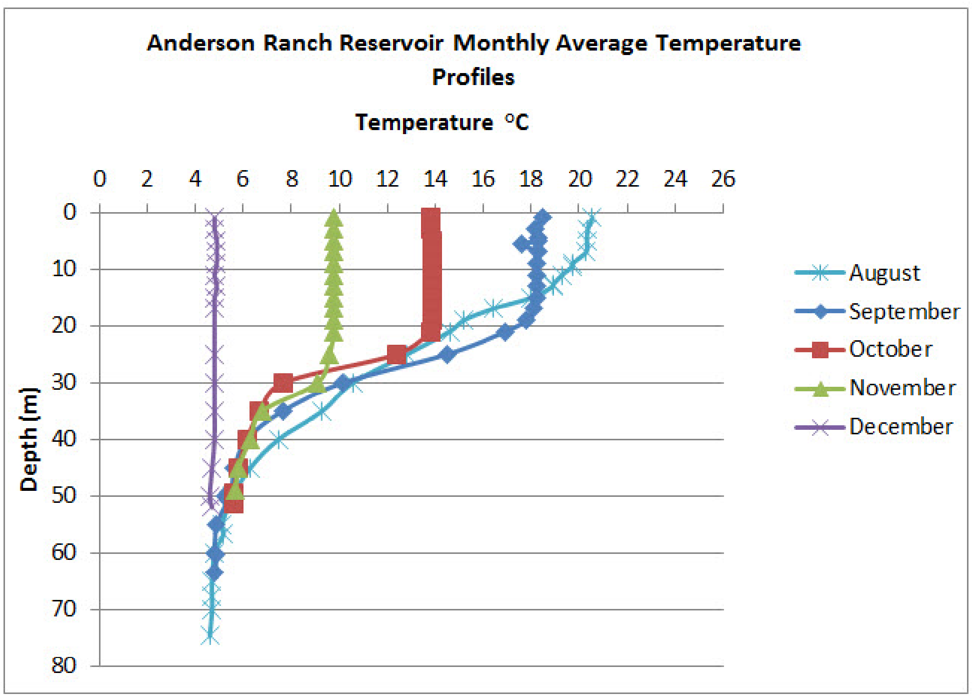

Figure 12. Monthly average temperature profiles of Anderson Ranch Reservoir, August through December.

Operational indicators for Anderson Ranch Reservoir have been developed to protect critical habitat by minimizing the frequency of drawdown below 62,000 acre-feet to 2 of 30 years (Table 3). These criteria aim to protect water quality (including water temperature) during periods of hot and dry weather. Deeper water habitat in the reservoir helps to maintain cold water refugia during periods when thermal refugia are not otherwise available (Figure 11 and Figure 12).

South Fork Boise River

PCE 5 is present in and contributes to FMO habitat in the South Fork Boise River. Water releases at Anderson Ranch Dam occur from the middle/lower water column in the reservoir except when spilling occurs occasionally in the spring. The South Fork Boise River temperatures at the top of the action area are directly related to the temperatures in the middle/lower water column of the reservoir. The midline of the intake structures to the dam ranges from 85 feet deep (26 meters) at 62,000 acre-feet to 196 feet deep (60 meters) at full pool. Generally the reservoir keeps the river temperature warmer in the winter and cooler in summer compared to unregulated tributaries above the dam. Releases from Anderson Ranch Reservoir remain at a relatively constant temperature between 4° and 6° C from January through June. By early June, the reservoir stratification breaks down and water begins to mix, resulting in river release temperatures slowly increasing until early September when it reaches its average maximum temperature of 13° C. The reservoir attenuates the daily and seasonal fluctuations in temperatures as compared to the South Fork Boise River above the reservoir.

Figure 13 illustrates the daily maximum temperatures of the South Fork Boise River in the Boise River system action area below Anderson Ranch Dam as well as the modulating effect of the reservoir.

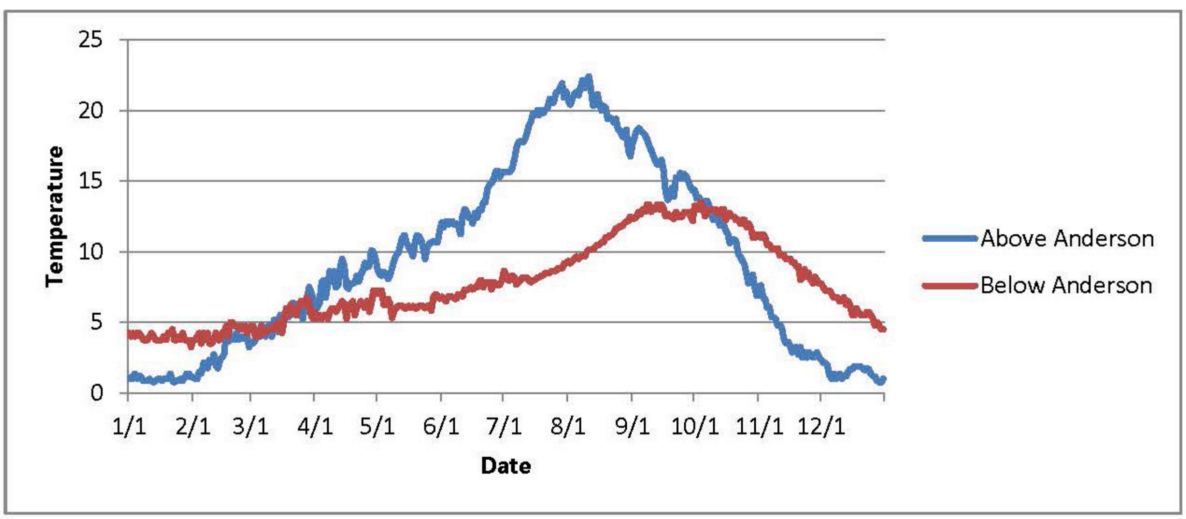

Figure 13. Daily maximum temperatures of the South Fork Boise River above and below Anderson Ranch Dam.

The regulating effect of the reservoir appears to extend downstream, as indicated by recent monitoring at Neal Bridge near the inflow to Arrowrock Reservoir, but is dependent on shade and groundwater mediating the impacts from solar loading. At Neal Bridge (28.1 miles [45.2 kilometers] downstream from Anderson Ranch Dam), stream temperatures fluctuate between 4° and 6° C from January through early March. By early June, the reservoir discharge keeps the river cool, below 15° C until late August. Maximum temperatures are reached in early September and peak near 16° C, above the PCE criterion for just a few days. In comparison, the Middle Fork Boise River without an upstream impoundment exceeds 15° C by the end of June and reaches maximum temperatures of over 21° C near the end of July.

Figure 14 illustrates the daily maximum temperatures of the South Fork Boise River at Neal Bridge as well as the comparison to the Middle Fork Boise River near Twin Springs, a similar unregulated stream nearby.

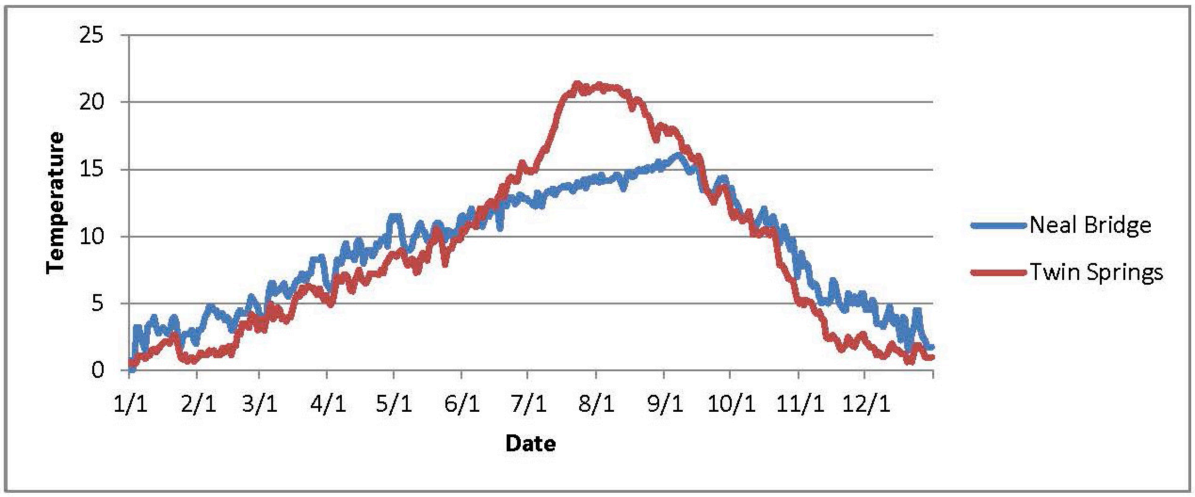

Figure 14. Daily maximum temperatures of the South Fork Boise River at Neal Bridge and the Middle Fork Boise River at Twin Springs.

Arrowrock Reservoir

PCE 5 is present in and contributes to FMO habitat in this area. Bull trout typically over-winter in Arrowrock Reservoir and typically move out of the reservoir January through June. January through April profiles indicate that the reservoir is isothermal with temperatures between 2° and 7° C (Figure 15) after which it gradually warms and begins to stratify, exceeding the PCE criteria of 15° C by the end of June. In August and September, the reservoir begins cooling and becomes isothermal with water temperatures below 14° C by October and down to about 4° C by December (Figure 16).

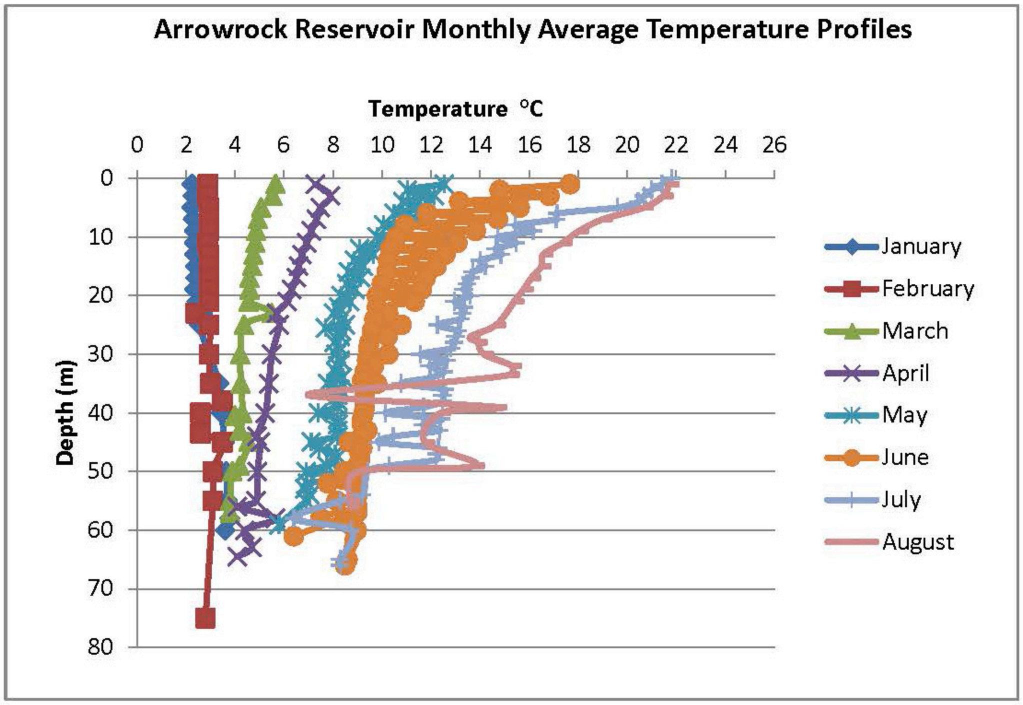

Figure 15. Monthly average temperature profiles of Arrowrock Reservoir, January through August.

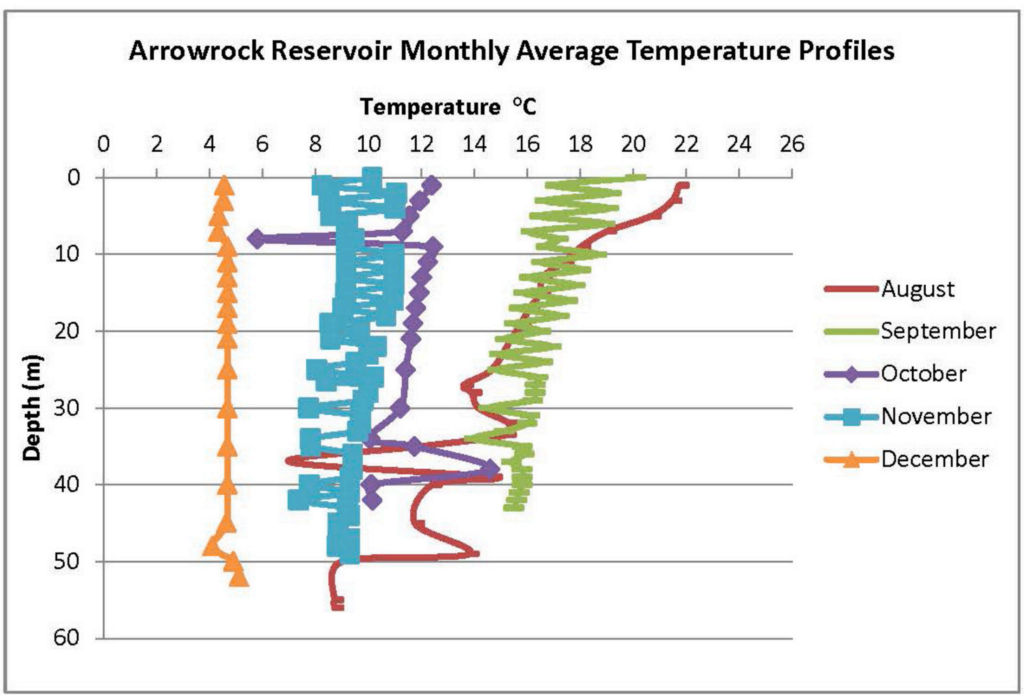

Figure 16. Monthly average temperature profiles of Arrowrock Reservoir, August through December.

An estimated 2 percent of the adfluvial population (subadult sized fish) remain in Arrowrock Reservoir during the summer months (USFWS 2005a, page 252); however, USGS conducted an acoustic telemetry study on subadult sized bull trout in 2012 and documented that all tagged fish left the reservoir by the end of June (Maret and Schultz 2013). The average summer temperature near the surface was over 21° C, with temperatures near the bottom relatively constant between 6° and 8° C. Oxygen was depleted below 16 feet (5 meters) in August and 26 feet (8 meters) in September so, unlike Anderson Ranch Reservoir, no area of thermal and oxygen refugia exists. Migration corridors are open throughout the year for fish to move between the reservoir and riverine environments; however, water temperatures in tributaries also exceed thermal targets except for the South Fork Boise River. Deep water releases from Anderson Ranch Dam provide thermal refugia in the South Fork Boise River during summer months.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present in any areas evaluated in this chapter (75 FR 63898).

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is a natural hydrograph including peak, high, low, and base flows, or if flows are controlled, minimal flow departure from a natural hydrograph. PCE 7 addresses the amount and timing of stream flow, a characteristic that is by definition not present in a reservoir environment. As a result, PCE 7 is not present in Anderson Ranch or Arrowrock reservoirs.

South Fork Boise River

PCE 7 is present in and provides a limited contribution to FMO habitat in this area. Generally, there is an altered hydrograph characterized by flows that are higher in the winter, generally lower during the spring peak, and higher during the summer when flows are held artificially high from irrigation deliveries. The effects of lower spring releases on stream discharge are attenuated by tributary inflows from 24 separate tributaries, starting with Dixie Creek located 1.8 miles (2.9 kilometers) from the base of the dam. The hydrograph, although varying from natural, currently provides for adequate foraging, connectivity, and over-wintering habitat.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Anderson Ranch Reservoir

PCE 8 is present in and contributes to FMO habitat in this area. Water quality and quantity allows adult and subadult bull trout to use Anderson Ranch Reservoir as FMO habitat throughout the year. The water quality and quantity in Anderson Ranch Reservoir is generally good, but may show seasonal limitations when severe drawdowns (below 62,000 acre-feet) occur. The reservoir is classified as oligotrophic, indicating that a nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir. Suitable water temperatures (PCE 5) and dissolved oxygen levels exist in the reservoir throughout the year (see Appendix B). Sediment and turbidity levels are typically very low and should not impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity. Water quality and quantity is adequate to allow the prey base (fish, aquatic invertebrates, and zooplankton) to remain at sufficient levels to support bull trout. The TN:TP ratios indicate that blue green algae and other unpalatable forms of nitrogen-fixing algae should not dominate the reservoir as nitrogen is common. Furthermore, the types of algae that are often associated with the observed TN:TP ratios should provide suitable forage for zooplankton and other aquatic invertebrates.

South Fork Boise River

PCE 8 is present in and contributes to FMO habitat in this area. Water quality and quantity allows bull trout to use the South Fork Boise River as FMO habitat throughout the year. The water quality and quantity in the South Fork Boise River meets targets for Idaho water quality standards for cold water biota throughout the year. Nutrients are retained in Anderson Ranch Reservoir during most of the year, but nutrient levels are within the range expected in the intermountain xeric west (Appendix B). Suitable water temperatures and dissolved oxygen levels exist throughout the year. Sediment and turbidity levels are typically very low and should not impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity. Water quality and quantity is adequate to allow the prey base (fish, aquatic invertebrates, and zooplankton) to remain at sufficient levels to support bull trout.

Bull trout in the South Fork Boise River action area are part of the Arrowrock Reservoir metapopulation and show an average or above average condition factor (Seo 2013 in draft), suggesting suitable water quality and quantity for bull trout and the bull trout prey base (PCE 3). Reclamation is conducting work in the Boise River system action area to determine effects of ramping on aquatic habitat and stranding; work is expected to be completed in fiscal year (FY) 2015.

Arrowrock Reservoir

PCE 8 is present in and contributes to FMO habitat in this area. Water quality and quantity allow adult and subadult bull trout to over-winter in Arrowrock Reservoir, but does show seasonal limitations during the summer months. The reservoir is classified as oligotrophic, indicating that a nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir. Water temperatures and dissolved oxygen levels may also show seasonal limitations in August and September (see Appendix B). Sediment and turbidity data is limited, but shows seasonal limitations typically in September; however, not at levels that should impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity. Water quality and quantity is adequate to allow the prey base (fish, aquatic invertebrates and zooplankton) to remain at sufficient levels to support bull trout. The TN:TP ratios indicate that blue-green algae and other unpalatable forms of nitrogen-fixing algae should not dominate the reservoir as nitrogen is common; however, they could begin to dominate the reservoir in August when nitrogen is limited. The types of algae that are often associated with TN:TP ratios such as these may not be suitable forage for zooplankton and other aquatic invertebrates.

An estimated 2 percent of the adfluvial population (subadult-sized fish) remain in Arrowrock Reservoir during the summer months (USFWS 2005a, page 252); however, the USGS conducted an acoustic telemetry study on subadult sized bull trout in 2012 and documented that all tagged fish left the reservoir by the end of June (Maret and Schultz 2013). Bull trout return to Arrowrock Reservoir after spawning. For the majority of fish, the post-spawn migration occurs after the water quality conditions described earlier have returned to target levels. Because most, if not all, bull trout leave the reservoir during the summer months, water quality conditions are believed to not affect bull trout directly, but may impact the prey base (USFWS 2005a).

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Fish stocking and management of fish populations within the State of Idaho is regulated by the IDFG.

Anderson Ranch Reservoir

PCE 9 is present, but provides a limited contribution to FMO habitat in Anderson Ranch Reservoir. Nonnative fishes are currently present in Anderson Ranch Reservoir include rainbow trout, Chinook salmon, smallmouth bass, yellow perch, common carp, and kokanee. Kamloop rainbow trout and kokanee have been stocked annually in Anderson Ranch

Reservoir since 2003. Young nonnative fish are prey for bull trout in Anderson Ranch Reservoir; however, adult rainbow trout, smallmouth bass, and Chinook salmon may prey on young bull trout. Kokanee provide a food base for bull trout. There is no evidence that stocked rainbow trout, smallmouth bass, and Chinook salmon are significant competitors with bull trout in the core area.

Interbreeding has been documented in the core area, bull trout x brook trout hybrids (Steed et al. 1998; BNF, in litt. 2003). In the South Fork Boise River drainage, brook trout occur in lower and middle Fall Creek, Salt Creek, Little Smoky Creek, Lick Creek, Five Points Creek, and Paradise Creek and are likely occur in other areas. Brook trout in the South Fork Boise River are thought to have originated from fish introduced in alpine lakes and stocked streams by State and Federal resource agencies and private individuals during the 1940s and 1950s.

South Fork Boise River

PCE 9 is present in and contributes to FMO habitat in the South Fork Boise River. Fish assemblages in the South Fork Boise River are dominated by native species. Diet overlap occurs with most species present in the Boise River system action area; however, smaller age classes are prey for bull trout. Spawning occurs outside of Boise River system action area, but hybridization with nonnative brook trout has been documented in the river basin (Steed et al. 1998).

Arrowrock Reservoir

PCE 9 is present, but provides a limited contribution to FMO habitat in Arrowrock Reservoir. Nonnative fishes currently present in Arrowrock Reservoir include rainbow trout, smallmouth bass, yellow perch, and kokanee. Stocking of game fishes has occurred annually since 1968 and Kamloop rainbow trout and kokanee have been stocked annually in Arrowrock Reservoir since 2004. Kokanee provide a food base for bull trout. Young nonnative fish are prey for bull trout in Arrowrock Reservoir, but adult rainbow trout may prey on subadult-sized bull trout. There is no evidence that stocked rainbow trout are significant competitors to bull trout in the core area. Spawning occurs outside of Boise River system action area; however, hybridization with nonnative brook trout has been documented in the river basin (Steed et al. 1998).

4.4 Effects of the Proposed Actions

4.4.1 Effects of the Proposed Action on Bull Trout

Reclamation has considered new information relevant to bull trout use of the Boise Project in the Boise River drainage available since the 2005 (Table 5). The new information provides more precise detail and data than was available previously; however, no new information exists that would indicate an effect of a different degree or nature than was previously considered in the 2004 Upper Snake BA and 2005 USFWS BiOp. Therefore, Reclamation has determined that the previous findings are still appropriate and there is no need to reinitiate consultation at this time for the species in this section.

4.4.2 Effects of the Proposed Action on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Anderson Ranch Reservoir

The operation of Anderson Ranch Dam will have discountable effects on PCE 1 within Anderson Ranch Reservoir. As noted previously, springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quantity or water quality in Anderson Ranch Reservoir. Although, reservoir operations may influence shallow groundwater exchange, the influence of this exchange is not of sufficient scale to influence thermal refugia in the reservoir as a whole.

South Fork Boise River

The operation of Anderson Ranch Dam will have insignificant effects on PCE 1 in the South Fork Boise River. Generally, reservoir operations (amount of discharge) have the potential to affect hyporheic exchange by changing groundwater residence time (Reclamation et al. 2011) or by diminishing the function of cold water refugia by releasing warm water. A functioning hyporheic influence persists under baseline conditions (USGS and Reclamation 2009 unpublished); however, to the extent increased flows may influence the groundwater exchange, reductions in hyporheic exchange are likely masked by the impacts of releasing of cold water from Anderson Ranch Reservoir.

Arrowrock Reservoir

The operation of Arrowrock Dam will have discountable effects on PCE 1 within Arrowrock Reservoir. As noted above, springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quantity or water quality in Arrowrock Reservoir. Although, reservoir operation may influence shallow groundwater exchange, the influence of this exchange is not of sufficient scale to influence thermal refugia in the reservoir as a whole.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Anderson Ranch Reservoir

Operation of Anderson Ranch Dam may have infrequent adverse effects on PCE 2 during the fall migration period in low water years when reservoir volumes drop below 62,000 acre-feet (in 2 of 30 years). These adverse effects would be the result of an increased length in the varial zone and lack of structural diversity within the varial zone. The length of the varial zone during the fall migration ranges from 0.7 to 2.9 miles (1.06 to 4.61 kilometers), but this range may be exceeded when the reservoir volume falls below 62,000 acre-feet in 2 of 30 years (Table 3).

Migration corridors in the spring are in good condition. No migration impediments occur during the spring migration period for fish migrating out of the reservoir to spawning habitat. Reservoir drawdowns can expose varial zones during the fall migration season in most years; however, connectivity is maintained at all times. The migration zone experiences a reduction of structural diversity in the fall. As structural diversity is reduced, the risk of predation increases. If predation increases to significant levels, it could pose a biological barrier.

Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 7).

A couple of factors minimize effects of the varial zone: 1) typical migration behavior (timing and rate of migration) and 2) reservoir operations during 28 of 30 years. Typical migration behavior (timing and rate of migration) of bull trout minimizes potential effects of moving through areas with reduced instream structure (from small headwater tributaries to over-wintering habitat). Reclamation data show bull trout typically migrate through varial zones at night and generally within a few hours (Reclamation internal data from Deadwood and Arrowrock Reservoirs). By moving through the varial zone in one evening, the migrating fish minimize risk of predation due to a lack of structural diversity within the varial zone.

Reservoir conditions within the range of the operational indicators have been shown to provide habitat conditions suitable for bull trout to migrate through the varial zone in one evening. It is assumed that during 2 of 30 years fish may not be able to migrate through the varial zone in one evening because of the increased length of the varial zone or water depth impediments restricting the migration corridor.

Reclamation anticipates adverse effects due to increased predation when reservoir levels are below 62,000 acre-feet in 2 of 30 years, because of the length of the varial zone and the lack of structural diversity within the varial zone. The varial zone does not present a physical barrier for bull trout migrating to FMO habitat in Anderson Ranch Reservoir; nevertheless, the length of the varial zone may diminish the effectiveness of bull trout's ability to migrate through varial zones within a short amount of time.

South Fork Boise River

Operation of Anderson Ranch Dam will have insignificant effects on PCE 2 in the South Fork Boise River. Generally, operation of Anderson Ranch Dam reduces flow in the winter and increases flow in the summer. Under both winter and summer operation, Reclamation has observed no physical, biological, or water quality impediments to bull trout migration in the South Fork Boise River between Anderson Ranch Dam and Arrowrock Reservoir. While winter warm-water releases have been associated with intermittent ice barriers in other systems, no similar ice dams have been observed in the South Fork Boise River. Climate change forecasts suggest baseline conditions will maintain flows within the range analyzed in the proposed action.

Arrowrock Reservoir

The operation of Arrowrock Dam may have infrequent adverse effects on PCE 2 during the fall migration season when Arrowrock Reservoir falls below elevation 3100 feet in 18 of 30 years. Migration corridors in the spring are in good condition with no migration impediments for fish migrating out of the reservoir to spawning habitat. Reservoir drawdowns can expose varial zones during the fall migration season in most years; however, connectivity is maintained at all times. The migration zones experience a reduction of structural diversity in the fall, but remain functional when bull trout return to FMO habitat after spawning. Habitat surveys performed in the fall of 2011 and 2012 by Reclamation compared habitat between the varial zones and immediately upstream and found no physical barriers to migration; however, instream and riparian cover was less in the varial zone. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 9).

Instream habitat diversity is seasonally reduced in the varial zone in most reservoir environments; however, varial zone length and functionality as a migration corridor vary depending on the tributary, reservoir, and season. The maximum length of varial zones in Arrowrock Reservoir occurs annually in the fall in association with the end of the irrigation season and low reservoir storage levels (Figure 9) which coincides with the fall migration of bull trout returning to Arrowrock Reservoir from spawning tributaries. Varial zone lengths are not expected to exceed 5.6 miles (9.0 kilometers) for the Middle Fork Boise River and

6.8 miles (10.9 kilometers) for the South Fork Boise River. The Middle Fork Boise River varial zone maintains its function as a migration corridor; however, the length combined with a lack of instream habitat diversity results in adverse seasonal effects on PCE 2 when the reservoir is below elevation 3100 feet. These effects are primarily due to the increased risk of predation. The South Fork Boise River provides a greater diversity of instream structure and does not present an adverse seasonal effect to migration.

A couple of factors minimize effects of the varial zone: 1) typical migration behavior (timing and rate of migration) and 2) reservoir operations during 12 of 30 years. Typical migration behavior (timing and rate of migration) of bull trout minimizes potential effects of moving through areas with reduced instream structure (from small headwater tributaries to over-wintering habitat). Reclamation data show bull trout typically migrate through varial zones at night and generally within a few hours (Reclamation internal data from Deadwood and Arrowrock Reservoirs). By moving through the varial zone in one evening the migrating fish minimize risk of predation due to a lack of structural diversity within the varial zone.

Reservoir conditions within the range of the operational indicators have been shown to provide habitat conditions suitable for bull trout to migrate through the varial zone in one evening. It is assumed that during 18 of 30 years fish may not be able to migrate through the varial zone in one evening because of the increased length of the varial zone or water depth impediments restricting the migration corridor.

Reclamation anticipates adverse effects due to increased predation when reservoir levels are below a water surface elevation of 3100 feet in 18 of 30 years, because of the length of the varial zone and the lack of structural diversity within the varial zone. The varial zone does not present a physical barrier for bull trout migrating to FMO habitat in Arrowrock Reservoir; nevertheless, the length of the varial zone may diminish the effectiveness of bull trout's ability to migrate through varial zones within a short amount of time.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Anderson Ranch Reservoir

The operation of Anderson Ranch Reservoir has an infrequent adverse effect on PCE 3 when water volume drops below 62,000 acre-feet in 2 out of 30 years and hot calm weather conditions persist for an extended period (USFWS 2005a, page 242). When those conditions occur (late summer or fall), adverse water quality conditions may cause lethal conditions to kokanee, a principle prey item for bull trout (USFWS 2005a). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 9).

South Fork Boise River

Operation of Anderson Ranch Reservoir has an infrequent adverse effect on PCE 3 when minimum flows drop below 300 cfs in the winter in less than 1 of 30 years (Reclamation 2004a, page 202). Very low streamflows may impact prey base by the loss of available over-wintering habitat. This may occur in back-to-back dry years when there is insufficient water in Anderson Ranch Reservoir to provide 300 cfs in the South Fork Boise River. While Reclamation anticipates effects similar to those observed under the environmental baseline will continue, climate change forecasts suggest higher reservoir elevations in dry years, indicating a lower probability of flows below 300 cfs (Figure 5).

Annual downramping in the fall could also strand prey fishes and invertebrates, but it does not appear that this stranding translates to impacts to prey base. The growth observed in bull trout within this area suggests that prey is not limited. Growth and condition factors of bull trout from 2011-2012 data collection activities indicate bull trout are maintaining an average to above-average condition in the South Fork and sufficient prey exist to support bull trout.

Arrowrock Reservoir

The operation of Arrowrock Dam has an infrequent adverse effect on PCE 3 when reservoir volume drops below 200,000 acre-feet at the end of June in 3 of 30 years. When those conditions occur, adverse water quality conditions may cause reduced primary productivity (Reclamation 2004a, USFWS 2005a). Reclamation also considered whether typical reservoir elevations in August and September affect PCE 3 and concludes effects are insignificant because the PCE 3 remains functional. Between August and September of each year, the thermocline erodes, causing nutrient ratios associated with algae that are not suitable forage for zooplankton and other aquatic invertebrates (Appendix B). It does not appear these conditions affect prey base.

In 2011 and 2012, Reclamation sampled the fish community in Arrowrock Reservoir. As part of this work Reclamation also analyzed the stomach contents from 25 bull trout (Reclamation internal data) and found that fish constituted 98 percent of the prey consumed by bull trout during the winter season. The identified prey species targeted by bull trout during this time included yellow perch, bridgelip sucker, and northern pikeminnow. The species richness was similar to sampling performed in 1996 and 1997 by IDFG, although densities of nongame fishes were greater. The large numbers of fishes sampled suggest that primary productivity is sufficient to sustain an adequate prey base for bull trout. Additionally, a fish health analysis (condition factor) described in the baseline condition for PCE 3 demonstrates that sufficient prey is available for all species to maintain average or above average health throughout the winter, the season when bull trout are most likely to be present in the reservoir. These data suggest impacts to primary productivity in Arrowrock Reservoir do not directly correlate to reduced prey base.

While Reclamation anticipates conditions to be similar to those observed in the environmental baseline, some factors suggest reduced impacts to prey base. In the past, the rapid drawdowns during irrigation season passed some portion of nutrients, food organisms, and fish through the dam into Lucky Peak Reservoir (USFWS 2005a). Since installation of clamshell gates in 2005, Reclamation now drafts water from lower in the water column, leaving warmer, more productive water in the reservoir and entrains fewer prey species from the reservoir. Further, climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 9) with slightly higher elevations in June of dry years. This may suggest a lower severity of adverse effects than those observed under baseline conditions.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Anderson Ranch Reservoir

The operation of Anderson Ranch Dam has an insignificant effect on PCE 4. In general, Anderson Ranch Reservoir provides a variety of complex habitat features including bays where tributaries enter the reservoir, a shallow delta area with established vegetation near the mouth of the South Fork Boise River, and depth refuge within the reservoir. These habitats provide substrate for terrestrial and aquatic macroinvertebrates as well as cover for many species juvenile fish (prey for bull trout).

Operational indicators for Anderson Ranch Reservoir (Table 3) have been developed to protect critical habitat by minimizing the frequency of drawdown below 62,000 acre-feet to 2 of 30 years. These criteria aim to protect water quality during dry periods, but also maintain the habitat complexity associated with pool volumes at or above 62,000 acre-feet. Deeper water habitat and submerged structure provide established habitat for bull trout and the species they are sympatric with. Although habitats within the reservoir change continually with changing pool volumes, functional complexity exists throughout the year. While drawdowns may reduce the interface with shoreline vegetation, bull trout retain access to riparian vegetation elsewhere in the CHU. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 9). Changes in habitat complexity are insignificant because the overall function of this PCE within the reservoir remains functional and access to tributaries remains open.

South Fork Boise River

The operation of Anderson Ranch Dam has an insignificant effect on PCE 4 in the South Fork Boise River. The South Fork Boise River provides a variety of complex habitat features including an established riparian zone, side channels, and habitat types (i.e., pools, riffles, runs) expected in a river environment. An established riparian zone and interaction with the wetted channel throughout most of the year increases habitat complexity and provides refugia for aquatic biota outside the action area that experience summer base flows. Outside of the irrigation season, the proposed action retains the function of the PCE by maintaining a minimum flow of 300 cfs. Winter flows may limit side channel habitat, but have an insignificant effect because bull trout use main channel habitats in the South Fork Boise River throughout the year and during all flows (Salow 2001; Reclamation telemetry surveys 2012-2014). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 8).

Arrowrock Reservoir

The operation of Arrowrock Dam has an insignificant effect on PCE 4. In general, Arrowrock Reservoir provides a variety of complex habitat features including bays where tributaries enter the reservoir, a shallow delta area with established vegetation near the mouth of the Middle Fork Boise River, and depth refuge within the reservoir. These habitats provide substrate for terrestrial and aquatic macroinvertebrates as well as cover for juvenile fishes (prey for bull trout). Although habitats within the reservoir change continually with pool elevation, functional complexity exists throughout the year. While, drawdowns may reduce the interface with shoreline vegetation, bull trout retain access to riparian vegetation elsewhere in the CHU. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 9). Changes in habitat complexity are insignificant because bull trout retain access to diverse habitats in the reservoir and in upstream tributaries, allowing this PCE to remain functional.

A couple of factors maintain a variety of habitats seasonally for bull trout in Arrowrock Reservoir. Reclamation reduces fall drawdowns below elevation 3100 feet to 18 of 30 years (Table 3). These criteria aim to increase productivity and reduce predation, respectively; however, these measures also help to maintain a variety of habitats throughout the year that provide depth and complexity.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Anderson Ranch Reservoir

The operation of Anderson Ranch Reservoir has an infrequent, adverse effect on PCE 5 when water volume falls below 62,000 acre-feet in 2 of 30 years. Reservoir operation influences water temperature and water quality conditions indirectly through a set of complex interactions between incoming water temperature, solar loading, release of cold water from the bottom of the reservoir, and the influence of reservoir elevation on thermal stratification. At volumes below 62,000 acre-feet, elevated water temperatures are possible in much of the reservoir (Reclamation 2004a). In the remainder of years, the proposed action provides water temperature refugia during the summer.

Reclamation operates the uppermost reservoir in the Boise River system (Anderson Ranch) to maximize refill capabilities of the system (section 4.3.1). Managing water in this way generally means Anderson Ranch Reservoir maintains thermal stratification (Appendix B).

South Fork Boise River

The operation of Anderson Ranch Reservoir will have beneficial effects on PCE 5 in the South Fork Boise River. Hypolimnetic releases from Anderson Ranch Dam maintain water temperatures between 2° and 15° C throughout most of the year. Operational indicators for Anderson Ranch Reservoir protect critical habitat by minimizing the frequency of spill to 6 of 30 years (Table 3). These criteria aim to protect water quality (water temperature) by reducing temperature spikes that could occur as a result of discharging surface water from Anderson Ranch Reservoir. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will be maintained within the range analyzed in the proposed action (Figure 8).

Similar to other regulated systems, the South Fork Boise River displays colder summer temperatures and warmer winter temperatures than nearby unregulated systems, with reduced diel fluctuations (Lehmkuhl 1974; Munn and Brusven 1991). During the summer season, water temperatures discharged from Anderson Ranch Reservoir warm daily to approximately 7° C (Appendix B). Spill from Anderson Ranch could occur in the spring (May or June) and increase water temperature, but not likely outside PCE targets. The frequency of spill is limited to 20 percent of the years under the proposed action (Table 3) and has not occurred since 2006; otherwise, deep water releases from the dam maintain consistent water temperatures throughout most of the year. Warming occurs along the 26.0 miles (41.8 kilometers) of the action area as a result of natural thermal loading, but seldom exceeds the PCE temperature targets (Figure 14). Furthermore, under the proposed action, similar ramping rates and seasonal flows occur annually allowing riparian vegetation to become well established that in turn maintains shading and overhead cover habitat, features that reduce thermal loading.

Arrowrock Reservoir

The operation of Arrowrock Dam has a seasonal adverse effect on PCE 5 when temperatures exceed 15° C from July through September in average years. Arrowrock Dam operation affects water temperature through the release of hypolimnetic water from the lower levels of the reservoir. Subadult bull trout could be present at the time these effects occur, although current data suggests both subadult and adult bull trout migrate from the reservoir before July and return in October. By October, the reservoir pool has begun to refill (Figure 9) and water temperatures are below 15° C in most of the reservoir (Figure 16). By November, water temperatures are below 15° C throughout the reservoir.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Anderson Ranch Reservoir, Arrowrock Reservoir, and the South Fork Boise River between the reservoirs have not been designated as spawning and rearing habitat (USFWS 2010a, pages 629, 641); therefore, the effects were not analyzed.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

Anderson Ranch and Arrowrock Reservoirs

PCE 7 is not present in either reservoir; therefore, the effects were not analyzed.

South Fork Boise River

The operation of Anderson Ranch Reservoir adversely affects PCE 7 in the South Fork Boise River throughout the year; however, the PCE provides beneficial effects to other PCEs as a result of being altered (PCE 4 and 5). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 8).

The influence of Anderson Ranch and Arrowrock dams operations on the South Fork Boise River is adverse because in general, reservoir operations regulate the hydrograph with flows that are lower in the winter and spring, lower during the spring peak, and higher in the summer which does not follow daily and seasonal fluctuations of nearby unregulated systems. The South Fork Boise River has a ramped increasing hydrograph throughout the spring and then decreases and maintains flows between 600 and 1,800 cfs during the summer. The river has a ramped decreasing hydrograph after irrigation season and then ramps down to winter flows of 300 cfs.

Effects of the proposed action on bull trout migration behavior (habitat use) is being examined by Reclamation as part of the T&Cs (Table 3). Telemetry studies performed over the last 10 years and preliminary results from recent work suggest that bull trout use main channel habitats throughout the year, are not displaced by ramping events, and migrate within the same time frame as fish that over-winter in Arrowrock Reservoir. Effects of ramping rates on the fishery and habitat in this part of the action area are being addressed through the T&Cs of the 2005 USFWS BiOp (Table 2).

Reclamation is also conducting work in the Boise River system action area to determine effects of ramping on aquatic habitat and stranding of juvenile fishes; work is expected to be completed in FY 2015. Trend sampling by IDFG for young-of-year and adult rainbow trout show natural variability, but have not appreciably changed over the last 10 years during which ramping has occurred within the current range of operation (Butts 2012). These data suggest that stranding may be seasonally limiting the abundance of prey fishes (PCE 3), but not affecting the persistence of prey species.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Anderson Ranch Reservoir

The operation of Anderson Ranch Reservoir has an infrequent adverse effect on PCE 8 when the reservoir volume drops below 62,000 acre-feet between July and October in 2 of 30 years. Reservoir operation influences water quality and temperature indirectly through a set of complex interactions with incoming water temperature, solar loading, release of cold water from the bottom of the reservoir, and the influence of reservoir elevation on thermal stratification. Water quality conditions in the reservoir are suitable for bull trout and bull trout prey (PCE 3) at volumes above 62,000 acre-feet (USFWS 2005a). Below 62,000 acre-feet, there may be an increased probability of degraded dissolved oxygen conditions. These conditions would affect bull trout and kokanee, a primary prey species, but would not affect other prey species. Few bull trout are present at this time (estimated 4 percent of the population) and they have access through the migration corridor to better habitat. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 7).

Effects of water temperature and water quality conditions on the function of PCE 8 would be reflected in the normal reproduction, growth, and survival of bull trout. Recent data on bull trout recruitment (reproduction) is not available; however, core area assessments updated in 2008 (USFWS 2008c) indicate a slight increase in the documented bull trout population in the Anderson Ranch core area in comparison to data collected between 1993 and 2003.

Operational indicators for Anderson Ranch Reservoir have been developed to protect critical habitat by minimizing the frequency of drawdown below 62,000 acre-feet to 2 of 30 years (Table 3). These criteria aim to protect water quality (USFWS 2005a) by maintaining thermal stratification during periods of hot and dry weather. Anderson Ranch Reservoir has not been drafted to the 62,000-acre-foot level since the 2005 USFWS BiOp.

South Fork Boise River

The operation of Anderson Ranch Dam has an insignificant effect on PCE 8 in the South Fork Boise River. Water quality and quantity in the South Fork Boise River meet targets for Idaho water quality standards for cold water biota throughout the year. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 8).

Effects of water quality and water quantity conditions on the function of PCE 8 would be reflected in the normal reproduction, growth, and survival of bull trout. Water quality conditions include nutrients, dissolved gas concentrations, and temperature (addressed in PCE 5) and indicate a functional PCE for both bull trout and bull trout prey (Appendix B). An average to above-average condition factor analysis performed for bull trout in the Arrowrock metapopulation, which includes the South Fork Boise River action area, provides further data to support a functional PCE (Seo 2013 in draft).

Arrowrock Reservoir

The operation of Arrowrock Dam has a seasonal adverse effect on PCE 8 from July through September; however, bull trout are not likely to be present. Bull trout that may be present during that time have access through a functional migration corridor to thermal refugia in the South Fork Boise River. Reservoir operation influences water temperature and water quality conditions indirectly through a set of complex interactions with incoming water temperature, solar loading, release of cold water from the bottom of the reservoir, and the influence of reservoir elevation on thermal stratification. Although adverse effects may seasonally occur, water quality conditions indicate a functional PCE for bull trout when they are likely to be present and no effects to the bull trout prey base (PCE 3) in Arrowrock Reservoir (Appendix B). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 9).

Effects of water quality and water quantity conditions on the function of PCE 8 would be reflected in the normal reproduction, growth, and survival of bull trout. Recent data for bull trout recruitment (reproduction) and growth has not been analyzed; however, preliminary results indicate a slight increase in the documented bull trout population (Reclamation 2012) and average or above-average growth (PCE 3).

Several factors minimize adverse effects to this PCE in Arrowrock Reservoir. First, only a small number of bull trout are likely to be present during the time effects could occur. Recent data suggests all fish may leave the reservoir during those months. Most bull trout return to the reservoir in November from their spawning migration (PCE 2). Second, effects are believed to be seasonal and non-lethal (USFWS 2005a, page 235). Third, recent sampling indicates large numbers of potential prey fish and average or above average growth for all species during the winter.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Anderson Ranch Reservoir, South Fork Boise River, Arrowrock Reservoir

Operations will have an insignificant effect on PCE 9. The proposed action provides an environment that allows the survival of nonnative fishes; however, IDFG exclusively manages the fisheries including stocking and regulations that favor the presence of individual species. The proposed action plays an insignificant role in the occurrence of nonnative fishes compared to variables (fish management and interbreeding) independent from operations.

4.4.3 Summary of the Effects of the Proposed Action on Critical Habitat

Under the proposed action, future conditions in Anderson Ranch and Arrowrock reservoirs throughout most of the year will continue to provide conditions important for the survival of bull trout. Seasonally, however, depending on climate patterns and water needs, the availability of bull trout habitat may be limited. Yearly and seasonal fluctuations in water supply and irrigation demand will continue. During periods of warm summer conditions and extreme drawdowns, migration corridors may provide access to more favorable conditions. The baseline conditions in unregulated portions of the watershed do not provide ideal habitat conditions throughout the year.

Table 6. Summary of the effects of the proposed action for Anderson Ranch Reservoir, South Fork Boise River (below Anderson Ranch Dam), and Arrowrock Reservoir.

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action		
		Anderson Ranch Reservoir	**South Fork Boise River**	**Arrowrock Reservoir**
1	Springs, seeps, groundwater sources	Discountable effect	Insignificant effect	Discountable effect
2	Migration habitats with minimal impediments.	Infrequent adverse effect may exist in varial zones in fall due to low reservoir levels in 2 of 30 years.	Insignificant effect	Infrequent seasonal adverse effects may exist in the varial zones in fall due to low reservoir levels in 18 of 30 years
3	Abundant food base	Infrequent adverse effects in the summer in 2 of 30 years	Infrequent adverse effects in 1 of 30 years	Infrequent adverse effects in June in 3 of 30 years
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effects	Insignificant effects	Insignificant effects
5	Water temps ranging from 2°-15^{o} C with adequate thermal refugia	Infrequent adverse effects in summer when reservoir volume falls below 62,000 acre-feet in 2 of 30 years	Beneficial effects	Seasonal adverse effects in fall when water temperatures rise above PCE targets
6	Spawning/rearing substrate.	Not present	Not present	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present	Adverse effects	Not present
8	Sufficient water quality and quantity	Infrequent adverse effects in summer/fall when reservoir volume falls below 62,000 acre-feet in 2 of 30 years	Insignificant effect	Seasonal adverse effects in late summer/early fall
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect	Insignificant effect	Insignificant effect

4.5 Cumulative Effects

Climate change may alter aquatic habitat (e.g., quantity, hydrograph peaks, temperature) in the Boise River basin. Climate change modeling indicates increased precipitation in the Pacific Northwest, but warming trends may result in shifting cool season precipitation from snow to more rain events. Warming is expected to reduce the snowpack from late fall through early spring, resulting in diminished runoff. The amount and timing of precipitation and increasing water temperatures may reduce suitable critical habitat (physical). These same variables may also cause behavioral changes in the life history of the bull trout.

Future environmental conditions will likely affect bull trout and their critical habitat inside and outside of the Boise River system action areas as defined in this document. Connectivity between core critical habitats will be crucial for the continued existence of the migratory life stage of this highly migratory species. Current studies demonstrate the ability of bull trout to temporarily tolerate conditions outside their previously defined ranges. The life history of adfluvial bull trout may adapt to more fluvial habitats, using reservoir environments seasonally as is currently observed in some reservoirs, as long as migration corridors are open.

Bull trout in the Boise River system action areas are part of a metapopulation of adfluvial bull trout that represent only a portion of the total bull trout found in the basin. These fish use the reservoirs as either a migration corridor, post spawn/wintering, or foraging habitat. Most adfluvial fish only rely on the reservoirs for half of the year. Because of the life history of this population and the distance they travel out of the Boise River system action areas to spawning areas, they are susceptible to many factors not related to the operation of the reservoirs.

Cumulative effects could include increases in recreational fishing pressure and the resulting stress or mortality (subadult and adult survival); the effects of large fires (spawning, rearing, and migration corridor); increased sedimentation from roads or timber harvest and mining activities (spawning, rearing and migration corridor); connectivity to spawning tributaries (spawning and rearing); and quality of spawning habitat. Furthermore, climate change modeling suggest that suitability of headwater spawning habitats may be limited with only slight changes in water temperature (Rieman et al. 2007).

4.6 Determination

Reclamation has determined that future O&M activities in the Boise River system **may affect and are likely to adversely affect** bull trout critical habitat in Anderson Ranch Reservoir, Arrowrock Reservoir, and the South Fork Boise River between Anderson Ranch and Arrowrock reservoirs.

Adverse effects to bull trout critical habitat at Anderson Ranch Reservoir occur in 2 of 30 years when the 62,000-acre-foot conservation pool is not maintained, affecting PCEs 2, 3, 5, and 8.

Adverse effects to bull trout critical habitat in the South Fork Boise River between Anderson Ranch Dam and Arrowrock reservoirs occur yearly as the natural hydrograph is altered by storage and delivery of water (PCE 7); however, PCE 7 remains functional and provides beneficial effects to PCEs 4 and 5 as a result of being altered. Adverse effects to bull trout critical habitat will occur when winter flows fall below 300 cfs in 1 of 30 years, potentially limiting rearing habitat for bull trout prey (PCE 3) (USFWS 2005a, page 240).

Adverse effects to bull trout critical habitat at Arrowrock Reservoir occur in 2 of 30 years when the reservoir water surface falls below 3100 feet in elevation and causes a loss of cover and an increased exposure to predation in the varial zone of the Middle Fork Boise River, affecting PCEs 2, 3, 5, and 8.

5.0 DEADWOOD AND SOUTH FORK PAYETTE RIVER SYSTEMS

5.1 Proposed Action

The future O&M of the Deadwood and South Fork Payette River systems (Payette Division of the Boise Project) is described in the 2004 Upper Snake BA (Reclamation 2004a, page 20) and in the Operations Descriptions for Reclamation's projects in the Snake River above Brownlee (Reclamation 2004b, pages 79-115). In 2010, Reclamation received a biological opinion on repairs to an access bridge to Deadwood Dam (USFWS 2010b) and repaired the bridge in fall 2010. Other than this repair, all facilities and O&M activities remain the same as described in the 2004 Upper Snake BA.

The proposed action also incorporates T&Cs from the 2005 USFWS BiOp that pertain to operation of Deadwood Dam. Table 7 shows the T&Cs, the purpose of the T&Cs, the studies or activities designed to address the T&Cs, and the current status of the studies or activities.

Table 7. Terms and Conditions (T&C) from the 2005 USFWS BiOp that pertain to Deadwood Dam and Reservoir.

T&C	Action Area	Description	Purpose	Studies
3.a.	Deadwood Reservoir and River	Within the range of proposed operation, decrease the effects to bull trout below the dam when winter outflow does not match inflow	Reduce the level of take (bull trout) from loss of winter habitat	Ongoing
3.b.	Deadwood Reservoir and River	Within the range of proposed operations, reduce the extreme low temperatures below the dam	Minimize harm associated with reduced prey abundance that results from extreme cold discharge	Ongoing
3.c.	Deadwood Reservoir and River	Determine and implement ramping rates that reduce harassment and harm of bull trout downstream of the dam	Ramping rates could strand or flush bull trout or prey base	Ongoing
3.d.	Deadwood Reservoir and River	Determine flexibility within the proposed action to manage flows from and to minimize disruption of biological processes to bull trout in the river downstream of the dam	How may discharge from Deadwood Dam affect the migratory and biological cues of bull trout below the dam	Ongoing
3.e.	Deadwood Reservoir and River	Minimize use of the spillway to avoid entrainment	Conditions leading to entrainment could occur when the spillway is being used	Ongoing

To implement the T&Cs of the 2005 USFWS BiOp, Reclamation prepared a monitoring and implementation plan that identified operational indicators to monitor incidental take associated with the proposed action (Reclamation 2006). Operational indicators describe a set of measurable criteria, such as specific reservoir elevations, that allow Reclamation to verify compliance with the T&Cs of the 2005 Incidental Take Statement (USFWS 2005a). Table 8 lists the four operational indicators associated with Deadwood Dam.

Table 8. Operational Indicators associated with Deadwood Dam (Reclamation 2006). Data updated through Water Year 2012.

Facility	Anticipated Take	Operational Indicator	Critical Season	Expected Occurrence/ Recorded Occurrences
Deadwood Dam	Up to 4 percent of bull trout in Deadwood Reservoir are entrained into the Deadwood River below the dam.	Water discharged over the spillway.	Spring	11 of 30 years; this has occurred 4 times since 2006
Deadwood Dam	Up to 4 percent of bull trout in Deadwood Reservoir are affected by degraded water quality.	Reservoir storage volume falls below 50,000 acre-feet.	August through October	2 of 30 years; this has not occurred since 2006
Deadwood Dam	All bull trout in the Deadwood River downstream from the dam are affected by spillway discharges that disrupt timing of migration and spawning and that alter metabolic rates.	Water is discharged over the spillway	May through July	11 of 30 years; this has occurred 4 times since 2006
Deadwood Dam	All bull trout in the Deadwood River downstream from the dam are affected by low winter streamflows and temperatures that affect bull trout movement and growth and reproduction of bull trout and the prey base.	Deep water releases at Deadwood Dam and low flows below the dam.	Spring increases, fall reductions, winter discharge	30 of 30 years; this has occurred each year since 2006

5.2 Action Area

A detailed description of the Payette River system portion of the action area appears in the 2004 Upper Snake BA (Reclamation 2004a, pages 184-188). The analysis in this chapter focuses on three locations where the Payette River system overlaps with the Deadwood River and South Fork Payette River critical habitat subunits:

- **Deadwood Reservoir** (2,957.8 acres [1,197.0 hectares]) overlaps with the Deadwood River CHSU and contains FMO habitat.

- **Lower Deadwood River** from its confluence with the South Fork Payette River upstream 23.0 miles (37.0 kilometers) to Deadwood Dam overlaps with the Deadwood River CHSU and contains FMO habitat.

- Portions of the **South Fork Payette River** from its confluence with the Middle Fork Payette River upstream to the confluence of Deadwood River 24.5 miles (39.4 kilometers) overlaps with the South Fork Payette River CHSU and contains FMO habitat.

The Deadwood River and South Fork Payette River CHSUs are part of the broader Southwest Idaho River Basins CHU (CHU 26) (75 FR 63898, page 64043). The Southwest Idaho River Basins CHU is one of six CHUs that comprise the Upper Snake River RU and is considered essential to bull trout conservation because of the presence of populations exhibiting rare adfluvial life history expressions, moderate number of local populations, moderate to large numbers of individuals, moderate amount of habitat, and few threats (USFWS and IDFW 2010). The Southwest Idaho River Basins CHU includes approximately 1,335.9 miles (2,150.0 kilometers) of streams and 10,651.5 acres (4,310.5 hectares) of lake and reservoir surface area designated as critical habitat and includes eight CHSUs: Anderson Ranch Reservoir, Arrowrock Reservoir, South Fork Payette River, Deadwood River, Middle Fork Payette River, North Fork Payette River, Squaw Creek, and Weiser River (Table 9; Appendix A).

Table 9. Critical habitat stream miles, surface area and storage volumes within the Southwest Idaho River Basin Critical Habitat (CHU) 26 and Critical Habitat Subunits (CHSUs). Subunits described in this chapter are highlighted. Designated critical habitat within the action area is totaled.

Critical Habitat Unit or Subunit	Critical Habitat, Stream Miles (kilometers)	Critical Habitat, Surface Area Acres (hectares)	Critical Habitat, Water Storage (in acre-feet)	Action Area
CHU 26 - 4,158.3 total stream miles (6,692.2 kilometers)	**1335.2 (2149.0)**	**10,652.5 (4311.0)**	**901,100**	
Weiser River CHSU	70.4 (113.3)	0	0	0
Squaw Creek CHSU	44.9 (72.3)	0	0	0
North Fork Payette River CHSU	19.3 (31.1)	0	0	0
Middle Fork Payette River CHSU	122.7 (197.6)	0	0	0
Upper South Fork Payette River CHSU	**278.0 (447.4)**	**0**	**0**	**47.5 miles**
Deadwood River CHSU	**77.0 (123.9)**	**2,957.8 (1,197.0)**	**154,000**	**1,197 acres**
Arrowrock CHSU	447.4 (720.0)	3,093.7 (1,252.0)	272,200	See Chapter 4
Anderson Ranch CHSU	275.5 (443.4)	4,601.0 (1,862.0)	474,900	See Chapter 4

These subunits are considered essential to bull trout conservation because of the presence of populations exhibiting rare adfluvial life history expressions, moderate number of local populations, moderate to large numbers of individuals, moderate amount of habitat, and few threats (USFWS and IDFW 2010).

In addition, this project also contributes to the aggregate effect of upper Snake River projects on the designated critical habitat located on the mainstem Snake and Columbia rivers. Figure 17 shows the Payette River basin bull trout core areas coincident with the CHSUs, CHU boundaries, designated critical habitat streams and reservoirs, and the proposed action project boundaries for the Boise River basin projects. Effects where the proposed action influences the hydrology in designated critical habitat are analyzed in this section (bold red lines in Figure 17 show the area of overlap between the 2004 Upper Snake BA action area and designated critical habitat). Designated critical habitat on the mainstem Snake and Columbia rivers are part of the Mainstem Snake River CHU (CHU 23), Mainstem Columbia River CHU (CHU 22), and Lower Columbia CHU (CHU 8). These effects are analyzed in Section 8.

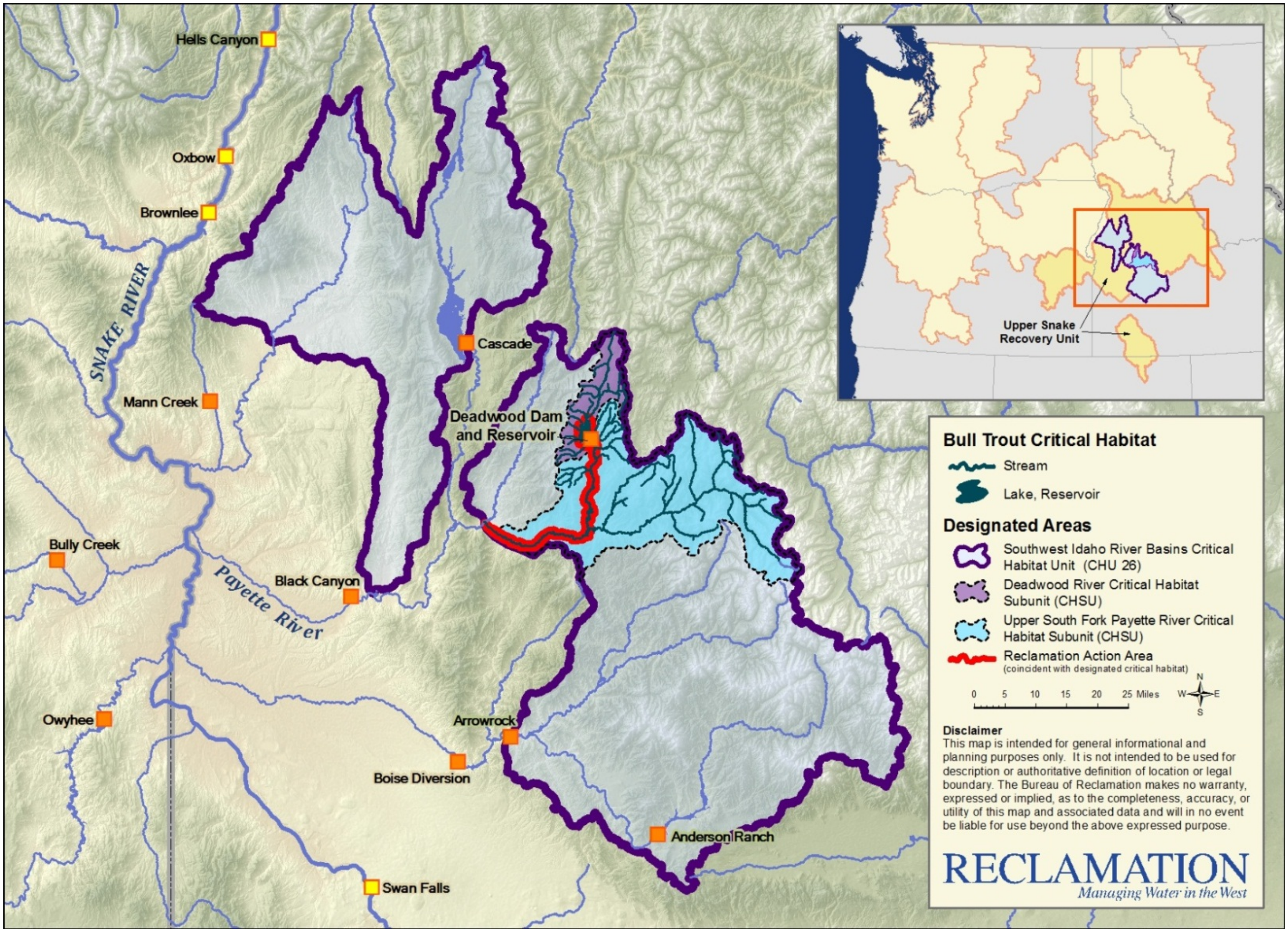

Figure 17. Southwest Idaho River Basin Critical Habitat Unit 26 boundary. The action area described in Section 5.0 only includes Deadwood Reservoir, Deadwood River downstream of Deadwood Dam, and South Fork Payette River between Deadwood River and the Middle Fork Pavette River.

5.3 Environmental Baseline

5.3.1 Baseline Hydrology

Deadwood Reservoir

Deadwood Dam, located on the Deadwood River, stores nearly 153,992 acre-feet (active storage) with a surface area of 3,180 acres (Figure 17). Deadwood Reservoir is a high elevation reservoir located 5334 feet above sea level and is located in an undeveloped drainage dominated by the highly granitic and exposed Idaho Batholith. The upper Deadwood River is the main source of water and nutrients to the reservoir followed by Trail Creek; however, several smaller tributaries contribute about one-third of the total inflow during each year (Reclamation et al. 2011).

Figure 2 presents a summary hydrograph of the 10 percent (wet), 50 percent (average), and 90 percent (dry) exceedances using historical modeled or observed (gaged) data from 1928-2008. Typically, Deadwood Reservoir fills to its maximum storage capacity by May or June (depending on the water year) and maintains a volume above 50,000 acre-feet in most years. The operations analyzed in the 2005 USFWS BiOp indicate that Deadwood Reservoir will maintain storage above 50,000 acre-feet August through October in all but 2 years of the 30 years analyzed (Figure 18).

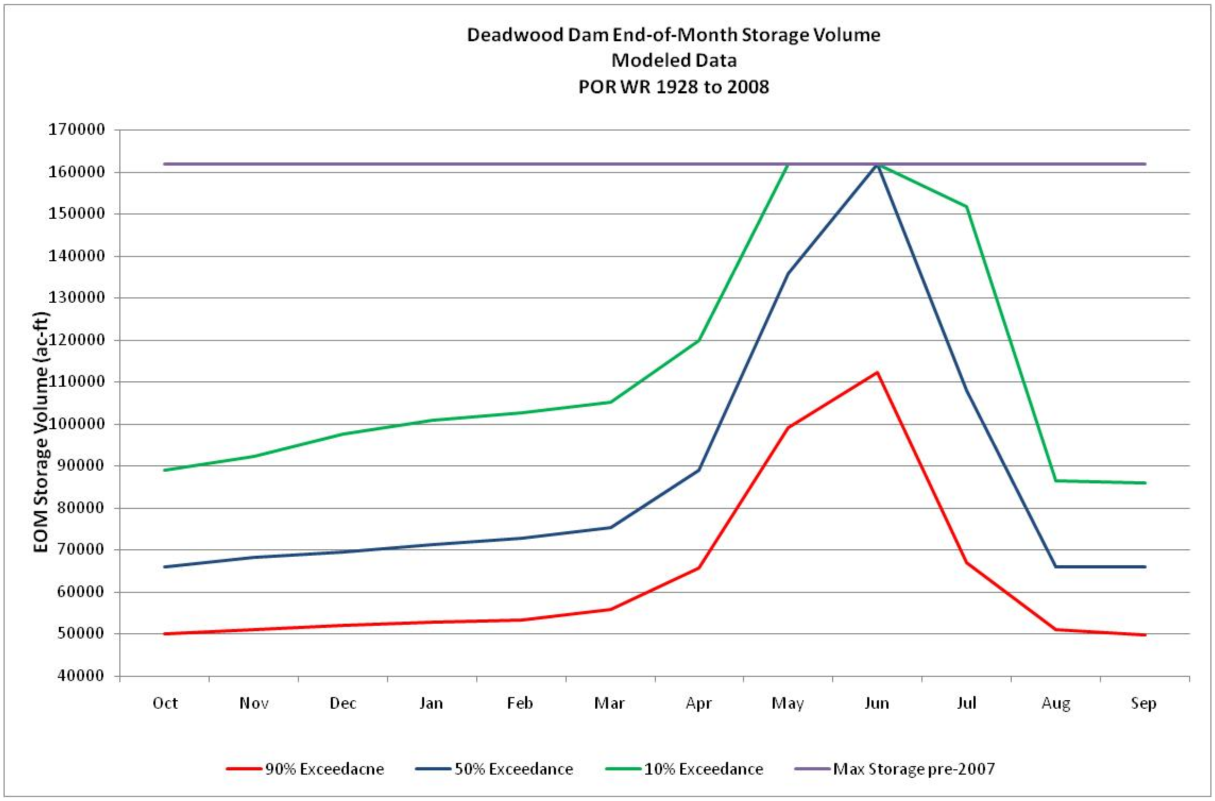

Figure 18. Modeled end-of-month (EOM) storage volume at Deadwood Reservoir on the South Fork Payette River. Hydrographs for 10%, 50%, and 90% exceedances are for the period of record (POR) from water years (WY) 1928 to 2008. The maximum storage line is shown.

Lower Deadwood River

The lower Deadwood River below Deadwood Dam flows from an elevation of 5197 feet (1584 meters) for a distance of approximately 23 miles (38 kilometers) to the confluence with the South Fork Payette River, which is at an elevation of 3700 feet (1128 meters). The lower river is a mountainous canyon river that is mostly confined, with limited floodplain features. The relatively steep hill slopes and canyon-like nature of the basin limit the amount and duration of sunlight that is able to reach the river. The total watershed area both above and below the dam is approximately 237 square miles (614 square kilometers). The dominant type of precipitation is snow.

To understand how the operation of Deadwood Dam has affected flows on the lower Deadwood River, regulated and unregulated flow exceedances were compared. Exceedances of the historical observed daily record were determined and are shown in Figure 19. Unregulated flow patterns, shown by solid lines, tend to be higher in the winter and early spring than regulated flows, which are depicted by dashed lines. Only the time period that overlaps the two datasets is shown. Unregulated flows also have a significantly higher peak in late May or early June for all of the exceedances shows.

Regulation of the flows shifts the peak of the flow over a 3- or 4-month period from May to September as opposed to a single peak in May in the unregulated flow. In addition, regulation of flows results in a discharge of 50 cfs during the winter and early spring because flow is being stored for use in the summer.

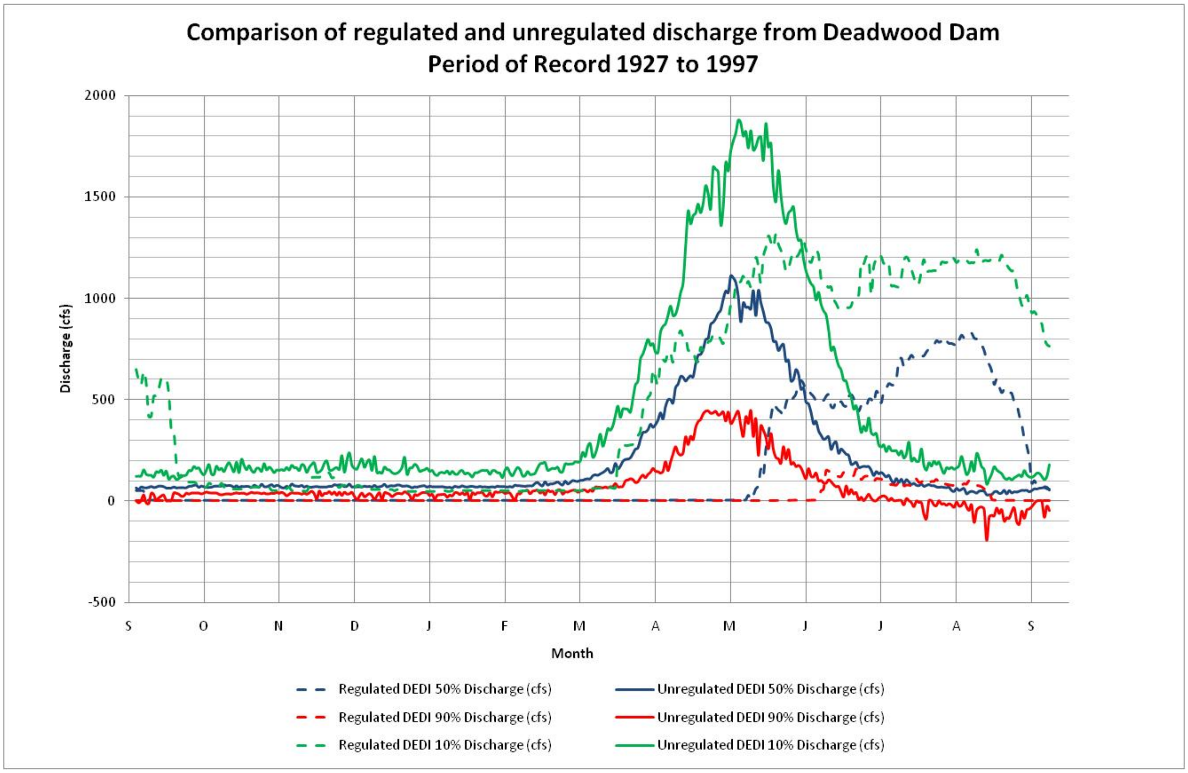

Figure 19. Comparison of regulated and unregulated discharge from Deadwood Dam (DEDI) for period of record (POR) 1927-1997. Daily summary hydrographs of 10%, 50%, and 90% exceedance flows.

South Fork Payette River to Confluence with the Middle Fork Payette River

The reach of river below the confluence of the South Fork Payette River and the Deadwood River is considered critical habitat and both rivers contribute to the hydrology in this reach. The observed flow from the gage on the South Fork Payette River at Lowman, Idaho (PRLI) and discharge from Deadwood Dam is shown in Figure 20. The PRLI gage is located upstream of the confluence between the Deadwood and South Fork Payette rivers where the river is not regulated.

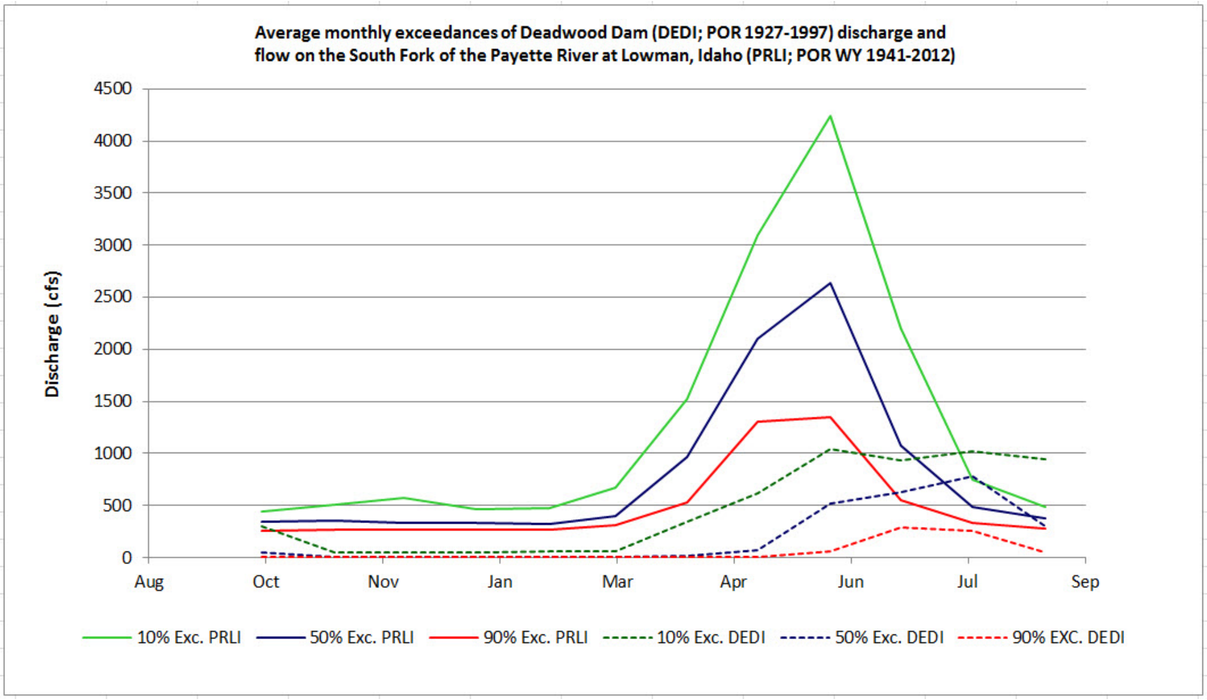

Figure 20. Observed monthly exceedances of Deadwood Dam discharge for the period of record (POR) 1927-1997 and South Fork Payette River at Lowman, Idaho (gage PRLI) flow (POR 1941 to 2011). Monthly summary hydrographs for wet (10%), average (50%), and dry (90%) exceedances are shown. DEDI denotes the Deadwood River below Deadwood Dam.

In Figure 21, the observed monthly average flow for wet (10 percent), average (50 percent), and dry (90 percent) exceedances on the South Fork Payette River near Lowman, Idaho is shown for the period of record from water years 1941 to 2011. The flow in all exceedances shown reaches its peak in the late spring, which is typical of snowmelt dominated systems, and is generally less than 500 cfs throughout most of the year, regardless of the type of water year. Peaks generally occur in May or June with only 10 percent of the flows during that time exceeding 4,200 cfs on average.

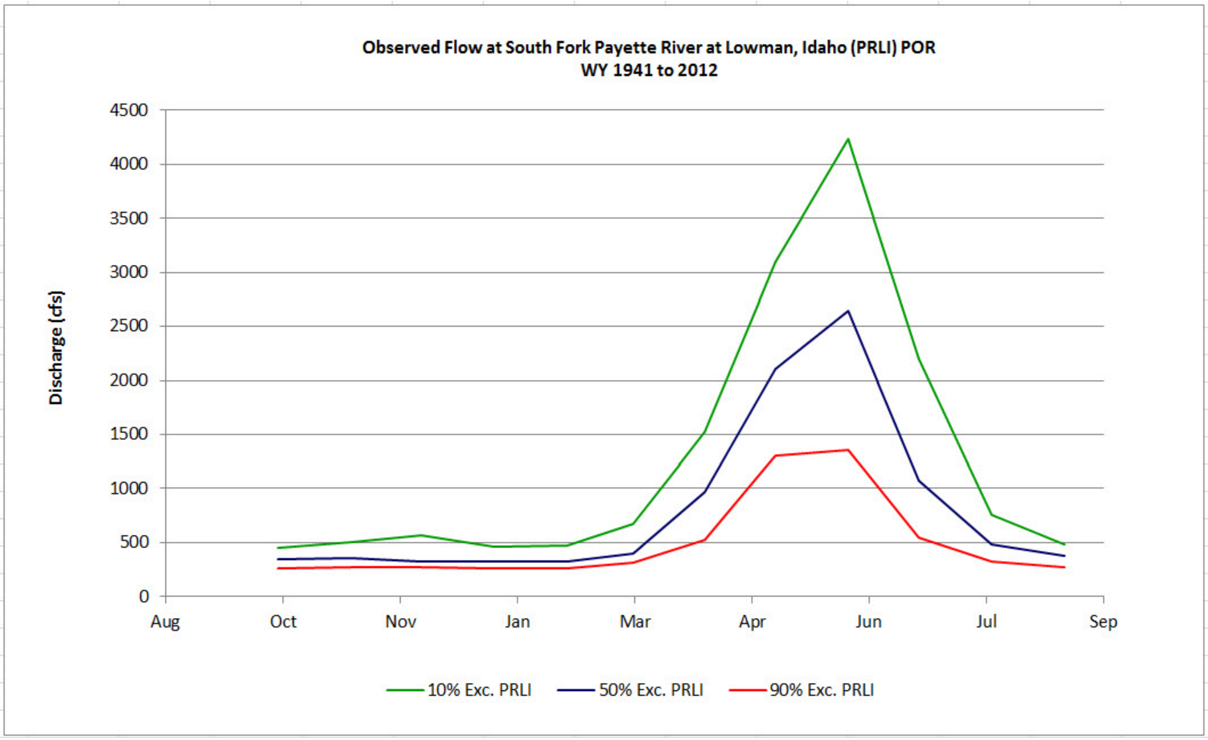

Figure 21. Observed monthly average flow on the South Fork Payette River at Lowman, Idaho (gage PRLI) for the period of record (POR) from water years (WY) 1941 to 2012. Hydrographs for wet (10%), average (50%), and dry (90%) exceedances are shown.

Releases from Deadwood Dam contribute to the hydrograph in the South Fork Payette River. In July and August, the natural hydrograph is reaching summer base flows, but is supplemented with irrigation releases and salmon augmentation flows being made. Regulated flows from Deadwood Reservoir slow the descending limb of the hydrograph in April, May, and June when releases from Deadwood Reservoir are increasing (Figure 21).

During the summer months, flows that enter the lower Deadwood River from local tributaries contribute to the flow at the confluence of the lower Deadwood and South Fork Payette Rivers. In addition, as shown in Figure 20, outflow from the Deadwood Dam during this time are at their maximum. During August, irrigation releases maintain the hydrograph at a higher level than what is observed naturally.

In the winter months (October through February or March depending on the water year), outflow from Deadwood Dam is minimal (Figure 20) and as described above, is lower than the natural hydrograph would have been. While studies are ongoing to collect flow volumes at the mouth of the lower Deadwood River, these studies are not complete and cannot be used for this biological assessment; however, initial results indicate that flow from local tributaries during the winter months supplement the flow in the lower Deadwood River to some degree.

Future Hydrology with Climate Change

As described in Section 2.2, a revised 2007 MODSIM model was used to simulate reservoir operation in potential climate change conditions. The following figures reflect the projected changes in historical and future flows using this revised MODSIM model adjusted to incorporated climate change flows (Reclamation 2011a). As shown in Figure 22 and Figure 23, future climate change inflows to Deadwood Reservoir generate increased end-of-month storage volumes in the cool season and less or similar inflows in the warmer months. Future projections show that during low inflow exceedance levels (90 percent exceedance), conditions in the reservoir is projected to improve above what is currently experienced. While peak end-of-month storage volumes for the average (50 percent exceedance) and large (10 percent exceedance) flow exceedances remain unchanged, the end-of-month storage volume is projected to be more than 20,000 acre-feet higher during the dry years than the historical volume.

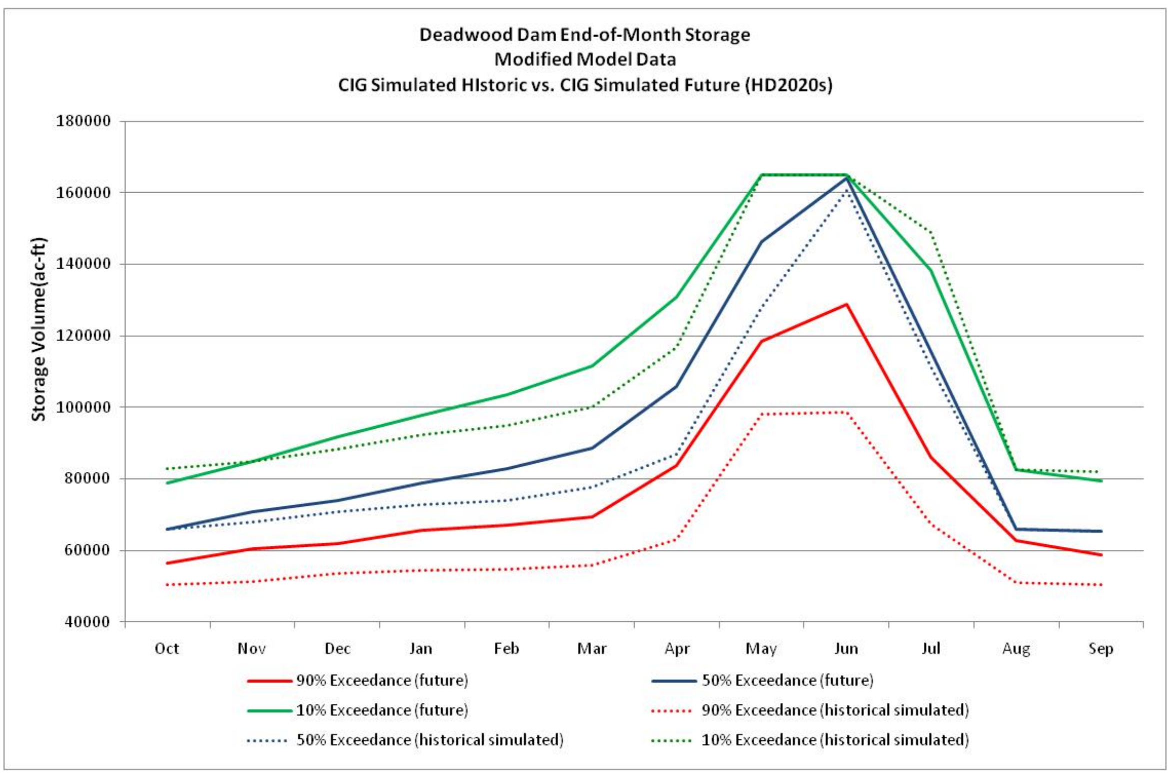

Figure 22. Deadwood Dam end-of-month storage volume using UW CIG generated simulated historical and future datasets. UW CIG simulated future flows were generated by developing a time series using the median of six future HD projections and then determining the average monthly discharge exceedances using that median time series. Monthly summary hydrographs for wet (10%), average (50%), and dry (90%) exceedances are shown. Solid lines depict future simulated elevations at the end of the month and dashed lines depict historical simulated.

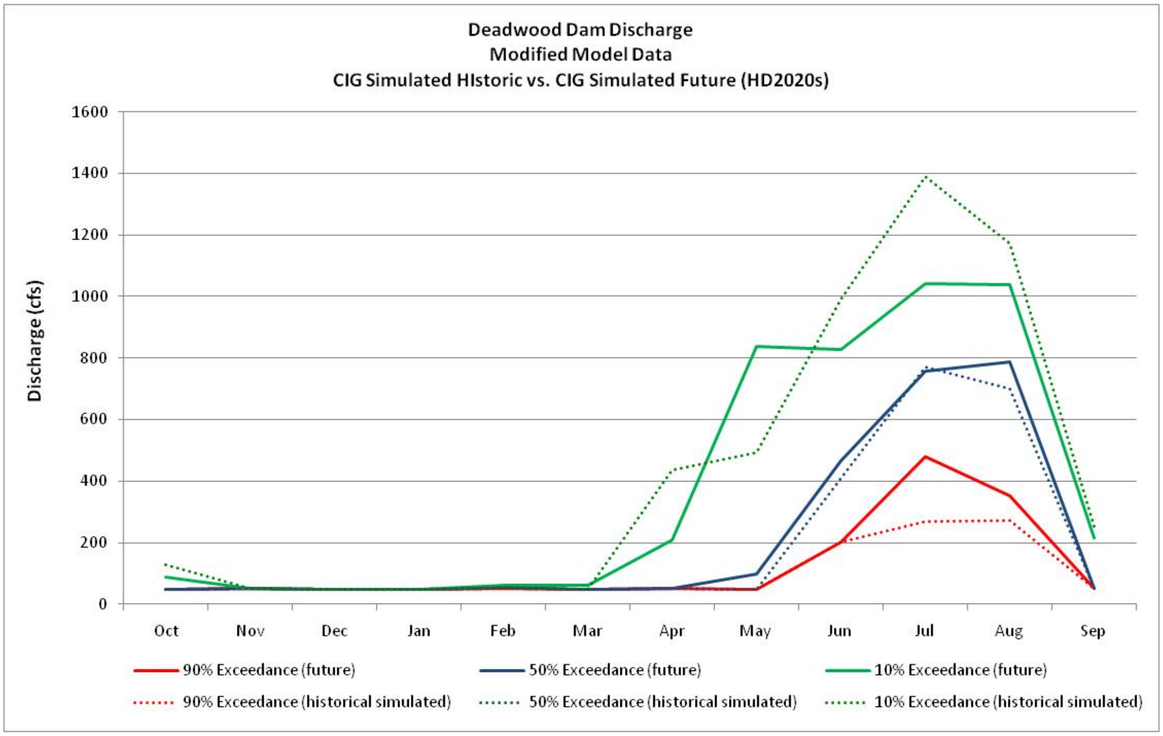

Figure 23. Deadwood Dam discharge using UW CIG generated simulated historical and future datasets. UW CIG simulated future flows were generated by developing a time series using the median of six future HD projections and then determining the average monthly discharge exceedances using that median time series. Monthly summary hydrographs for wet (10%), average (50%), and dry (90%) exceedances are shown. Solid lines depict future simulated elevations at the end of the month and dashed lines depict historical simulated.

This increase could be due to a couple of reasons. The projected changes could be in the forms and amount of precipitation that are projected to occur in the mountains due to climate change. More precipitation in the form of rain is projected due to climate change in April and May. This, along with snowmelt in the June, could create such an increase. This additional volume at the lower exceedance can be retained in the reservoir, while the 50 percent and 10 percent exceedance volumes already reach their maximum volume even in current conditions.

Deadwood Dam discharge reflecting the projected changes in historical and future flows using this revised MODSIM model adjusted to incorporated climate change flows is shown in Figure 23 (Reclamation 2011a). In the future, a slight increase in projected discharge in the 10 percent and 90 percent exceedance levels is shown during July and August. The increased discharge in the 90 percent exceedance level is indicative of the increase in inflow into the reservoir described above and shown in Figure 23. The decreased discharge in the future when compared to the historical 10 percent exceedance flow reflects the decrease in volume in the falling limb in Figure 23 (not seen in the 50 percent exceedance flow level).

5.3.2 Baseline Population Status and Trends

The 2004 Upper Snake BA and 2005 USFWS BiOp described current conditions in the Deadwood and South Fork Payette River action areas through 2004. Since 2005, Reclamation implemented numerous tasks and studies in compliance with the 2005 USFWS BiOp as described in the proposed action. Table 10 shows the studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to these action areas. This section provides relevant information from these studies.

Table 10. Studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to the Deadwood Reservoir and Deadwood River action areas.

Date	Reference	Title
2006-present	Reclamation in progress; expected completion date in 2014	Deadwood Reservoir Operations Flexibility Evaluation – Final Report pending
2007	Reclamation 2008	2007 Reclamation ESA Annual Report
2007	Dare and Rose 2007	Movement of stream fishes between mainstem and tributary habitat – Deadwood Reservoir downstream of Deadwood Dam.
2008	Sievers and Dillon 2008	2008 IDFG Bull Trout Weir Report
2008	USFWS 2008d	Core Area Assessments
2008	Prisciandaro and Schmasow 2008	2008 Sampling Permit Report to IDFG
2008	DeHaan and Ardren 2008	Genetic Analyses of Bull Trout in the Deadwood and Payette rivers, Idaho; Final Report Phase II
2008	Reclamation 2009a	2008 Reclamation ESA Annual Report
2009	Prisciandaro 2010	2009 Sampling Permit Report to IDFG
2006-2009	Butts et al. 2009	2006-2009 IDFG Deadwood Reservoir weir and Trawling Reports
2009	Reclamation 2010b	2009 Reclamation ESA Annual Report
2010	USFWS 2010b	Biological Opinion for the Repairs to Deadwood Dam Access Bridge Project
2010	Alsager et al. 2010	IDFG Nampa Fish Hatchery Annual Report-Deadwood weir
2010	DeHaan 2011	Genetic Analysis of Deadwood River Bull trout FY 2010 Interim Report
2010	Reclamation 2011c	2010 Reclamation ESA Annual Report
2010-2011	DeHaan 2012	Genetic Analysis of Deadwood and Payette River Bull Trout Final Report for FY 2010 and 2011
2011	Reclamation 2012	2011 Reclamation ESA Annual Report

The most relevant data from studies or reports in Table 10 are the final genetics evaluation, the Deadwood Flexibility Study, and continued fish sampling in the study area. The final genetics evaluation (DeHaan 2012) confirms that all bull trout sampled in the tailrace of Deadwood Dam were entrained from the reservoir; no other bull trout were sampled in the Deadwood River downstream of the tailrace. The Deadwood Flexibility Study began in 2007, taking an ecosystem approach to describing operational flexibility at Deadwood Dam, including modeling for hydrology, water quality, and the food web interactions in both the reservoir and Deadwood River downstream of the dam. Although the summary report is not complete, preliminary results are included in the PCE descriptions where applicable. Fish sampling efforts in the mainstem Deadwood River downstream of the dam have only sampled bull trout in the tailrace. Additionally, a sample of bull trout in Scott Creek (a tributary to Deadwood River) were radio tagged and monitored for 2 years. These fish were not documented leaving Scott Creek. Bull trout in the reservoir show consistent behavior to past observations, using habitat throughout the reservoir, but showing a preference toward the tributary bays. Telemetry data confirms that the varial zones are not barriers and that bull trout move through these areas quickly and at night.

5.3.3 Baseline Critical Habitat Conditions

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Deadwood Reservoir

PCE 1 is present, but provides a limited contribution to FMO habitat in Deadwood Reservoir. In reservoir environments, subsurface connectivity and thermal refugia are a function of several factors including thermal stratification within the reservoir, tributary inflow, wetland influence, and groundwater recharge. In deep reservoirs such as Deadwood, thermal stratification tends to be the primary driver of subsurface connectivity and thermal refugia. This relationship is more thoroughly described in the discussion of PCE 5. Tributary inflow may also play a role in providing subsurface connectivity between cold water refugia in the reservoir and tributary habitat.

Groundwater influence does not appear to provide a significant contribution to FMO habitat in Deadwood Reservoir. The topography along both sides of the reservoir is steep, which limits the influence of off-channel habitat and wetlands; however, there are small areas of wetlands associated with the mouths of tributaries predominantly along the west shoreline. High to full pool levels in the reservoir result in shallow groundwater recharge that is later released as reservoir levels drop during irrigation water withdrawals. Generally this groundwater release does not play a significant role in contributing to cold water refugia within the reservoir. Finally, there is no information indicating hyporheic exchange is occurring in the varial zones, but fine material deposited in the reservoir from naturally occurring erosion could reduce the hyporheic flow in the varial zones of the reservoir (Pruitt and Nadeau 1978). On average, the varial zone for the upper Deadwood River is 0.8 mile (1,350 meters) and 0.4 mile (573 meters) for Trail Creek.

Lower Deadwood River

PCE 1 is present, but provides a limited contribution to FMO habitat in the lower Deadwood River. The lower river travels through a narrow and deep canyon with limited alluvium depth. A generally porous substrate naturally affects the upwelling flux, creating multiple areas of riparian springs and seeps which contribute to hyporheic exchange (Reclamation 2010a).

South Fork Payette River

PCE 1 is present, but provides a limited contribution to FMO habitat in the South Fork Payette River. Geography of the river is characterized by canyons and large substrate. This type of geography likely contains multiple areas of riparian springs and seeps which contribute to hyporheic exchange.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Deadwood Reservoir

PCE 2 is present and functional and contributes to FMO habitat in Deadwood Reservoir. While bull trout are present in Deadwood Reservoir year-round, adult bull trout typically migrate out of the reservoir during the summer (July to September) and return in the fall (September to October). Migratory bull trout are known to use Trail Creek and the mainstem Deadwood River.

In Deadwood Reservoir, tributary flows are sufficient to maintain physical connectivity between the reservoir and tributaries at all times. Migration habitats in the fall experience longer varial zones and lack structural diversity. As such, bull trout may be exposed to a greater risk of predation risks. The varial zone is longest during August and September when the reservoir levels are lowest. The length of the varial zone will range from 0.5 to 1.7 miles (0.8 to 2.7 kilometers) in length depending on the water year types which correspond to 10-, 50-, and 90-percent exceedence levels. In the very driest years, this range may be exceeded when reservoir volumes drop below 50,000 acre-feet (anticipated in 2 of 30 years).

Lower Deadwood River

PCE 2 is present in and contributes to FMO habitat in the Lower Deadwood River. Deadwood Dam is a barrier to bull trout in the Deadwood River, isolating an adfluvial population of bull trout above the dam from those populations below. Below the dam, there are no known physical, water quality, or biological impediments that restrict migration to FMO habitat within the mainstream or to adjacent tributaries. Water temperatures are within the defined targets (see PCE 5). Water quantity is sufficient to maintain connectivity to the migration corridors and access to FMO habitat throughout the year. During winter, temporary and intermittent barriers may form due to the formation of anchor ice.

Currently, FMO habitat is present and functional, but no data exist to show that bull trout use this section of the river. There are two known resident bull trout populations downstream from Deadwood Dam in Scott Creek and Warm Springs Creek. Telemetry data collected from fish tagged in Scott Creek did not indicate any use of or migration to the mainstem Deadwood River. To date, the only portion of Deadwood River where bull trout have been sampled is immediately below Deadwood Dam and these were likely entrained from the reservoir (DeHaan 2012; Reclamation 2012). It is unclear what limits bull trout use of the Deadwood River. The migration corridor has no physical or biological barriers to and from any tributary creek. Tributary flows into the river, as well as releases from Deadwood Dam, are sufficient to maintain connectivity and habitat complexity throughout the year.

South Fork Payette River

PCE 2 is present in and contributes to FMO habitat in the South Fork Payette River. There are no known physical or water quality impediments that occur in the South Fork Payette River downstream of the confluence with the Deadwood River. The U.S. Forest Service (USFS) has radio tagged migratory bull trout that spawned in Clear Creek (a tributary of the South Fork Payette River upstream of Deadwood River), some of which over-winter in the South Fork Payette River below the confluence with the Deadwood River, confirming an open migration corridor. Big Falls may present a potential intermittent migration barrier in the South Fork Payette River 5.0 miles (8.0 kilometers) below the confluence of Deadwood River. While likely passable under median flow conditions, very high or very low flow may impede passage at this location.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Deadwood Reservoir

PCE 3 is present in and contributes to FMO habitat in Deadwood Reservoir. Reclamation is currently conducting a study quantifying food web interactions at each trophic level of the foodweb in Deadwood Reservoir. The Deadwood Flexibility Study summary report is expected to be completed in FY 2014; however, a few qualitative conclusions can be made at this time. Phytoplanktonic primary productivity in Deadwood Reservoir shows increases in the spring and autumn as is common to dimictic temperate lakes and reservoirs. Deadwood Reservoir is efficient in utilizing late-season nutrients to produce additional organic matter prior to onset of winter conditions and ice cover. Zooplankton sampling shows that community composition did not vary spatially between sites on given dates, suggesting that prey is available throughout the reservoir. The diet and stable isotope analysis for bull trout included a variety of prey items from different taxa similar to what is observed in other systems, suggesting that a diversity and density of prey is available for bull trout. Forage fish assemblages include a diversity of native fishes including whitefish, redband trout, sculpin, dace, and nonnative fishes as described in PCE 9.

Lower Deadwood River

PCE 3 is present in and contributes to FMO habitat in the Lower Deadwood River. Availability of terrestrial organisms of riparian origin are largely limited to the summer months during which time irrigation releases maintain flows to the point that the full channel is wetted. At this point, riparian vegetation can be utilized as cover and provide exposure to terrestrial organisms. Aquatic macroinvertebrate densities and species composition are currently being investigated for a food web modeling analysis under the Deadwood Flexibility Study (Reclamation in progress). Preliminary results suggest that while the prey base has changed, an abundance of suitable prey is available for bull trout. Forage fish assemblages include a diversity of native fishes including whitefish, redband trout, sculpin, dace, and nonnative fishes as described in PCE 9. Except for the area immediately below the dam where fish were confirmed by genetic analysis to be entrained, bull trout have not yet been found using FMO habitat in the lower Deadwood River despite the presence of PCE 3.

South Fork Payette River

PCE 3 is present in and contributes to FMO habitat in the South Fork Payette River. Fluvial bull trout are known to over-winter in the South Fork Payette River and have been tracked, using radio tags, below the confluence of the Deadwood River suggesting that adequate prey and over-wintering habitat is available in that reach to support bull trout. Forage fish assemblages include rainbow trout, dace, whitefish, and sculpin. IDFG fish sampling above the mouth of the Deadwood River found rainbow trout and whitefish to be the predominant species (IDFG 2006). Fish densities are limited by the geography of the portion of the South Fork Payette River which is largely characterized by canyons, large substrate, and higher gradient.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Deadwood Reservoir

PCE 4 is present in and contributes to FMO habitat in Deadwood Reservoir. Reservoir depth and shallow shoreline habitat provides the most significant habitat complexity and contribution toward FMO habitat. Depth allows temperature (PCE 5) and water quality conditions (PCE 8) to support bull trout use when they are known to be present. Shallow shoreline habitat allows increased primary productivity (PCE 3) that supports a diversity of prey fishes.

Habitat conditions of the watersheds that enter Deadwood Reservoir have been impacted by wildfire, floods, and debris torrents that enter Deadwood Reservoir (USFWS 2008d), contributing to a decreased complexity of reservoir habitat during drawdown conditions. Drawdowns expose the varial zone of the tributaries within Deadwood Reservoir. Habitat complexity is affected by changing the habitat features from a reservoir environment to a river type environment. A habitat survey was conducted in 2011 to quantify habitat variables in the varial zone within the reservoir (Prisciandaro 2012). Although the river habitats in the varial zone are different from those in the reservoir and degraded from unregulated systems, they still offer a variety of environments and an open migration corridor (PCE 2) that could be used by bull trout.

Lower Deadwood River

PCE 4 is present in and contributes to FMO habitat in the lower Deadwood River. The Deadwood River provides a variety of depth gradient and velocities throughout the year. The lower Deadwood River is classified as an alluvial reach with bedrock controls limiting lateral development and migration (Montgomery and Buffington 1997; 1998). It predominately has reaches characteristic of plain bed or pool riffle morphology; however, noteworthy step pool features exist, especially higher in the system. The river lacks recruitment of sediment and large woody material from sources upstream of Deadwood Dam, but recruits sediment and large woody material from sources that feed into the action area. Data collected to address T&Cs (USFWS 2005a) suggests that diverse aquatic habitats are present within the Deadwood River system action area (Reclamation in progress). The hydrograph is regulated, but produces a spring season high water peak that redistributes materials transported from unregulated tributaries throughout the Deadwood River system action area. Consistent summer flows have allowed a riparian area to become well established. The established riparian zone provides a number of benefits including, but not limited to, shading (thermal refugia), overhead cover, recruitment of large woody material, input of terrestrial prey, bank stability, and undercut banks.

The general substrate of the river below the dam is abnormally large, dominated by boulders and large cobbles and lack of fine sediments. The construction of Deadwood Dam may have contributed to this condition by creating a sediment disconnect between the upper and lower river, with most fine sediment from the upper basin being trapped within the reservoir; however, several tributaries downstream of the dam that feed into the action area contribute sediment. The lower Deadwood River is a Rosgen B2 stream type (Reclamation in progress), a moderately entrenched stream with gradients of 2 to 4 percent and bedforms dominated by boulder materials (Rosgen 1994; 1996). In the lower Deadwood River, fine materials are more common because natural recruitment is occurring through the tributaries that drain into the lower Deadwood River, starting with Wilson Creek that drains into the Deadwood River less than half a mile below the dam.

South Fork Payette River

PCE 4 is present in and contributes to FMO habitat in the South Fork Payette River. The natural geography of the reaches of the South Fork Payette River addressed in this analysis is largely characterized by canyons, large substrate, and steep gradient. It is likely these features exhibit a diversity and complexity of habitat types and processes. The river does not lack natural recruitment of sediment and large woody material from sources upstream of the action area. The riparian zone is limited because of the steep gradient, but does provide a number of benefits including, but not limited to, shading (thermal refugia), overhead cover, recruitment of large woody material, input of terrestrial prey, bank stability, and undercut banks.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Deadwood Reservoir

PCE 5 is present, but provides a limited contribution to FMO habitat in Deadwood Reservoir. From October through May, water temperatures in Deadwood Reservoir are generally suitable for bull trout throughout the water column. In early June, stratification begins, isolating cooler water lower in the water column. In wet and median years, cold water refuge is present in the lower portions of the water column and at the mouths of tributaries throughout the year. In August and September of dry years (10 percent of the years) when tributaries feeding into the action area exceed temperature criteria, the reservoir is more likely to mix, causing the cold water stratum to be evacuated. During these conditions, cold water refuge is only present at the tributary locations where sources of cold water are more likely. These areas usually provide thermal refuge when the reservoir temperatures exceed 15° C.

Water temperatures recorded in the reservoir are described in Appendix B. Monthly average temperature profiles are representative of conditions in the main reservoir (Figures 24 and 25), but may not accurately depict the conditions at the mouth of tributaries entering the reservoir. Water temperatures at the mouth of tributaries reflect a gradient of temperatures mixing from those in the tributary to those in the reservoir.

Migration corridors to tributaries exist throughout the year (Figure 24 and Figure 25). When water temperatures in the lower portions of tributaries exceed 15° C, the coolest temperatures are either in the reservoir near areas of groundwater influence (usually found to be insignificant) or at higher elevations in the tributaries.

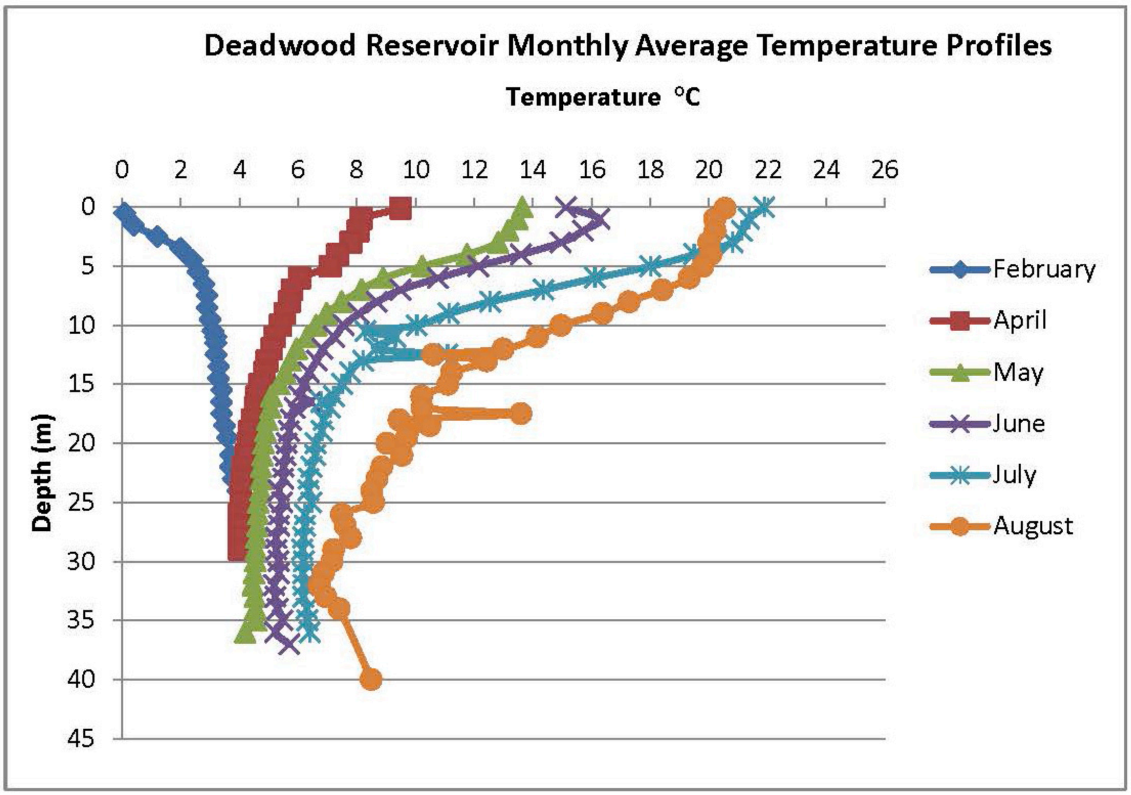

Figure 24. Monthly average temperature profiles for Deadwood Reservoir, February through August.

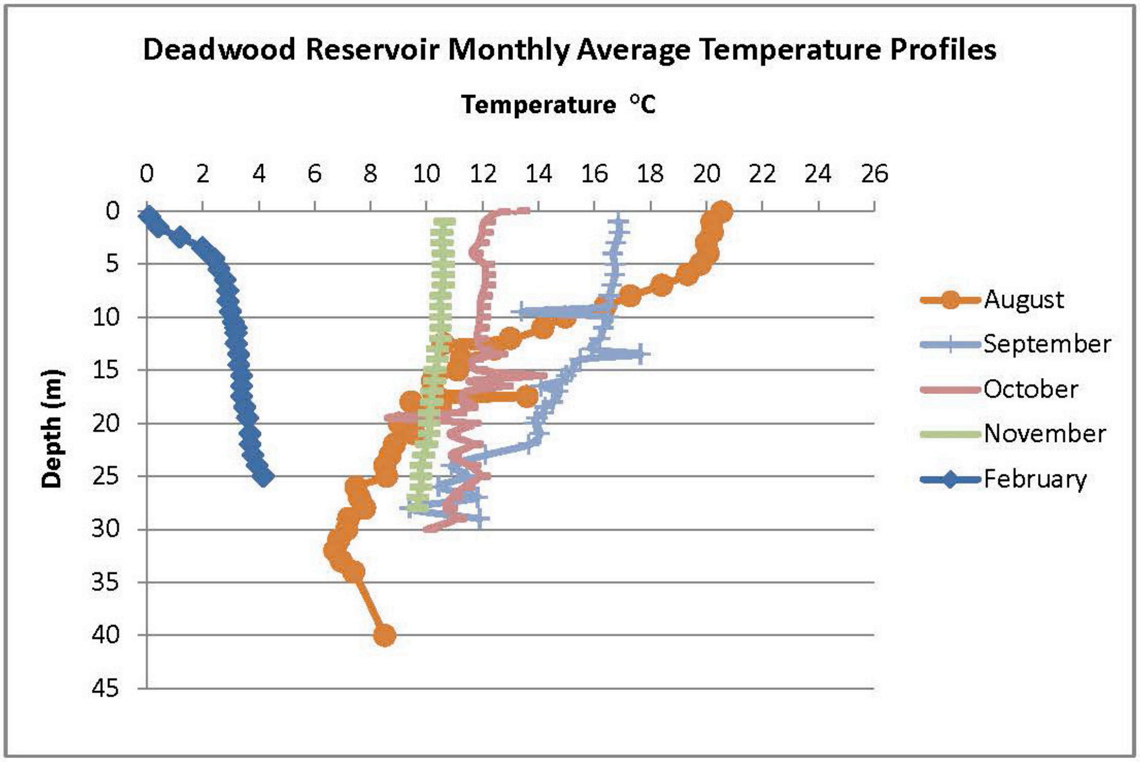

Figure 25. Monthly average temperature profile in Deadwood Reservoir, August through February.

Lower Deadwood River

PCE 5 is present, but provides a limited contribution to FMO habitat in the lower Deadwood River at all times. Water releases from the lower stratum of the reservoir keep the river temperature warmer in the winter and cooler in summer compared to unregulated tributaries above the dam. Water released exclusively through the outlet valve of the dam has temperatures between 3° and 12° C year-round except during the driest 10 percent of the years (Figure 26), although tributary inflows may exceed 15° C annually from July through August (Figure 27; Reclamation in progress). In very dry years or consecutive dry years, when the reservoir evacuates its cold water stratum, releases from Deadwood Dam may reach as high as 18° C for a short period of time in late August and September. These elevated temperatures may continue through October when cooler temperatures from the tributaries begin to influence reservoir and river temperatures (Figure 27). When elevated temperatures exist, cold water refuge is present in the Deadwood River within the main river channel where there is subsurface groundwater flow (PCE 1), in tributaries, or in the South Fork Payette River.

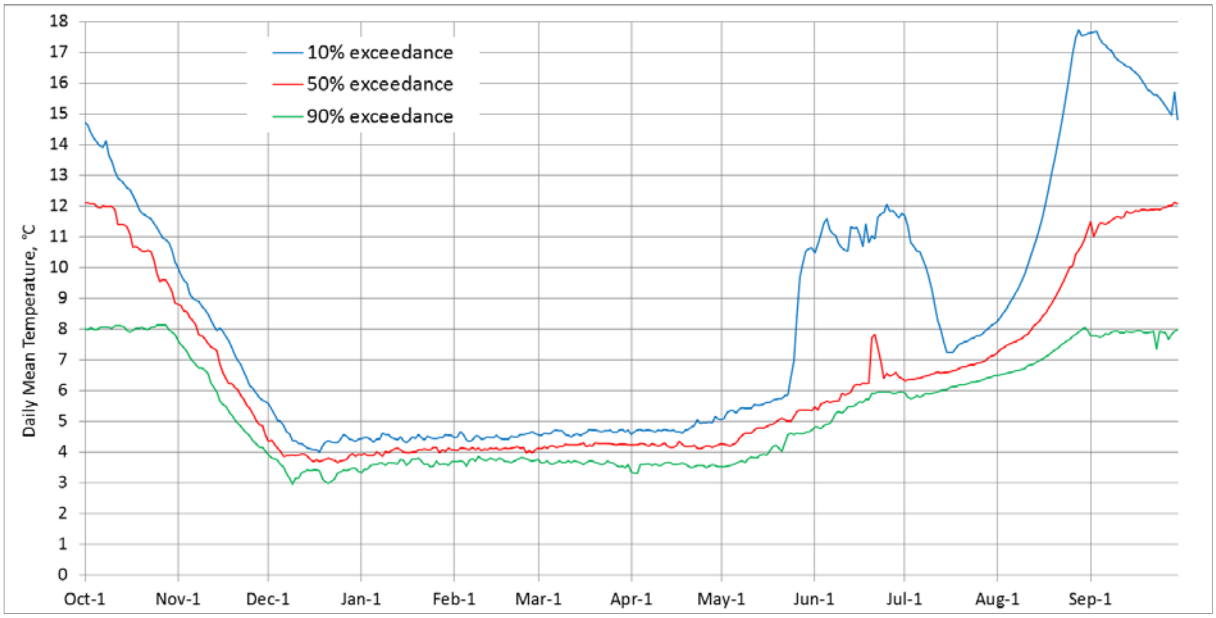

Figure 26. Summary Thermograph of Deadwood Dam Release from 1998-2012 (regulated) (Reclamation et al. 2011).

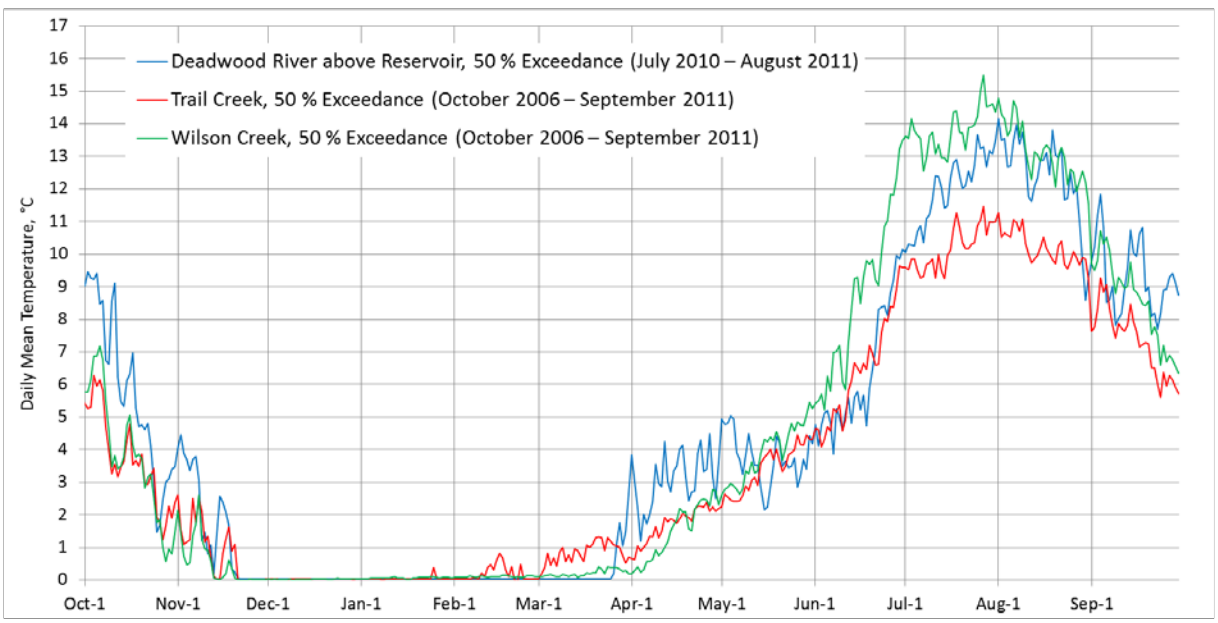

Figure 27. Summary thermograph depicting unregulated thermal regime. Trail Creek is a tributary into Deadwood Reservoir flowing (eastern exposure drainage) and Wilson Creek is a tributary flowing into the Deadwood River downstream of the reservoir (western exposure drainage).

South Fork Payette River

PCE 5 is present, but provides a limited contribution to FMO habitat in the South Fork Payette River. Temperatures in the South Fork Payette River annually exceed 15° C during the summer, reaching a high over 18° C, and fall below 2° C, reaching a low under 1° C despite the temperature influence from the Deadwood River (Figure 28, Reclamation in progress). Thermal refugia may be available in some tributaries; however, the tributary temperatures may exceed 15° C. As noted in PCE 1, there may be groundwater influence that provides thermal refugia, but its contribution may be limited. Bull trout that exhibit a fluvial life history, like the behavior recorded for bull trout that spawn in Clear Creek, likely migrate out of the mainstem South Fork Payette River before the water temperatures reach the summer maximum. Winter temperatures fall below 2° C, but are likely warmer than water entering the South Fork Payette River from tributaries.

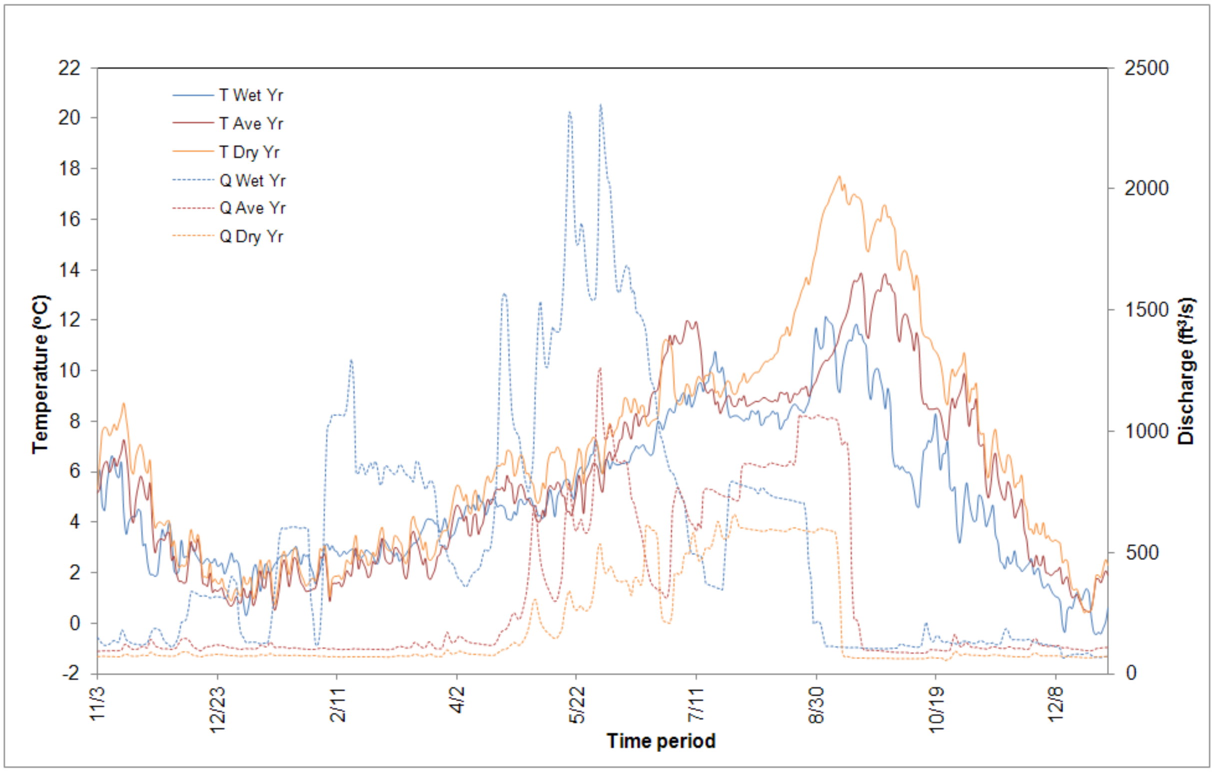

Figure 28. Regulated flow regime for the Deadwood River near the confluence with the South Fork Payette for dry, average and wet years: a) dashed lines represent the hydrograph (right axis), b) solid lines represent the thermograph (left axis) taken from Deadwood Flexibility Report (Reclamation in progress). Dry, average and wet years are similar but do not do not directly correspond to 10, 50, and 90% exceedences.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present in the areas analyzed in this section. No spawning and rearing habitat has been designated in the Deadwood Reservoir, Deadwood River downstream of the dam, or South Fork Payette River action areas (USFWS 2010a, pages 629, 641).

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

Deadwood Reservoir

PCE 7 is not present in Deadwood Reservoir. PCE 7 refers to "a natural hydrograph including peak, high, low and base flows, or if flows are controlled minimal flow departure from a natural hydrograph." Accordingly, PCE 7 addresses the timing and amount and timing of stream flow, a characteristic that is, by definition, not present in a reservoir environment.

Lower Deadwood River

PCE 7 is present, but provides a limited contribution to FMO habitat in the lower Deadwood River. A recent study modeled unregulated flow out of the Deadwood River basin (Figure 28; Reclamation et al. 2011) and this modeled hydrograph was compared to the current discharge from Deadwood Reservoir. Generally, there is an altered hydrograph characterized by flows that are lower in the winter and spring when the reservoir is refilling and higher in the summer from irrigation deliveries.

During the winter period, dam-regulated releases are generally 50 percent lower than the unregulated inflow into the reservoir. The effect of dam storage reduces late fall stream flows in the river below that dam and lowers the peak hydrograph during the spring runoff except when water is discharged over the spillway (11 of 30 years). In the summer, flows are artificially high due to irrigation deliveries which generally run through late August.

South Fork Payette River

PCE 7 is present in and contributes to FMO habitat in the South Fork Payette River. The river is not regulated and is characterized by the typical snow melt runoff hydrographs seen in the west. Managed flows from Deadwood Reservoir slow the descending limb of the hydrograph during the month of August (Figure 29). During the August irrigation season, releases maintain the hydrograph at a higher level than what is observed naturally, but are still within the range of the natural hydrograph.

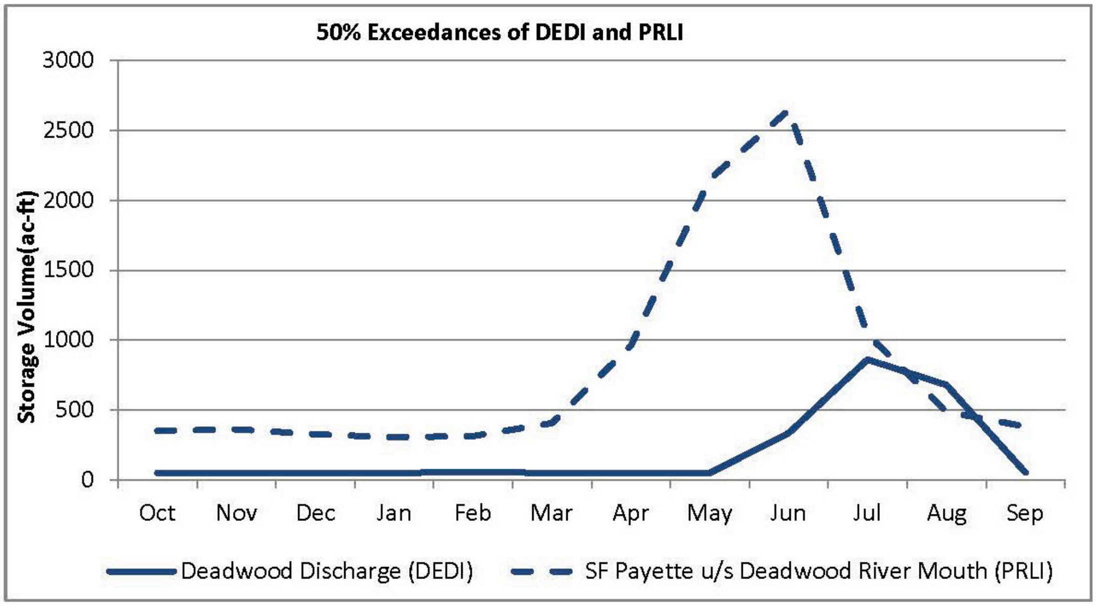

Figure 29. Comparison of 50% exceedance flow from Deadwood Dam (DEDI) and flow in the South Fork Payette River 3.0 miles (4.8 kilometers) upstream of the confluence with the Deadwood River (PRLI gage; Reclamation 2013).

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Deadwood Reservoir

PCE 8 is present in and contributes to FMO habitat in Deadwood Reservoir. Water quality and quantity allows adult and subadult bull trout to use Deadwood Reservoir as FMO habitat throughout the year, but shows seasonal limitations during 10 percent of the years when severe drawdowns may occur in combination with warm ambient air temperatures. The water quality and quantity in Deadwood Reservoir is more biologically productive than expected for a high-elevation reservoir situated in a relatively undeveloped drainage basin (Reclamation et al. 2011). The reservoir is classified as oligotrophic, indicating that a nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir.

Suitable water temperatures and dissolved oxygen levels typically exist in the reservoir throughout the year. Water temperature and dissolved oxygen conditions annually progress through stratification and thermocline breakdown. These processes will typically leave a thermal and oxygen refugia between 20 feet and 53 feet (6 and 16 meters) in the reservoir during the summer critical period (see Appendix B).

Sediment and turbidity levels are typically very low and should not impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity. Water quality and quantity are adequate to allow the prey base (fish, aquatic invertebrates and zooplankton) to remain at sufficient levels to support bull trout. The TN:TP ratios indicate that blue green algae and other unpalatable forms of nitrogen-fixing algae should not dominate the reservoir as nitrogen is common. Furthermore, the types of algae that are often associated with the observed TN:TP ratios should provide suitable forage for zooplankton and other aquatic invertebrates.

Lower Deadwood River

PCE 8 is present in and contributes to FMO habitat in the lower Deadwood River. Water quality and quantity would allow bull trout to use the lower Deadwood River as FMO habitat throughout the year if bull trout were present. Nutrients are retained in Deadwood Reservoir during most of the year; however, during periods of high flow from tributaries, nutrient inputs occur from natural sources. Nutrients and chlorophyll from the reservoir are important components of riverine productivity, which shift from a phytoplankton-dominated system in the reservoir to a periphyton-dominated one in the river (Reclamation et al. 2011, page 8). Water temperatures and dissolved oxygen levels may show seasonal limitations in September and October (see Appendix B and PCE 5). Sediment and turbidity levels are typically very low and should not impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity. Some tributaries, however, appear to contribute significant sediment loads to the lower Deadwood River and may limit the function of PCE 8 at some locations. Water quality and quantity are adequate to allow the prey base (fish, aquatic invertebrates and zooplankton) to remain at sufficient levels to support bull trout if present.

South Fork Payette River

PCE 8 is present in and contributes to FMO habitat in the South Fork Payette River. Generally, the water quality in the South Fork Payette River is suitable for bull trout. IDEQ's most recent 5-year review of the South Fork Payette River basin found only suspended sediment, largely a product of forest roads, as a factor that could limit bull trout habitat. Sediment levels exceeded target levels during years of high flow. IDEQ did not recommend developing sediment TMDL because the river appears to adequately transport suspended sediment without excessive aggradation or degradation (IDEQ 2011).

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Fish stocking and management of fish populations within the State of Idaho is regulated by the IDFG.

Deadwood Reservoir

PCE 9 is present in and contributes to FMO habitat in Deadwood Reservoir. Beginning in 2009, IDFG has stocked nonnative Kamloop rainbow trout and Chinook salmon in Deadwood Reservoir. Kokanee are also present (IDFG 2013b) and provide a food base for bull trout, adult rainbow trout, and Chinook salmon. While young nonnative fish are prey for predatory fishes, including bull trout in Deadwood Reservoir, adult rainbow trout and Chinook salmon may also prey on young bull trout. The degree to which nonnative rainbow trout and Chinook salmon compete with bull trout in Deadwood Reservoir is unknown. Their continued presence seems to create a risk of competition to bull trout and limit the presence of PCE 9 in the reservoir. Brook trout are not known to exist in this area.

Lower Deadwood River

PCE 9 is present in and contributes to FMO habitat in the lower Deadwood River. In the past, IDFG has stocked fish in the lower Deadwood River, but these programs were discontinued in 2003 (IDFG 2013b). Species composition in the Deadwood River below the dam is dominated by rainbow trout, sculpin, and dace. The most commonly sampled nonnative species in this reach are kokanee and rainbow trout. The only age class of kokanee that has been observed is young-of-year; few of these fish are thought to survive. The kokanee are likely entrained through the outlet works. While most of the entrained kokanee become prey for predators in the lower Deadwood River and do not survive, USFS staff observed four adult kokanee at the Clear Creek migration weir in the fall 2007. These fish could only have come from Deadwood Reservoir because no other populations are known to exist in the basin. The rainbow trout are likely a hybrid of native redband and introduced rainbow trout from past stocking efforts. Young nonnative fish are prey for bull trout and adults are not large enough to prey upon most size classes of bull trout.

South Fork Payette River

PCE 9 is present in and contributes to FMO habitat in the South Fork Payette River. No nonnative predatory fishes are known to exist in the South Fork Payette River. Brook trout have been documented in the watershed. Fish stocking has not occurred in the South Fork Payette River since 2007 (IDFG 2013).

5.4 Effects of the Proposed Action

5.4.1 Effects of the Proposed Action on Bull Trout

Reclamation has considered new information relevant to bull trout use of the Payette Division of the Boise Project in the Deadwood and Payette river drainages available since the 2005 (Table 10). The new information provides more precise detail and data than was previously available; however, no new information exists that would indicate an effect of a different degree or nature than was previously considered in the 2004 Upper Snake BA and 2005 USFWS BiOp. Therefore, Reclamation has determined that the previous findings are still appropriate and is not reinitiating consultation at this time for the species in this section.

5.4.2 Effects of the Proposed Action on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Deadwood Reservoir

The operation of Deadwood Dam will have discountable effects on PCE 1 within Deadwood Reservoir. As noted previously, springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quantity or water quality in Deadwood Reservoir. Although, reservoir operations may influence shallow groundwater exchange, the influence of this exchange is not of sufficient scale to influence thermal refugia in the reservoir as a whole.

Lower Deadwood River

The operation of Deadwood Dam has an insignificant effect on PCE 1 in the Deadwood River. Effects of discharge from Deadwood Dam on the hyporheic exchange in the river below the dam were modeled in the Deadwood Flexibility Study (Reclamation in progress). Preliminary results of this work suggest releases from Deadwood Reservoir greater than 400 cfs can lower the hyporheic exchange as a result of increased water pressure that limits where groundwater influence occurs. Flows greater than 400 cfs may occur in the spring under flood control conditions or more often, from mid-June through mid-August when releasing irrigation and salmon flow augmentation flows. At these times, hyporheic flows do not play a significant role in the Deadwood River because cold water released from Deadwood Reservoir provides adequate thermal refuge and because the quantity of subsurface flows is small relative to discharge from Deadwood Dam.

South Fork Payette River

The operation of Deadwood Dam has an insignificant effect on PCE 1 in the South Fork Payette River. In the Payette River, measuring the effects of operations on hyporheic flow has not been performed; however, the effects are thought to be minimal or immeasurable because of the relatively small proportion of flow that the Deadwood River contributes to the Payette River.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Deadwood Reservoir

The operation of Deadwood Dam has infrequent adverse effects on PCE 2 in the fall in low water years when reservoir volume drops below 50,000 acre-feet in 2 of 30 years. As described in the environmental baseline, reduced structural diversity and increased length of the varial zone may increase predation as bull trout migrate between the reservoir and tributary habitat. The operation of Deadwood Dam can extend the length of the varial zone in August and September when reservoir elevations are at their lowest. It is likely the proposed action will have similar effects to those observed under baseline conditions. Although climate change may increase reservoir elevations under dry conditions, August and September reservoir elevations under median and wet conditions are not expected to change substantially in the future. Accordingly, Reclamation anticipates a similar average varial zone length in the future.

Migration corridors in the spring are in good condition. No migration impediments occur during the spring migration period for fish migrating out of the reservoir to spawning habitat. Reservoir drawdowns can expose varial zones during the fall migration season in most years; however, connectivity is maintained at all times. The varial zone experiences a reduction of structural diversity in the fall, as structural diversity is reduced the risk of predation increases, if predation increases to significant levels, it could pose a biological barrier.

Despite varial zone effects, PCE 2 will continue to contribute to FMO habitat in Deadwood Reservoir. Depth and respective depth cover are seasonally limited in the varial zone of the reservoir, but do not create a barrier to migration. Reclamation data show bull trout typically migrate through varial zones at night and generally within a few hours (Reclamation internal data from Deadwood and Arrowrock Reservoirs). By moving through the varial zone in one evening, the migrating fish minimize risk of increased predation due to a lack of structural diversity within the varial zone. Reservoir conditions have been shown to provide habitat conditions suitable for bull trout to migrate through the varial zone in one evening.

Lower Deadwood River

The operation of Deadwood Dam will have an insignificant effect on PCE 2. The combination of releases from Deadwood Dam and tributary inflow are sufficient to maintain physical, water quality, and biological connectivity between the Deadwood River and its tributaries.

South Fork Payette River

The operation of Deadwood Dam will have an insignificant effect on PCE 2 in the South Fork Payette River. While timing of bull trout migration is not well documented in this reach, USFS estimates spawning migrations into tributaries occur in July and those fish return to the South Fork Payette River in September (Green 2008). Reclamation is delivering irrigation and salmon augmentation water at this time. These deliveries increase flows over natural conditions in the river. The deliveries are not likely to have any negative effects on the migration corridors in the river and may have a small beneficial effect by increasing flow conditions during that time period. While the effect of these releases on water temperature is not precisely known (see PCE 5), maximum temperatures released from the dam remain within the range suitable for bull trout migration (Howell et al. 2010).

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Deadwood Reservoir

The operation of Deadwood Reservoir has infrequent adverse effects on PCE 3 when the reservoir volume drops below 50,000 acre-feet in 2 of 30 years. These conditions typically occur in the fall, causing an indirect impact of water quality on primary productivity. Reservoir volumes above 50,000 acre-feet generally support water quality and condition suitable for both phytoplankton and zooplankton production, which in turn support the forage base within the reservoir. Additionally, the higher trophic levels have a diversity of prey species available, including kokanee, long nosed dace, juvenile mountain whitefish, sculpin, and redsided shiners. At reservoir volumes below 50,000 acre-feet, there is an increased risk that high ambient air temperatures could degrade water quality to an extent that would undercut primary productivity and impact the availability of prey fish. Climate change projections suggest low reservoir volumes may occur less frequently, but it is not yet clear how corresponding changes in regional climate may affect productivity. Accordingly, Reclamation anticipates the prey base in Deadwood Reservoir will remain an important contributor to bull trout habitat in most years.

Lower Deadwood River

The operation of Deadwood Dam will have an insignificant effect on of PCE 3 in the Deadwood River. Data collected in the Deadwood Flexibility Study from 2006 through 2012 showed that primary productivity in the river below Deadwood Dam is generally good. The Deadwood River supports densities of macroinvertebrates that are similar to those in reference sites outside the action area in adjacent unregulated watersheds. Under the proposed action, these conditions are expected to continue. The river environment is dominated by periphyton as compared to a phytoplankton-based productivity in the reservoir (PCE 8). Reclamation anticipates PCE 3 will continue to contribute to FMO habitat in the Deadwood River.

South Fork Payette River

The operation of Deadwood Dam will have an insignificant effect on PCE 3 in the South Fork Payette River. The operation of Deadwood Dam can affect flows in the South Fork Payette River; however, these impacts are attenuated by additional inflows from the broader South Fork Payette Basin. While little is data available, sampling performed by IDFG in 2006 showed similar fish assemblages to other areas in the watershed. Reclamation anticipates the conditions observed under the environmental baseline are likely to continue for the duration of the proposed action.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Deadwood Reservoir

The operation of Deadwood Dam has an insignificant effect on PCE 4. In general, Deadwood Reservoir provides a variety of complex habitat features, including bays where tributaries enter the reservoir, a shallow delta area with established vegetation near the mouth of tributaries, islands, and depth refuge within the reservoir. These habitats provide substrate for terrestrial and aquatic macroinvertebrates, as well as cover for juvenile fishes (prey for bull trout). Although habitats in the reservoir change continually with pool elevation, functional complexity exists throughout the year. While drawdowns may reduce the interface with shoreline vegetation, bull trout retain access to a diversity of habitats in the reservoir and a migration corridor to upstream tributaries, allowing this PCE to remain functional. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range analyzed in the proposed action (Figure 22).

The proposed action retains the function of the PCE by limiting fall drawdowns below 50,000 feet to 2 of 30 years analyzed (Table 8).

Lower Deadwood River

The operation of Deadwood Dam has an insignificant effect on PCE 4 in the Deadwood River. The lower Deadwood River provides a variety of complex habitat features including an established riparian zone, side channels, and habitat types (pools, riffles, runs) expected in a river environment. An established riparian zone and interaction with the wetted channel throughout most of the year increases habitat complexity. Outside of the irrigation season, the proposed action retains the function of the PCE by maintaining a minimum flow of 50 cfs. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

As noted in the baseline discussion of PCE 2, bull trout use of the lower Deadwood River is limited despite the presence of suitable FMO habitat. While reasons for this are not yet known, it may be that naturally occurring baseline factors limit the utility of FMO habitat in this reach.

The managed hydrograph of the proposed action has allowed an established riparian zone to be maintained, providing beneficial effects throughout the year.

South Fork Payette River

The operation of Deadwood Dam has an insignificant effect on PCE 4 in the South Fork Payette River. The South Fork Payette River provides a variety of complex habitat features including an established riparian zone, side channels and habitat types (pools, riffles, runs) expected in a river environment. An established riparian zone and interaction with the wetted channel throughout most of the year increases habitat complexity. During July and August, the South Fork Payette River hydrograph continues to decline, but at a slower pace as a result of water releases from Deadwood Reservoir. The effects of the proposed action are insignificant, as the natural geography of the reach is the primary factor impacting habitat. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Deadwood Reservoir

The operation of Deadwood Dam has an infrequent adverse effect on PCE 5 in Deadwood Reservoir when water volumes fall below 50,000 acre-feet in 2 of 30 years. Generally, water temperature and thermal refugia conditions in reservoir environments are the result of a complex relationship of tributary inflow volume and temperature; reservoir volume and releases; and climatic factors such as solar loading, wind, and air temperature. Operations contribute to this relationship when the cold water stratum is evacuated from the reservoir. These conditions are associated with higher water temperatures and reduced in-reservoir thermal refugia. Climate change forecasts suggest higher reservoir elevations in the future (see section 5.3.1).

When the reservoir volume exceeds 50,000 acre-feet, the stratified reservoir will continue to provide refugia for bull trout between the warmer epilimnion waters and the minor oxygen depletion in the hypolimnion waters (Appendix B). Under low water volume conditions (below 50,000 acre-feet), thermal refugia in the reservoir will be affected, but migration corridors to cooler tributaries remain open (Figure 26).

Lower Deadwood River

The operation of Deadwood Dam has both beneficial and infrequent adverse effects on PCE 5 in the lower Deadwood River when summer releases from Deadwood Dam exceed 15° C in 2 of 30 years. Releases from Deadwood Dam affect temperatures downstream differently depending on the time of year and the manner water is released from the reservoir. During the winter, water in the reservoir tends to be about 4° C warmer than surrounding tributaries, yet within the suitable range for bull trout. During the spring, releases through the outlet works (about 65 percent of the time) result in temperatures between 5° and 13° C. Release of water from the upper portion of the water column as spill (about 35 percent of the time) is warmer, resulting in temperatures between 10° and 14° C. Summer releases tend to come from the lower, cooler stratum in the reservoir, reducing summer temperatures by up to 4° C from those of the unmanaged tributaries and benefiting PCE 5. In dry years, when the reservoir water volume falls below 50,000 acre-feet, all of the cooler water may be evacuated and releases from the dam may reach 18° C. Generally, the operation of Deadwood Dam results in stream temperatures between 2° and 15° C. In dry years, there may be an adverse effect when temperatures below the dam may rise to 18° C, but cold water refugia and connectivity to cooler tributary habitats likely ameliorates the adverse effect of these high temperatures.

South Fork Payette River

The operation of Deadwood Dam has an insignificant effect on PCE 5 in the South Fork Payette River. Deadwood River flows, of which reservoir releases are one component, are less than 11 percent of the total flow in the Payette River. While the precise influence of Deadwood Dam operation on temperatures in the South Fork Payette River is unknown, it is likely the effects are insignificant and quickly dissipated. There is some indication that the Deadwood River is cooler in summer than the South Fork Payette River, potentially acting as a thermal refuge during July and August when South Fork Payette River temperatures are at their highest. Winter water temperatures recorded near the mouth of the Deadwood River are similar to those in the South Fork Payette River: cooler than 2° C, but warmer than most tributaries (PCE 5 for Deadwood River).

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Deadwood Reservoir and the Deadwood River downstream of the dam have not been designated as spawning and rearing habitat (USFWS 2010a, pages 629, 641); therefore, the effects were not analyzed.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

Deadwood Reservoir

PCE 7 is not present in Deadwood Reservoir; therefore, the effects were not analyzed.

Lower Deadwood River

The operation of Deadwood Dam adversely affects PCE 7 in the lower Deadwood River throughout the year; however, the PCE remains functional and provides beneficial effects to other PCEs as a result of being altered (PCE 4 and 5). Releases from Deadwood Dam will continue to affect the hydrograph in the Deadwood River by shifting peak flows to summer months, maintaining higher flows than unregulated conditions in summer months, reducing flows during from October through March, and diminishing diurnal fluctuations throughout the year. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

The effects of Deadwood Dam operation on the lower Deadwood River are adverse because in general, reservoir operations regulate the hydrograph characterized by flows that are lower in the winter and spring, lower during the spring peak, and higher in the summer with irrigation deliveries. Base flows of 50 cfs from October through March assure adequate migration corridors, but diminish some habitat characteristics (Pruitt and Nadeau 1978). The regulated hydrograph will retain general characteristics of a natural hydrograph, including high spring flows diminishing later in the year. Tributary inflow diminishes these effects as the Deadwood River travels downstream; thus, the greatest effect occurs immediately below Deadwood Dam.

South Fork Payette River

The operation of Deadwood Dam has an insignificant effect on PCE 7 in the lower South Fork Payette River throughout the year. As described in the environmental baseline, the South Fork Payette River retains most characteristics of a natural hydrograph, primarily because the operations of Deadwood Dam are relatively small when compared to tributary inflow between the dam and the South Fork Payette River. A slight effect occurs in July and August (see PCE 7 baseline) when irrigation flows and salmon augmentation releases increase summer base flows in accordance with the 2008 NOAA Fisheries BiOp. During this period, regulated flows slow the decline of the hydrograph, but do not cause the trajectory to change. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Deadwood Reservoir

The operation of Deadwood Dam has an infrequent adverse effect on PCE 8 when reservoir elevation drops below 50,000 acre-feet in August and September in 2 of 30 years. The operation of Deadwood Reservoir influences water temperatures and water quality conditions indirectly through a set of complex interactions with incoming water temperature, solar loading, release of cold water from the bottom of the reservoir, and the influence of reservoir elevation on thermal stratification. Water quality conditions in the reservoir are typically suitable for bull trout and bull trout prey (PCE 3) at volumes above 50,000 acre-feet (USFWS 2005a). Below that volume, an increased probability of degraded conditions for dissolved oxygen exists. Although adverse effects may infrequently occur, water quality conditions indicate a functional PCE for both bull trout and bull trout prey (PCE 3) in Deadwood Reservoir (Appendix B). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

Operational indicators for Deadwood Reservoir (Table 8) have been developed to protect critical habitat by minimizing the frequency of drawdown below 50,000 acre-feet to 2 of 30 years. Deadwood Reservoir has not been drafted to the 50,000 acre-foot level since the 2005 USFWS BiOp. The Flexibility Study is using newly acquired data to examine the T&C's and operational indicators to determine the most appropriate criteria to protect water quality during periods of hot and dry weather.

Lower Deadwood River

The operation of Deadwood Reservoir has a seasonal adverse effect on PCE 8 in the winter when the combination of no surface ice and air temperatures consistently below freezing cause frazil and anchor ice to form (Tiedemann 2013). Winter conditions allow the formation of subsurface ice because the water temperatures are too warm to promote stable surface ice formation. Surface ice functions to insulate the water beneath it, reducing the potential for the formation of frazil and anchor ice. Frazil ice forms when a "seed crystal" is created and suspended within the water column. Frazil ice recruits additional mass while suspended and tends to cling to unheated subsurface objects such as rock substrate, vegetation, or woody material (Brown et al. 2011). Frazil ice that adheres is called anchor ice. An accumulation of anchor ice can reduce flow, resulting in areas of increased velocity and sometimes ice dams. The primary effects of these ice dynamics on bull trout are the potential for increased metabolic expenditure to avoid areas of frazil or anchor ice accumulations and frazil ice to clog a fish's gills. Releases from Deadwood Dam are likely to remain within the historic range and the conditions that cause the ice formations described above are present in all years, but largely depend on ambient air temperatures. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

Operations affect water quality in the spring and summer through biotic processes in Deadwood Reservoir which influences nutrient loads downstream (Reclamation et al. 2011, page 2). While nutrient loads do not directly impact bull trout, they can influence the productivity of the Deadwood River. However, work performed during the Deadwood Flexibility Study suggests that the water quality is sufficient to provide macroinvertebrate densities similar to unmanaged reference streams within the basin.

Operations also affect the quantity of water in the Deadwood River. Reclamation releases a base flow of 50 cfs from Deadwood Reservoir which maintains a sufficient flow for migration (Pruitt and Nadeau 1978). Furthermore, habitat surveys performed during the Deadwood Flexibility Study suggest that the frequency and depth of pools available for over-wintering maintains the function of PCE 8.

South Fork Payette River

Operation of Deadwood Dam has an insignificant effect on PCE 8 in the South Fork Payette River. Nutrient concentrations will continue to be diluted as they move downstream, presumably reaching levels close to those in the South Fork Payette River (Reclamation et al. 2011). The small amount of influence on the South Fork Payette hydrograph by the Deadwood River would suggest that, although not measured in the South Fork Payette River, nutrient concentrations reach ambient conditions through dilution soon after mixing. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 22).

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Deadwood Reservoir, Lower Deadwood River, South Fork Payette River Basin

The operation of Deadwood Dam has an insignificant effect on PCE 9. The proposed action provides an environment that allows the survival of nonnative fishes; however, IDFG exclusively manages the fisheries including stocking and regulations that favor the presence of individual species. The proposed action plays an insignificant role in the occurrence of nonnative fishes compared to variables (fish management and interbreeding) independent from the operation of Deadwood Dam.

5.4.3 Summary of the Effects of the Proposed Action

Under the proposed action, conditions in the Payette Division of the Boise Project in the Deadwood and Payette river drainages would continue to provide conditions throughout most of the year that were identified by the PCEs as important for the survival of bull trout. Depending on climate patterns and water needs, the availability of bull trout habitat may be limited by yearly and seasonal fluctuations in water supply and irrigation demands. Based on available trend data, habitat conditions created by the current reservoir operations support a stable and at times, increasing population of adfluvial bull trout.

Table 11. Summary of the effects of the proposed action for Deadwood Reservoir, lower Deadwood River, and South Fork Payette River.

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action		
		Deadwood Reservoir	Lower Deadwood River	South Fork Payette River
PCE 1	Springs, seeps, groundwater sources	Discountable	Insignificant effect	Insignificant effect
PCE 2	Migration habitats with minimal impediments.	Infrequent adverse effects when reservoir volume drops below 50,000 acre-feet in 2 of 30 years	Insignificant effect	Insignificant effect
PCE 3	Abundant food base	Infrequent adverse effects when reservoir volumes drop below 50,000 acre-feet in 2 of 30 years	Insignificant effect	Insignificant effect
PCE 4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect	Insignificant effect	Insignificant effect
PCE 5	Water temps ranging from 2°-15 ^{o}C with adequate thermal refugia	Infrequent adverse effects when reservoir volumes drop below 50,000 acre-feet in 2 of 30 years	Infrequent adverse effect in 2 of 30 years	Insignificant effect
PCE 6	Spawning/rearing substrate.	Not present	Not present	Not present
PCE 7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present.	Adverse effect, but hydrograph remains functional and beneficial to PCEs 4 and 5	Insignificant effect
PCE 8	Sufficient water quality and quantity	Infrequent adverse effects when reservoir volumes drop below 50,000 acre-feet in 2 of 30 years	Seasonal adverse effect if frazil ice forms in winter	Insignificant effect
PCE 9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect	Insignificant effect	Insignificant effect

5.5 Cumulative Effects

Climate change may alter aquatic habitat (e.g., quantity, peaks, temperature) in the Deadwood River basin. Climate change modeling indicates increased precipitation in the Pacific Northwest, but warming trends may result in shifting cool season precipitation from snow to more rain events. Warming is expected to reduce the snowpack from late fall through early spring, resulting in diminished runoff. The amount and timing of precipitation and increasing water temperatures may reduce suitable critical habitat. These same variables may also cause behavioral changes in the life history of the bull trout.

Future environmental conditions will likely affect bull trout and their critical habitat inside and outside of the core area as defined in this document. Connectivity between core critical habitats will be crucial for the continued existence of the migratory life stage of this species. Current studies demonstrate the ability of bull trout to temporarily tolerate conditions outside their previously defined ranges. The life history of adfluvial bull trout may adapt to more fluvial habitats, using reservoir environments seasonally as is currently observed in some reservoirs, as long as migration corridors are open.

Cumulative effects could include increases in recreational fishing pressure and the resulting stress or mortality (subadult and adult survival); the effects of large fires (spawning, rearing, and migration corridor); increased sedimentation from roads, timber harvest, and mining activities (spawning, rearing and migration corridor); connectivity to spawning tributaries (spawning and rearing); and quality of spawning habitat. Furthermore, climate change modeling suggests that suitability of headwater spawning habitats may be limited with only slight changes in water temperature (Rieman et al. 2007).

5.6 Determination

Reclamation has determined that future O&M in the Deadwood River system **may affect and is likely to adversely affect** bull trout critical habitat in Deadwood Reservoir and the Deadwood River downstream of the dam. Not all PCEs are supported by habitats in every action area. Future O&M in the Deadwood River system does not significantly affect bull trout critical habitat in the South Fork Payette River.

Adverse effects to bull trout critical habitat at Deadwood Reservoir occur in 2 of 30 years when Deadwood Reservoir is drawn down below 50,000-acre-feet, affecting PCEs 2, 3, 5, and 8.

Adverse effects to bull trout critical habitat in the Deadwood River below the dam occur yearly as the natural hydrograph is altered by storage and delivery of water (PCE 7). However, PCE 7 remains some functional and provides some beneficial effects to PCEs 4 and 5 as a result of being altered. Adverse effects to bull trout critical habitat will occur in 2 of 30 years in the fall when water temperatures exceed the range specified in the PCE. Adverse effects may occur seasonally in the winter if frazil ice forms when water is discharged from Deadwood Reservoir.

6.0 MALHEUR RIVER SYSTEM

6.1 Proposed Action

The future O&M of the Malheur River system is described in the 2004 Upper Snake BA (Reclamation 2004a, page 21) and in the 2004 Operations (Reclamation 2004b, pages 119-127). The proposed action includes the continued O&M of the Vale Project. Since the 2004 Upper Snake BA, no new facilities have been constructed in the Malheur River system. All other features and O&M activities are the same as described in the 2004 Upper Snake BA.

The proposed action also incorporates implementation of T&Cs from the 2005 USFWS BiOp. Table 12 lists T&Cs, the purposes of the T&Cs, and the current status of studies or activities designed to address the T&Cs.

Table 12. Terms and Conditions (T&C) from the 2005 USFWS BiOp that pertain to Agency Valley Dam and Beulah Reservoir.

T&C	Action Area	Description	Purpose	Studies
4.a	Agency Valley Dam	Reduce frequency and extent of drawdown of Beulah Reservoir. Work to identify target reservoir elevation to minimize take effects from reservoir drawdown.	Reduce harm and harassment associated with reduced or eliminated prey.	Ongoing
4.b.	Agency Valley Dam	When conditions preclude maintaining water levels that support a viable bull trout prey base, supplement Beulah Reservoir with suitable prey fish. Supplemental stocking occurs every year that Beulah Reservoir is reduced below the level identified as part of Term and Condition 4.a.	Reduce take associated with reduced reservoir productivity and prey abundance that results from extreme drawdown.	Ongoing

T&C	Action Area	Description	Purpose	Studies
4.c.	Agency Valley Dam	Work to implement any potential mechanism to reduce reservoir drawdown so that the reservoir does not go below a level sufficient to maintain some habitat for bull trout prey.	Reduce anticipated take from reservoir drawdown.	A minimum pool of 2,000 acre-feet has been put in place during ongoing studies until reservoir levels identified in T&C 4.a. have been identified.
4.d.	Agency Valley Dam	Continue all existing efforts to trap and return bull trout that are entrained during all years when the spillway is used at Agency Valley Dam back to Beulah Reservoir or the North Fork Malheur River upstream of Agency Valley Dam.	Reduce anticipated take from entrainment during years when spill occurs.	Implemented according to Monitoring and Implementation Plan (Reclamation 2006)

To implement the T&Cs of the 2005 USFWS BiOp, Reclamation prepared a monitoring and implementation plan that identified operational indicators to monitor incidental take associated with the proposed action (Reclamation 2006). Operational indicators describe a set of measurable criteria, such as specific reservoir elevations, that allow Reclamation to verify compliance with the T&Cs of the 2005 incidental take statement. Table 13 lists the two operational indicators associated with the Vale Project.

Table 13. Operational Indicators associated with Agency Valley Dam/ Beulah Reservoir (Reclamation 2006). Data updated through Water Year 2012.

Facility	Anticipated Take	Operational Indicator	Critical Season	Expected Occurrence/Recorded Occurrences
Agency Valley Dam/Beulah Reservoir	Up to 10 percent of bull trout in Beulah Reservoir are entrained into the North Fork Malheur River below Agency Valley Dam.	Water is dicharged over the spillway	May through June	3 of 30 years; this has occurred twice since 2006
Agency Valley Dam/Beulah Reservoir	All bull trout that return to Beulah Reserovir to over-winter are affected by a reduced prey base.	Reservoir storage volume falls below 2,000 acre-feet	August through October	10 of 30 years; this has occurred 4 times since 2006

6.2 Action Area

A detailed description of the Malheur River system action area appears in the 2004 Upper Snake BA (Reclamation 2004a, page 21) and the 2004 Operations for Reclamation projects in the Snake River above Brownlee Dam (Reclamation 2004b, page 119-127). The analysis in this chapter focuses on one location where the Malheur River system action area overlaps with the Malheur River CHSU:

- **Beulah Reservoir** (1,769 acres [716 hectares]) is part of the North Fork Malheur River CHSU and contains FMO habitat.

Bull trout in the Malheur River system are part of the Malheur River Basin CHU (CHU 24) as defined in 75 FR 63898 and Chapter 24 of the *Bull Trout Final Critical Habitat Justification* (USFWS and IDFW 2010). The Malheur River Basin CHU is one of five CHUs that comprise the Upper Snake River RU and is considered essential to bull trout conservation because of the presence of populations exhibiting rare adfluvial life history expressions, moderate number of local populations, moderate to large numbers of individuals, moderate amount of habitat, and few threats (USFWS and IDFW 2010). The Malheur River Basin CHU includes approximately 2,642.9 miles (1,642.3 kilometers) of streams and 716.0 acres (1,769.0 hectares) of reservoir designated as critical habitat. The Malheur CHU has two local populations: the Malheur River and the North Fork Malheur River. The Vale Project is located within the North Fork Malheur River CHSU. The North Fork Malheur CHSU is the only subunit that overlaps with the action area (Appendix A). Table 14 summarizes stream miles, surface area, and critical habitat storage.

Table 14. Critical habitat stream miles, surface area, and storage within the Malheur River Basin Critical Habitat Unit (CHU); only Beulah Reservoir (59,212 acre-feet of storage) is located within the action area.

Critical Habitat Unit	Critical Habitat Stream Miles (kilometers)	Critical Habitat Surface Area Acres (hectares)	Critical Habitat Storage (acre-feet)
Malheur River Basin 24 – 1,642.3 total stream miles (2,642.9 kilometers)	**169.2 (272.4)**	**1,769.0 (716.0)**	**59,212**
Malheur River Basin CHU Subunits			
Malheur River	109.8 (176.8)	0	0
North Fork Malheur River	59.4 (95.6)	1,769.0 (716.0)	59,212

Figure 30 shows the Malheur River Basin bull trout core areas (coincident with the CHSUs), CHU boundaries, designated critical habitat streams and reservoirs, and the proposed action project boundaries for the Vale Project. This section analyzes effects where the proposed action influences the hydrology in designated critical habitat (bold red lines show the area of overlap between the 2004 Upper Snake BA action area and designated critical habitat). Operation of the Malheur River system also contributes to the aggregate effect of upper Snake River projects on designated critical habitat located on the mainstem Snake and Columbia rivers. Designated critical habitat on the mainstem Snake and Columbia rivers are part of the Mainstem Snake River CHU (CHU 23), Mainstem Columbia River CHU (CHU 22), and Lower Columbia CHU (CHU 8) and these effects are analyzed in Section 8.

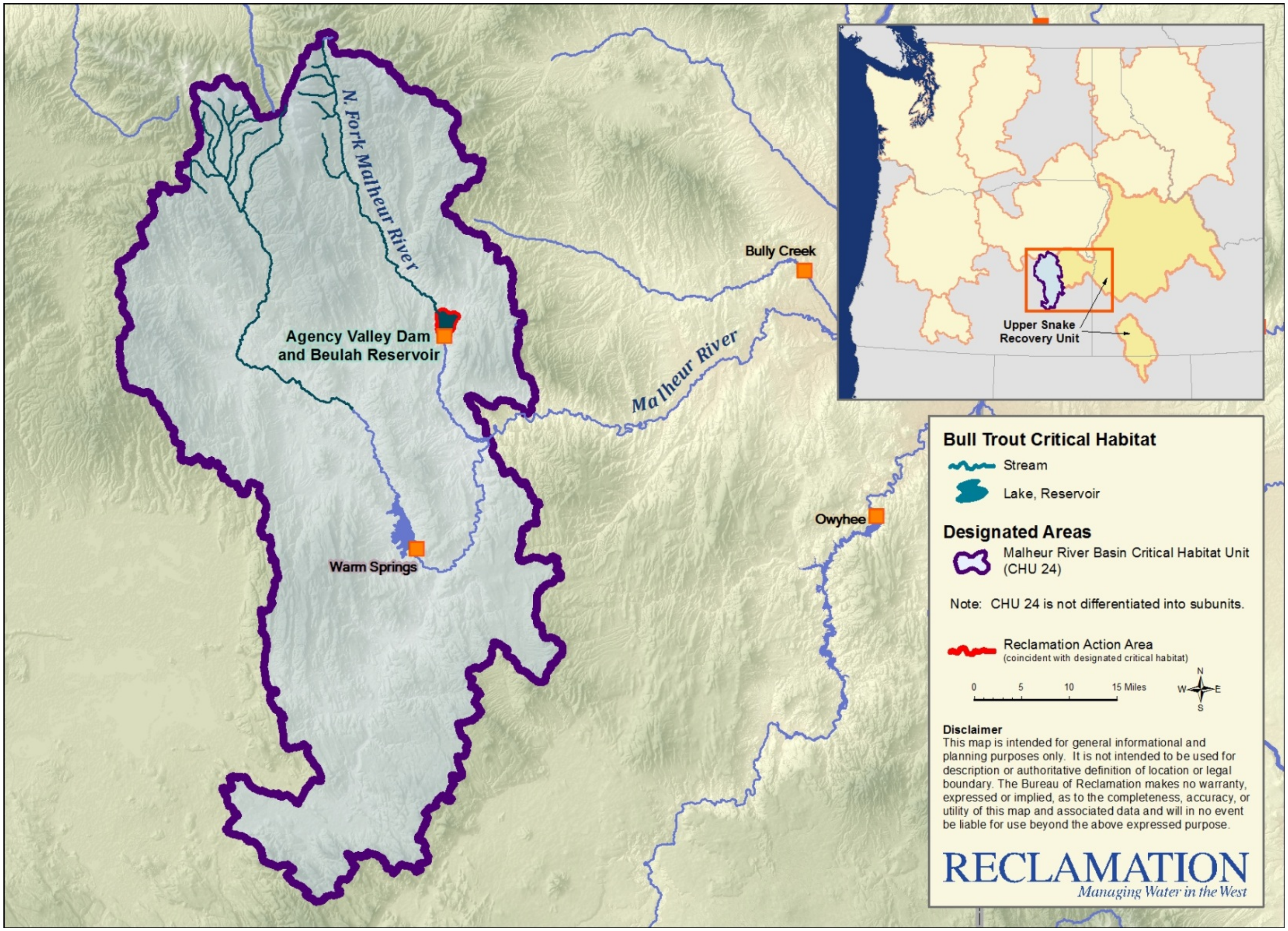

Figure 30. Malheur River Basin Critical Habitat Unit 24 boundary. The action area described in Section 6.0 only includes Beulah Reservoir within the North Fork Malheur Critical Habitat Subunit.

6.3 Environmental Baseline

6.3.1 Baseline Hydrology

Agency Valley Dam that forms Beulah Reservoir provides storage facilities on the North Fork Malheur River as part of the Vale Project. The full pool storage volume is 59,212 acre-feet which equates to about 1,913 surface acres. The facilities are operated solely for irrigation and flood control with no minimum streamflow requirements below the dam.

The reservoir generally starts refilling in mid to late October after irrigation deliveries are turned off. The primary tributary to Beulah Reservoir is the North Fork Malheur River. All inflow into Beulah Reservoir is stored for irrigation unless flood control criteria require some flow to be passed downstream. An exceedance plot of historical inflow into Beulah Reservoir is represented in Figure 31. Generally inflow is greatest during the early spring runoff period with minimum inflows being reached during the late summer and winter months. Inflows are important to understand as they directly affect the habitat for bull trout during the last part of their over-wintering period within the reservoir and they also affect the prey base of fish upon which bull trout feed.

Irrigation deliveries generally begin in late spring or early summer and continue through October 15 if water is available. See Reclamation’s 2004 Operations for more detailed information on operations (Reclamation 2004b). Hydrographs representing the 10 percent (wet), 50 percent (average), and 90 percent (dry) exceedance are provided in this section using observed (gaged) datasets for the entire period of record available (Figure 31).

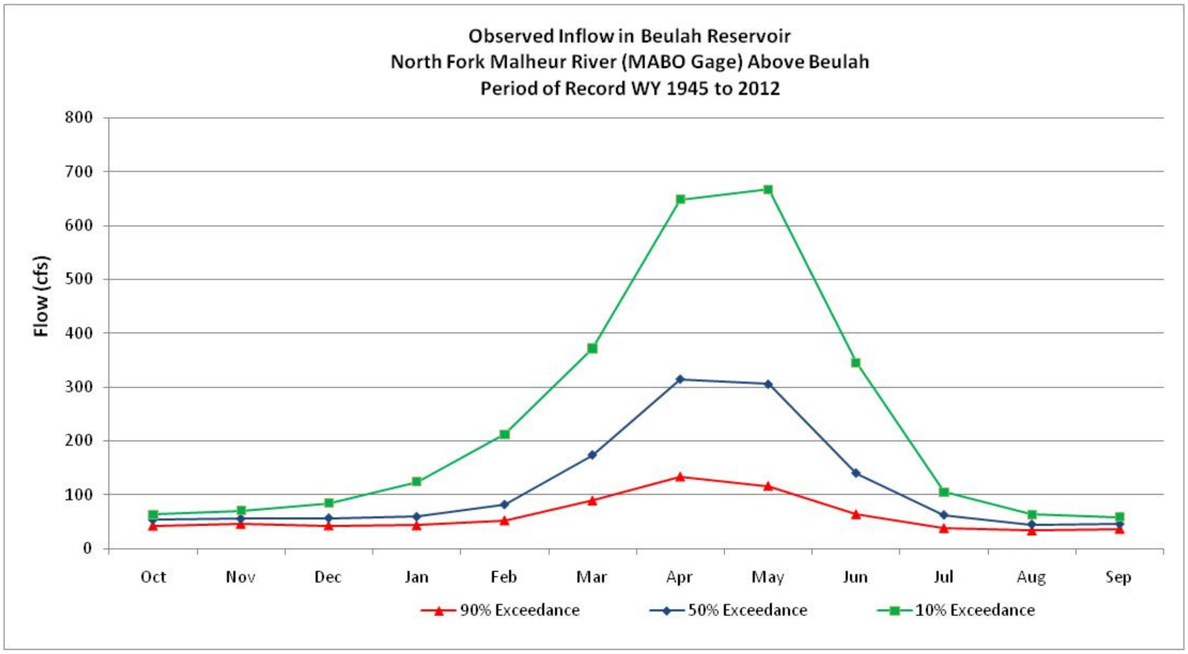

Figure 31. Monthly summary of 10%, 50%, and 90% exceedance levels of observed inflow to the Beulah Reservoir at the inlet gage (MABO) using a period of record for water years (WY) 1945 to 2012.

In addition to understanding the monthly summary hydrographs for the full period of record, the last 20 years were plotted to better determine if changes in climate have occurred in the basin. As shown in Figure 32, there have been minor changes to all of the exceedance inflow levels. In the lower flow and median events, only changes at the peak inflow are observed. At the 10 percent exceedance, inflow has decreased slightly in the spring, but is slightly higher during the peak of April and May. These changes are likely to have had minimal effects on fisheries.

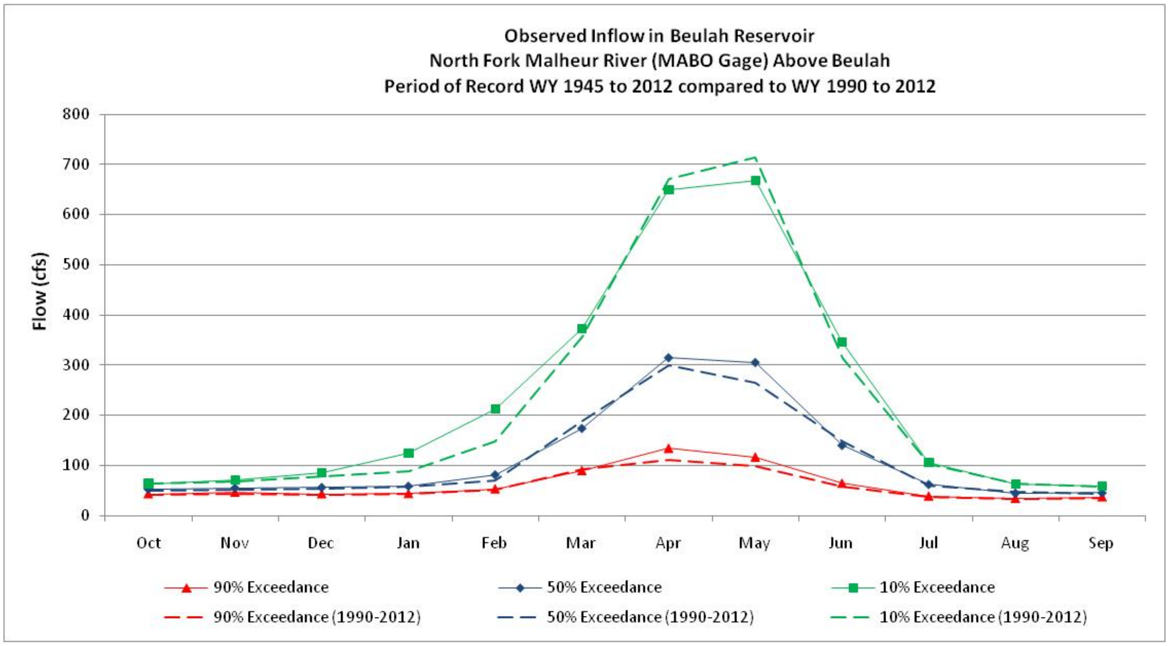

Figure 32. Monthly summary of Beulah Reservoir inflow at the MABO gage comparing water year (WY) 1990 to WY 2012 to the full period of record of 1945 to 2012. Hydrographs for dry (90%), average (50%), and wet (10%) exceedance levels are shown.

As described later in Section 6.3.3, spawning and juvenile rearing takes place in some headwater tributaries of the Malheur River as well as the North Fork Malheur River. Bull trout in the North Fork Malheur River exhibit an adfluvial life history expression, migrating to and over-winter in Beulah Reservoir (Schwabe et al. 2000).

In dry years, 100 percent of the storage in Beulah Reservoir is used for irrigation, resulting in a reservoir volume less than 2,000 acre-feet by late summer. This condition has occurred in 20 of the last 42 years. Because Beulah has no inactive storage space, it is generally operated as run-of-river when this occurs, passing all inflow through Agency Valley Dam for irrigation deliveries. These run-of-river periods occurred primarily in late July (4 percent of the total days in July in 42 years), August (17 percent), September (31 percent), and early October (24 percent).

The proposed action incorporates the operational indicators and T&Cs set forth in the 2005 USFWS BiOp. For Beulah Reservoir, the 2005 USFWS BiOp sets the reservoir storage threshold at less than 2,000 acre-feet. The proposed action indicates these levels are projected to occur in 10 of the next 30 years, based on the historical record.

The end-of-month storage volume for the WY1970-2012 is shown in Figure 33. In general, inflow peaks in April and May each year and reaches minimum storage volume in August and September. In the 90 percent exceedance volume level, storage volume on monthly average has been less than 200 acre-feet during August and September. The exceedance plot in Figure

33 includes daily data that are averaged into a single monthly value over the entire period of record. The appropriate percentiles (i.e., 10 percent, 50 percent, and 90 percent in this instance) are then determined, exceedances calculated, and results reported. The 200 acre-feet in August and September in Figure 33 includes values prior to the 2005 threshold.

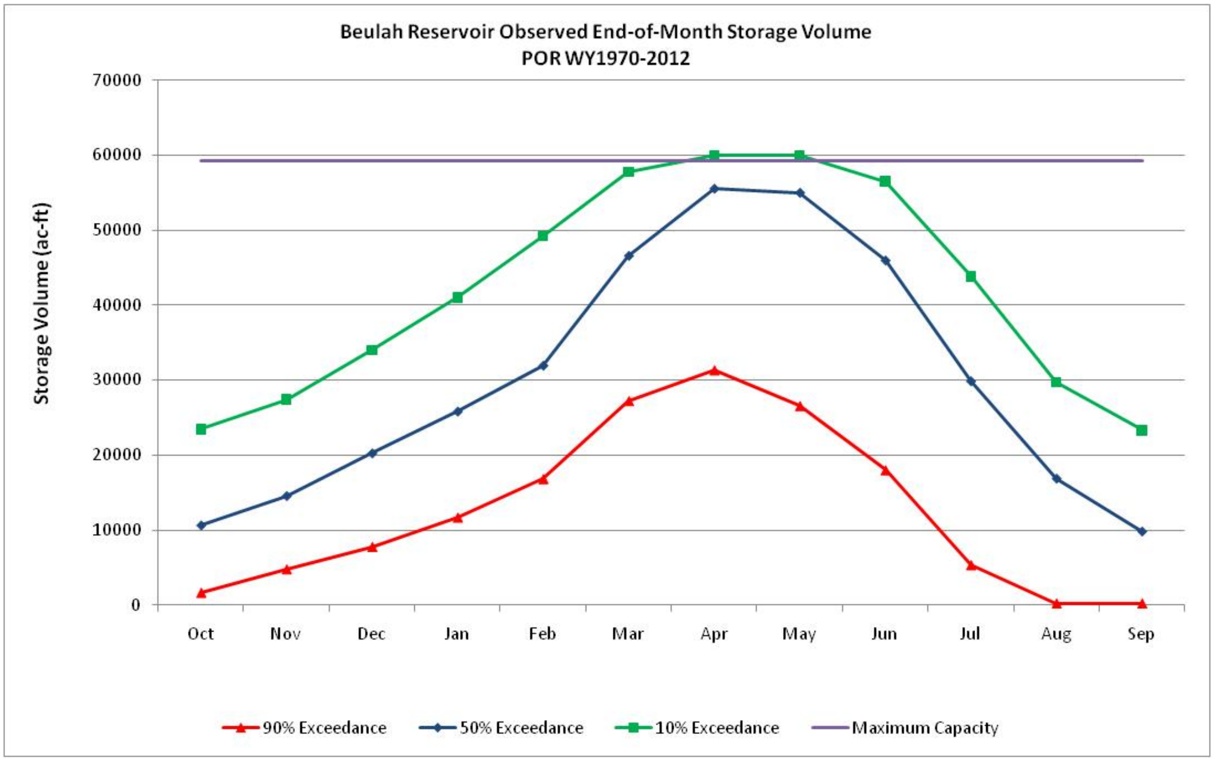

Figure 33. Observed end-of-month average monthly storage volume at Beulah Reservoir. Hydrographs for 10%, 50%, and 90% exceedances are for the period of record (POR) from water years (WY) 1970 to 2012. The horizontal line represents the maximum reservoir storage volume (note that the minor discrepancy is because the maximum capacity was adjusted down from 60,000 acre-feet to 59,212 acre-feet following completion of a sedimentation survey in 2000).

As shown in Figure 34, outflow from Beulah Reservoir is reduced to 0 cfs from November through March at the 10 and 50 percent exceedance levels; at the 90 percent exceedance level, outflows are reduced to 0 cfs only during the November period. Outflow rates increase consistently through May at which time water is managed for irrigation demands. Though bull trout critical habitat does not occur immediately below Agency Valley Dam, it is evident that any bull trout that pass through the dam will not survive total dewatering. Reclamation has developed mitigation by limiting the amount of spill to avoid/reduce entrainment of both bull trout and prey fish species, as well as conducting trap-and-haul efforts in the event spill does occur. All fish salvaged in the stilling basin below the dam are transported and released either into the reservoir or into the North Fork Malheur River above the reservoir. Currently a PIT-tag array has been installed downstream of the dam to determine if any tagged bull trout are able to pass through the dam outlet during nonspill conditions. It is possible that fish may pass through the dam outlet during drawdowns to run-of-river. Previous entrainment studies of tagged bull trout did not indicate bull trout passage through the dam during nonspill periods.

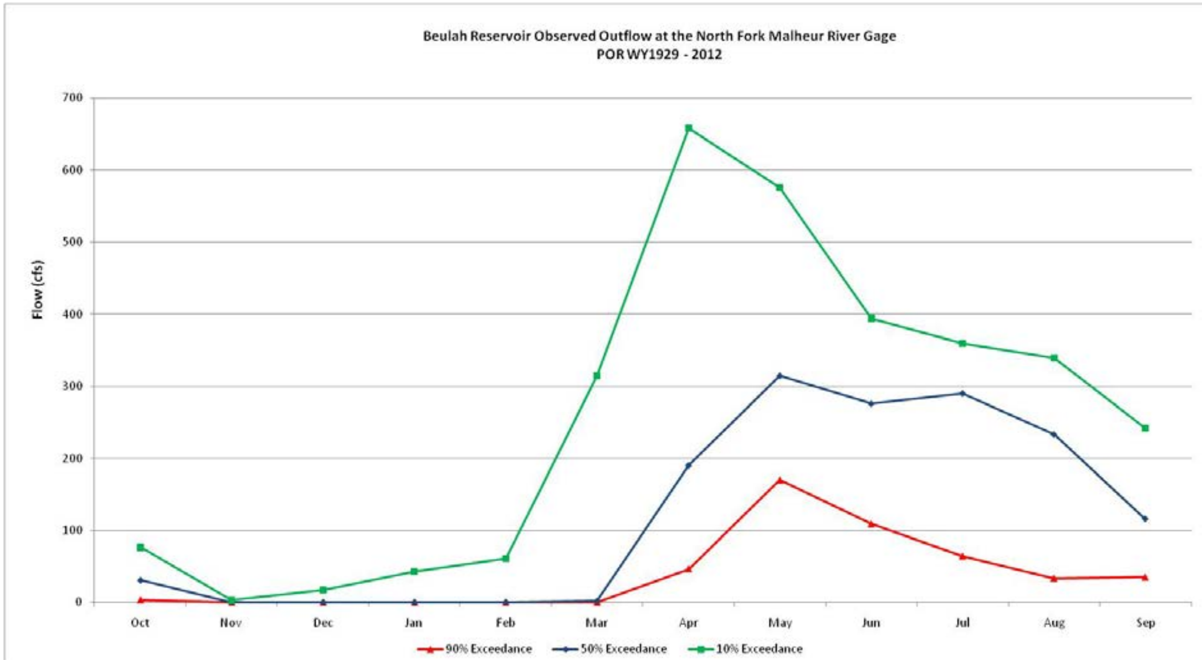

Figure 34. Monthly summary of observed 90%, 50%, and 10% exceedance level outflow from Beulah Reservoir (BEU gage) below Agency Dam for period of record (POR) from water years (WY) 1929 to 2011.

Future Hydrology with Climate Change

Currently there is no reservoir model constructed for the Malheur River system so no modeled data are available. Hydroclimate Data Network sites are not present in the subbasin. Because of the lack of modeled data and processed climate change flow data, a qualitative description of the potential impacts of climate change on a basin with similar attributes as the Malheur River basin is provided.

The attributes of the Malheur River basin are a semi-arid climate with hot, dry summers and cold winters. Precipitation falls between 8 and 40 inches per year, with the higher elevations receiving mostly snow. Short, intense storms are known to occur in the area as well, causing flooding and channel erosion. The basin is also impacted by rain-on-snow events which can occur in the transitional elevation of mountain ranges (ODA 2011, page 12).

Basins with similar attributes as described above to the Malheur River basin may experience a greater increase in climate variability, which could mean an increase in change between wet and dry periods (Reclamation 2011a; OCCRI 2010). Because flooding can be a result of the rain-on-snow events, flooding events, both in number and size, could increase as the climate changes in the Malheur River basin. Finally, as with many other systems, a shift in the timing of the peak inflow to the reservoir to earlier in the year will likely occur with decreased inflows during the summer months. This may translate into Beulah Reservoir filling earlier in the season. Due to earlier runoff, greater irrigation demand, and warming temperatures, the end-of-month storage volumes will likely be greater in the winter and spring and lower in the summer and fall. Beulah Reservoir is a managed system and as such, it will continue to operate within the ranges previously analyzed in the 2005 USWFS BiOp with the exception that fall storage volumes will be maintained at or above 2,000 acre-feet in at least 10 of 30 years.

6.3.2 Baseline Population Status and Trends

The 2004 Upper Snake BA and 2005 USFWS BiOp described conditions in the action area through 2004. Since 2005, Reclamation implemented numerous tasks and studies in compliance with the 2005 USFWS BiOp as described in the proposed action section. Table 15 shows the studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to the action area. This section provides relevant information from these studies. New information since the 2005 USFWS BiOp can be grouped into three areas: (1) reservoir studies; (2) spawning surveys; and (3) trap-and-haul efforts.

Table 15. Studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to the Malheur River Basin core area.

Date	Reference	Title
2006	Reclamation 2006	Utah Valvata and Bull Trout Monitoring and Implementation Plan
2006	Rose and Mesa 2009a	Bull trout forage investigations in Beulah Reservoir, Annual Report for 2006
2007	Reclamation 2008	2007 Reclamation ESA Annual Report
2008	Reclamation 2009a	2008 Reclamation ESA Annual Report
2009	Rose & Mesa 2009b	Minimum Pool and Bull Trout Prey base Investigations at Beulah Reservoir – Final Report for 2008
2010	Reclamation 2011c	2010 Reclamation ESA Annual Report
2011	Reclamation 2012	2011 Reclamation ESA Annual Report
2012	Best 2012a	2011 Beulah Reservoir Prey Base/Minimum Pool Studies. Annual Report for Federal Fish & Wildlife Permit No. TE28745A-0

Reservoir Studies

To meet T&C 4.a., 4.b., and 4.c. addressing impacts to the prey base, Reclamation entered into an agreement with USGS in 2007 to evaluate the impacts of specific reservoir volumes to the fish species composition in Beulah Reservoir and to identify the threshold at which bull trout and prey species (fish, invertebrates, and zooplankton) are harmed. In 2008, Rose and Mesa (2009b) of USGS found that low pool elevations limit prey base for bull trout, but prey base can recover during subsequent years. The extent of drawdown and consecutive years of drawdown influence the rate of prey base recovery. In 2009, Reclamation concluded that minimum pool recommendations could not be determined using available data; however, USGS studies of 2001 and 2002 (Petersen and Kofoot 2002 and Petersen et al. 2003) suggested a pool volume of 2,000 acre-feet may provide a benefit to prey species.

In 2010, USFWS extended the deadline to address T&C 4.a., 4.b., and 4.c. to April 2015. Reclamation worked with the Bull Trout Working Group and Vale Oregon Irrigation District to formulate research objectives to address these T&Cs. A study design was developed that was consistent with work done by USGS in 2006 through 2008 (Rose and Mesa 2009a, 2009b). This consistency allows data collected during previous USGS studies (Petersen and Kofoot 2002 and Petersen et al. 2003) to be combined with new data and used in a bioenergetics model developed by USGS (Mesa et al. 2013). This current study was initiated in FY 2011 to continue sampling fish, invertebrate, zooplankton, and water quality sampling in lower drawdown levels and to complete bioenergetics modeling. As part of the study Reclamation worked with Vale Oregon Irrigation District to maintain a minimum pool of 2,000 acre-feet until T&C 4.a., 4.b., and 4.c. are addressed in April 2015.

Additionally a pilot fish salvage effort was conducted October 17-21, 2010, in the tailrace of Agency Valley Dam to explore the possibility of trapping and transporting entrained prey fishes back into the reservoir as a method to address T&C 4.b. This cooperative effort was successful in returning 2,682 native fishes to the reservoir. Future fish salvage efforts will be addressed in Reclamation’s recommendations to the USFWS in 2015.

Figure 35 shows the maximum-minimum Beulah Reservoir levels from 1997 through 2012. Petersen et al. (2003) indicates that historically, gill net catches of various species in Beulah Reservoir following a reservoir drawdown to river level (run-of-river) appear to lag from 1 to 3 years. Rose and Mesa (2009b) also reported significant decrease in prey abundance following a drawdown in 2007 to run-of-river. In the period from 1997 to 2012, Beulah Reservoir has been drawn down to run-of-river levels in 2002, 2003, 2004, and 2007. Recent work in 2011 and 2012 have shown high levels of prey abundance (Best 2012a, 2012b), which corresponds to fairly modest summer drawdowns.

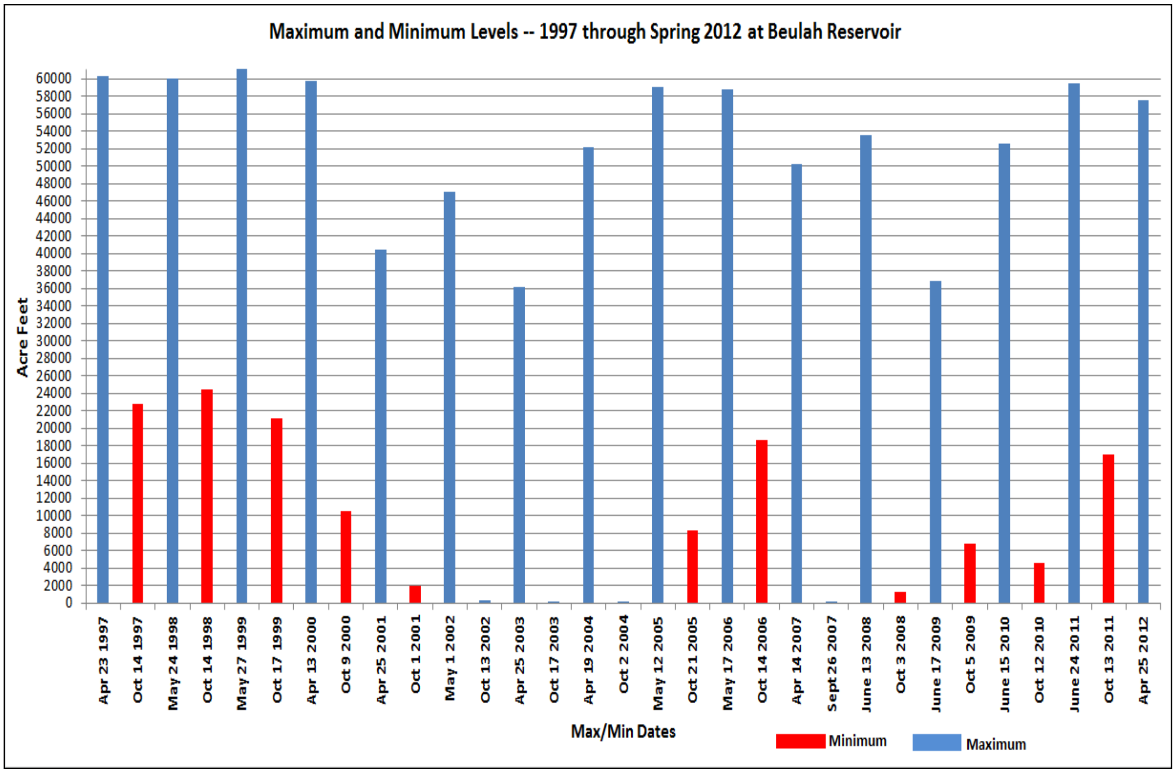

Figure 35. Maximum and minimum levels (acre-feet of storage) for Beulah Reservoir, 1997–2012.

Table 16 summarizes the results of recent bull trout studies conducted by USGS and Reclamation in Beulah Reservoir. USGS conducted prey base and bull trout studies from 2006 through 2008 (Rose and Mesa 2009a and 2009b). The USGS study did not estimate bull trout populations in Beulah Reservoir, but used population categories in their energetics modeling which included a hypothetical bull trout population estimate of 188 and 1,000 as a population goal. Reclamation is currently conducting bull trout and prey base studies in Beulah Reservoir that began in FY 2011 and will continue through FY 2014 with the ultimate aim of determining a biologically justified minimum pool level.

Table 16. Adult and subadult bull trout captures – Beulah Reservoir 2006-2012.

Sample Period	Year	Reference	# Bull Trout Captures	# Bull Trout Recaps	Population Estimate
Spring	2012	Best 2012b	36	5	116 (63-781)
Fall	2011	Best 2012a	0	0	0
Spring	2011	Best 2012a	17	6	31 (21-61)
Fall	2010	Best 2012a	prey base only		
Spring	2008	Rose and Mesa 2009b	14	3	no estimate*
Fall	2007	Rose and Mesa 2009b	3	2	no estimate
Spring	2007	Rose and Mesa 2009b	5	0	no estimate
Fall	2006	Rose and Mesa 2009a	0	0	-
Spring	2006	Rose and Mesa 2009a	0	0	-
Spring	2003	Schwabe et al. 2003a	0	1	-
Spring	2002	Schwabe et al. 2003b	5		-
Spring	1999	Schwabe et al. 2000	19	4	-
Spring	1998	Gonzalez et al. 1998	33	2	-

* Rose and Mesa 2009b used population categories for bull trout in their energetics modeling: 188 hypothetical populations and 1,000 as a population goal.

Spawning Surveys

Under the leadership of the Oregon Department of Fish and Wildlife (ODFW), spawning surveys were conducted annually since the release of the 2005 USFWS BiOp. A total of 110 redds were counted in 2007 and 76 were counted in 2008. Wildfires affected some survey reaches in 2008 and budget cutbacks reduced coverage of some reaches; subsequently, values were adjusted to allow comparison with the original surveys using estimates of 2.68 bull trout per redd from Al-Chokhachy et al. (2005). In 2009, 82 redds were counted which yielded an estimated 219 adfluvial adult bull trout present. In 2010, 55 redds were counted with an estimated 147 adult bull trout present and in 2011, 53 redds were counted with an estimated 142 adult bull trout present. In 2009, Beulah Reservoir had carryover storage; however, a direct link between carryover pool volumes and bull trout redd counts remains speculative. Surveys were not performed in 2012 due to budget cutbacks.

Trap-and-Haul Operations

T&C 4.d. requires Reclamation to continue to trap and haul bull trout that are entrained at Agency Valley Dam back to Beulah Reservoir or the North Fork Malheur River. Efforts to move entrained bull trout were originally to occur every year that the spillway was used. Spill occurred in 2006, with seven bull trout captured and moved, and in 2008, with no bull trout captured. Since 2000, Reclamation has operated the dam to reduce the surface spill when feasible. Reducing spill may limit the frequency of bull trout entrainment as correlated to catch rates during trap-and-haul efforts.

The original 2006 Monitoring and Implementation Plan identified trap-and-haul activities to be initiated when the reservoir pool volume dropped below 2,000 acre-feet or when the spillway was used. Based on the data from 1999-2008, the trap-and-haul requirements were revised to only be conducted only when spill occurs (Reclamation 2009b). No spill occurred in 2009 or 2010, but did occur in 2011, resulting in a trap-and-haul effort. The Burns Paiute Tribe spent a total of 144.5 hours sampling in the tailrace immediately below Agency Valley Dam between May 19 and June 16 using hook-and-line methods. A total of 124 fish were counted during this sampling effort, including rainbow trout, large-scale sucker, mountain whitefish, northern pike minnow, and five bull trout (Poole 2011).

6.3.3 Baseline Critical Habitat Conditions

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 1 is present, but provides a limited contribution to FMO habitat in Beulah Reservoir. PCE 1 primarily pertains to bull trout spawning and rearing habitat in a watershed's headwaters where spawning areas are often associated with cold-water springs, snow melt, and groundwater upwelling (75 FR 63898). The North Fork Malheur River is the main source of water for the reservoir. Warm Springs Creek, Spring Creek, and nine other small seasonal creeks flow into the reservoir, with at least three of the seasonal creeks originating from springs. There are wetlands in the interface with the reservoir at full pool associated with the North Fork Malheur River and Warm Springs Creek, as well as some very small wetlands in some of the coves along the shoreline of the reservoir. The topography along both sides of the reservoir is steep, which limits the influence of off-channel habitat.

High to full pool levels in the reservoir result in groundwater storage from recharge that later is released to the North Fork Malheur River as reservoir levels drop during irrigation water withdrawals. This floodplain connectivity is similar to the process that would have occurred to an unmanaged river in this location as seasonally high river levels result in groundwater recharge. The existing wetlands appear to be maintained by flows from the river and Warm Springs Creek and do not rely on groundwater recharge or hyporheic flows from the reservoir.

Hyporheic flow could be reduced in the varial zones due to the deposition of fines from sources outside the action area. Habitat surveys conducted in the varial zone of Beulah Reservoir, reference pool, and riffle habitats indicate that the percent of fines in the varial zone is 45.46 percent compared to reference of 5.6 percent (Prisciandaro 2012). In general, reservoir storage is directly related to flows in the river, with only minor dependence on subsurface water connectivity. The degree to which soil compaction has decreased infiltration has little bearing to the reservoir levels or to the river in the reservoir footprint.

Groundwater is not a significant factor influencing water quality (PCE 8) and availability of thermal refugia (PCE 5) in the reservoir. The primary drivers of water quality, temperature, and the amount of thermal refugia at Beulah Reservoir are derived from inflows of the North Fork Malheur River as well as operation of Agency Valley Dam.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

PCE 2 is present in and contributes to FMO habitat in Beulah Reservoir. There are no physical or biological barriers between over-wintering habitat in Beulah Reservoir and the migration corridor out of the reservoir leading to spawning and rearing habitat in the North Fork Malheur River and associated tributaries; however, there is a seasonal water quality barrier that occurs in Beulah Reservoir. Starting usually in mid-May and lasting through October, water temperatures and low dissolved oxygen levels exceed bull trout tolerances (PCE 5); however, the effects of this temperature increase are offset since subadult and adult bull trout migrate out of Beulah Reservoir into the North Fork Malheur River and tributaries to over-summer and to spawn (Rose and Mesa 2009a, 2009b; Gonzalez et al.1998; Schwabe et al. 2000, 2001, 2003, 2004; Best 2012a, 2012b). Bull trout remain in the North Fork Malheur River until fall when they migrate back to the reservoir; at this time, water temperature and dissolved oxygen levels have returned to tolerable levels.

Multiple years of drought can worsen the seasonal temperature effects by significantly reducing the reservoir levels, resulting in greater temperature maximums and lower dissolved oxygen levels. Conditions in the North Fork Malheur River may deteriorate somewhat, but adult and subadult bull trout should be able to find thermal refugia in the river and in springs in headwaters areas. In the event of extremely low runoff and subsequent low reservoir pool levels during the bull trout outmigration period, bull trout exhibit flexibility in the actual migration dates. If the conditions become too warm and low, bull trout leave the reservoir earlier in the spring season.

Migration corridors in the spring are in good condition. No migration impediments occur during the spring migration period for fish migrating out of the reservoir to spawning habitat. Reservoir drawdowns can expose varial zones during the fall migration season in most years; however, connectivity is maintained at all times. The migration zone experiences a reduction of structural diversity in the fall which causes the risk of predation to increase; however, depth cover is maintained better than in other action areas because of the more incised stream channel and narrow delta entering the reservoir. The presence of a stream channel and established vegetation within the delta (compared to other action areas) maintains more depth and reduces the risk of predation than a channel that spreads out within a wide delta.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

PCE 3 is present in and contributes to FMO habitat in Beulah Reservoir. Beulah Reservoir is eutrophic and very productive. Reservoir sampling in 2011 resulted in 17,794 total individuals of 11 fish species caught in fyke nets, gill nets, and a weir during a wet year (Reclamation 2012). Rose and Mesa (2009a) reported similar levels of catch during 2006 during a moderate drawdown. However, Rose and Mesa (2009b) reported a significant decline in forage fish following a drawdown to run-of-river. Petersen and Kofoot (2002) indicate that annual recruitment of prey species from the North Fork Malheur River may ameliorate some of the effects of reservoir drawdowns on the bull trout prey base.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes, that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths gradients velocities and structure.

PCE 4 is present, but provides a limited contribution to FMO habitat in Beulah Reservoir. In general, reservoir operation allows for the development of abundant shoreline vegetation (willows, grass) which in turn provides substrate for terrestrial and aquatic macroinvertebrates as well as cover for juvenile fish of many species (prey for bull trout). During nondrought years, the reservoir provides a variety of depths; however, dry and drought years result in extreme drawdown events. The reservoir has dropped to run-of-river four times in recent history (1988, 2002, 2003, and 2004). Since 1973, the reservoir has also been drawn down to less than 500 acre-feet during 12 years. These extreme drawdowns reduce lacustrine habitat complexity, adversely affecting prey base and cover.

A habitat survey was conducted in 2011 to quantify habitat variables in the river within Beulah Reservoir (Prisciandaro 2012). It was found that within this relatively small area of the North Fork Malheur River, major habitat features consisted of 14 percent pool, 65 percent riffle, and 21 percent run. These habitat features are unlikely to be utilized by bull trout because drawdown occurs during the summer and early fall months when water temperatures exceed tolerance levels and bull trout are not present in the action area. The reservoir begins to refill in October and water temperatures drop significantly, providing suitable over-wintering habitat for bull trout returning to the reservoir.

An extensive area of riparian habitat remains at the North Fork Malheur River inlet to the reservoir. Reservoir operations have eliminated riparian habitat along the North Fork Malheur River channel through the reservoir; however, riparian habitat exists along the edge of Beulah Reservoir in extensive areas of the shoreline. During high and full pool conditions, these areas are partially inundated and fish, including bull trout, utilize these areas for shelter and foraging.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

PCE 5 is present, but provides a limited contribution to FMO habitat in Beulah Reservoir. Beulah Reservoir provides adequate water temperatures for bull trout foraging, rearing, and over-wintering November through mid-May (Figure 36), a period when bull trout are present in the reservoir; however, there are no thermal refugia in Beulah Reservoir June through October. Water temperatures and dissolved oxygen levels become unsuitable for bull trout beginning in mid- to late May and continuing through October. During this time, all adult and subadult bull trout to migrate out of the reservoir into the North Fork Malheur River.

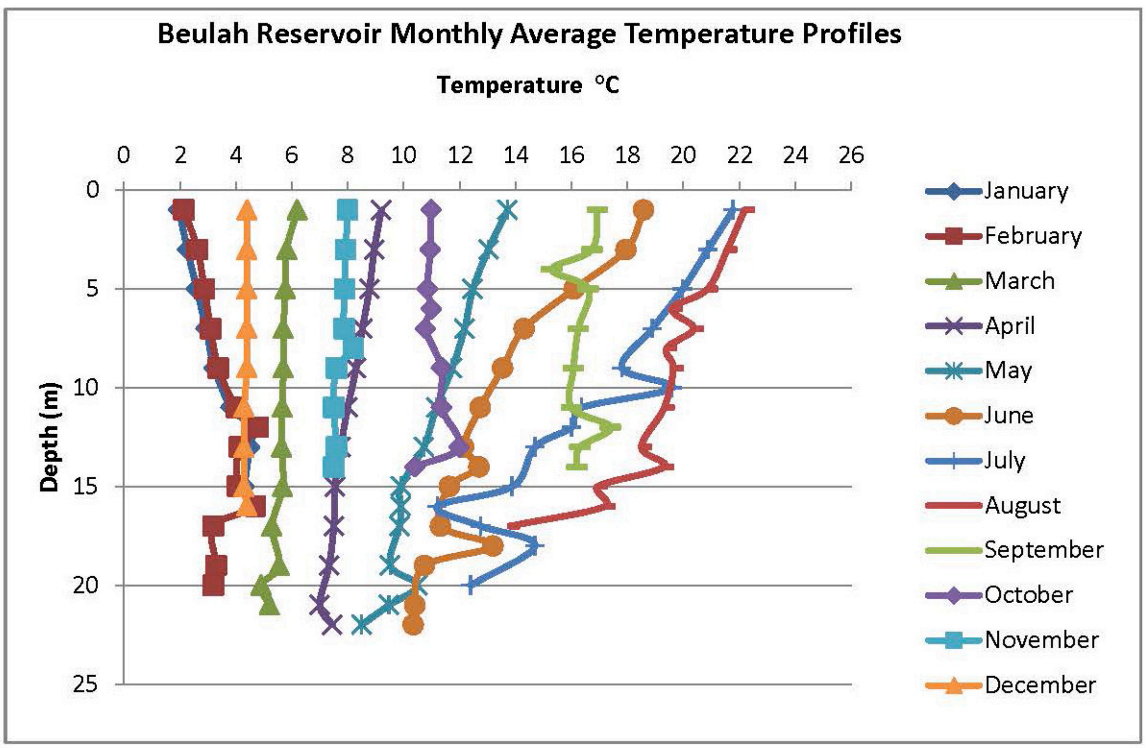

Figure 36. Monthly average temperature profiles in Beulah Reservoir, January through December.

The functionality of PCE 5 in Beulah Reservoir is partially affected by conditions outside of the action area. Water temperatures in the North Fork Malheur River upstream of the action area exceed 15° C from June through October (Figure 37); however, bull trout leave the reservoir early enough in the spring to migrate above the potential thermal barriers in the river. Conditions in the North Fork Malheur River may deteriorate somewhat, but thermal refugia at higher elevations in the river and in springs in headwaters areas are available to adult and subadult bull trout.

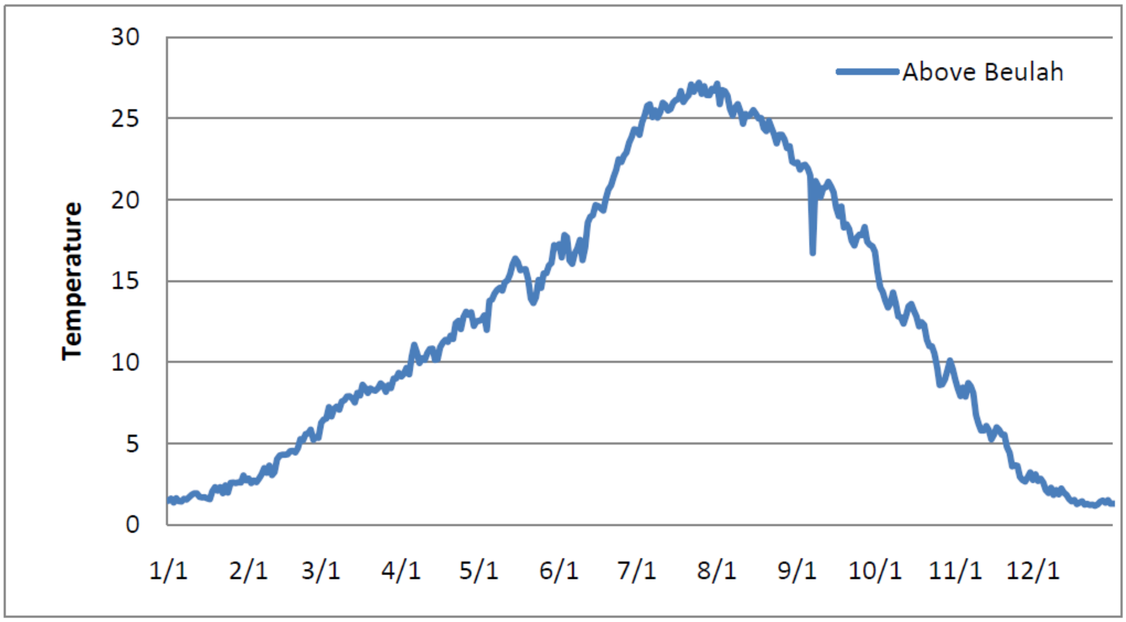

Figure 37. Daily maximum temperature of the North Fork Malheur River entering Beulah Reservoir.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present in any of the CHUs evaluated in this chapter (75 FR 63898)

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is a natural hydrograph including peak, high, low and base flows, or if flows are controlled minimal flow departure from a natural hydrograph. PCE 7 addresses the amount and timing of stream flow, a characteristic that is by definition not present in a reservoir environment. As a result, PCE 7 is not present in Beulah Reservoir.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

PCE 8 is present in and contributes to FMO habitat in Beulah Reservoir. Water quality and quantity allows adult and subadult bull trout to over-winter successfully in Beulah Reservoir. The reservoir is classified as eutrophic, indicating that excess nutrients may be impairing the aquatic life of the reservoir. Water temperatures and dissolved oxygen levels show seasonal limitations from mid-May through October; however, bull trout are not present during this time (PCE 2). Sediment and turbidity levels may be seasonally high due to the eutrophic nature of the reservoir, but should not impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity (Appendix B). Water quality is adequate to allow the prey base (fish, aquatic invertebrates and zooplankton) to remain at sufficient levels to support bull trout; however, no minimum pool has been established. A 4-year study initiated in 2010 as part of T&C 4.a. will be completed in 2014 and will provide a minimum pool recommendation. The establishment of a biologically-based minimum pool recommendation will reduce the adverse impacts to the prey base in Beulah Reservoir from periodic drawdowns below 2,000 acre-feet.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout

PCE 9 is present, but provides a limited contribution to FMO habitat in Beulah Reservoir. Nonnative fishes are present in Beulah Reservoir (including stocked rainbow trout), but are not a significant source of predation or competition. Bull trout spawning and rearing habitat is in the North Fork Malheur River and associated tributaries, and nonnative predators have not been identified as a factor affecting bull trout survival during these vulnerable larval and juvenile life stages. The nonnative fish themselves become prey for over-wintering bull trout in Beulah Reservoir. There is no evidence that stocked rainbow trout are significant competitors to bull trout, given the large prey base present during nondrought years along with large numbers of rainbow trout (2011 catch: 17,794 all spp., 440 stocked rainbow trout as shown in 2011 reservoir study). Additionally, our data shows that bull trout have a good condition factor, which suggests low levels of competition (Best 2012b). White crappie were discovered in the catch at Beulah in 2008 (Rose and Mesa 2009b), as well as in the catch in the fall of 2012 along with largemouth bass (Horn 2012). Thus far, no brook trout, which are known to interbreed with bull trout, have been identified in either the North Fork Malheur River or Beulah Reservoir.

6.4 Effects of the Proposed Actions

6.4.1 Effects of the Proposed Action on Bull Trout

The 2004 Upper Snake BA and 2005 USFWS BiOp described current conditions in the action areas through 2004. Since 2005, Reclamation implemented numerous tasks and studies in compliance with the 2005 USFWS BiOp as described in the proposed action. Table 15 shows the studies, monitoring or reports that have been completed since the 2005 BiOp. Increasing population trends have been documented in Beulah Reservoir for 2010 through 2012.

Reclamation has considered new information relevant to bull trout use of the Malheur River system available since the 2005. The new information provides more precise detail and data than was previously available; however, no new information exists that would indicate an effect of a different degree or nature than was previously considered in the 2004 Upper Snake BA and 2005 USFWS BiOp. Therefore, Reclamation has determined that the previous findings are still appropriate and there is no need to reinitiate consultation at this time for the species in this section.

6.4.2 Effects of the Proposed Action on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The operation of Agency Valley Dam will have discountable effects on PCE 1 within Beulah Reservoir. As noted previously, springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quantity or water quality in Beulah Reservoir. Although, reservoir operations may influence shallow groundwater exchange, the influence of this exchange is not of sufficient scale to influence thermal refugia in the reservoir as a whole.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The operation of Agency Valley Dam will have insignificant effects on PCE 2 in Beulah Reservoir. There are no physical or biological barriers between over-wintering habitat in Beulah Reservoir and spawning and rearing habitat in the North Fork Malheur River and associated tributaries; however, there is a seasonal water quality barrier that occurs in Beulah Reservoir when bull trout are not present. Starting usually in mid-May and lasting through October, water temperatures and low dissolved oxygen levels exceed bull trout tolerances.

Bull trout leave the reservoir during this time and remain in the North Fork Malheur River until water temperature and dissolved oxygen return to tolerable levels in the reservoir (PCE 8). This response is typical for migratory bull trout and is not unique to Beulah Reservoir.

Reservoir operations do not appear to affect migration timing because upstream water temperatures in the North Fork Malheur River reflect a similar pattern of warming. Prey fishes are unlikely to be adversely affected by this temperature increase, with the exception of stocked rainbow trout. Multiple years of drought can worsen the seasonal temperature effects by significantly reducing the reservoir storage, resulting in greater temperature maximums and lower dissolved oxygen levels.

The proposed action will continue to periodically result in spill when releases from the dam exceed 650 cfs with a small risk of bull trout entrainment. Spillway salvage operations will be implemented to capture bull trout for release back into the reservoir. Entrainment of bull trout as well as other fish species in Beulah Reservoir has been documented when spill occurs.

Agency Valley Dam isolates a population of adfluvial bull trout and is a barrier to upstream migration. For bull trout entrained out of the reservoir, the dam is not equipped with fish passage facilities. Bull trout that may be present downstream of Agency Valley Dam are believed to have been entrained from Beulah Reservoir when the spillway is used. To mitigate for entrainment of bull trout from Beulah Reservoir (T&C 4.d; USFWS 2005a), Reclamation traps these bull trout in the tailrace of Agency Valley Dam (see section 6.3.2) and hauls them around the dam, releasing them back into the adfluvial population in Beulah Reservoir

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The operation of Beulah Reservoir has an infrequent adverse effect on PCE 3 when water volumes drop below 2,000 acre-feet in 10 of the 30 years (USFWS 2005a). At times, these drawdowns can be to run-of-river. When those conditions occur (generally in late summer or fall), adverse water quality conditions may cause lethal conditions for the prey base of bull trout (USFWS 2005a). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 33). Since 2006, the reservoir volume has fallen below 2,000 acre-feet four times.

Beulah Reservoir is eutrophic and very productive. Reservoir sampling in 2011 resulted in 17,794 total individuals of 11 fish species caught in fyke nets, gill nets, and a weir (Best 2012a). Water conditions during 2011 were above average (wet year). Rose and Mesa (2009b) reported similar levels of catch during 2006 during a moderate drawdown. However, Rose and Mesa (2009a) reported a significant decline in forage fish following a drawdown to run-of-river. Petersen and Kofoot (2002) indicated that annual recruitment of prey species from the North Fork Malheur River may ameliorate some of the effects of reservoir drawdowns on the bull trout prey base.

Periodic run-of-river drawdowns will continue to occur. The analysis indicated that in 10 of the 30 years analyzed, reservoir volumes will be below 2,000 acre-feet. Periodic run-of-river drawdowns at Beulah Reservoir temporarily affect prey fish species. Prey fish are able to recolonize from the North Fork Malheur River and Warms Springs Creek; however, there is a decrease in prey available for over-wintering bull trout. Petersen et al. (2003) indicated that historically, gill net catches of various species in Beulah Reservoir following a reservoir drawdown to river level (run-of-river) appear to lag from 1 to 3 years. Rose and Mesa (2009b) also reported significant decrease in prey abundance following a drawdown in 2007 to run-of-river. Prey fish populations recover to previous abundance given sufficient time, indicating that the reservoir is resilient to repeated drawdowns. It is likely that given the depressed numbers of bull trout in the North Fork Malheur River, sufficient prey exists in the reservoir during the over-winter period; however, the periodic reductions of prey may adversely impact larger numbers of over-wintering bull trout.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

The operation of Beulah Reservoir has an insignificant effect on PCE 4. In general, reservoir operations allow for the development of abundant shoreline vegetation (willows, grass) which in turn provides substrate for terrestrial and aquatic macroinvertebrates as well as cover for many species juvenile fish (prey for bull trout). When full, the reservoir provides a variety of depths with the deepest areas nearest the dam; however, when the reservoir is drawn down, those habitats are unavailable. Extensive drawdowns in general would not damage complex lentic habitat; drawdowns simply render complex habitats unavailable. This applies mostly late July through early October when bull trout have migrated out of the reservoir. Prey fish, however, do not migrate and must cope with reduced habitat complexity, resulting in potential population losses. This in turn may affect bull trout returning to over-winter in the reservoir.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Operation of Agency Valley Dam may affect PCE 5 from mid-May through October. This effect is insignificant because bull trout do not use the reservoir at these times. Reservoir water temperatures may exceed 15° C from mid-May through October, with little to no thermal refugia at these times. These conditions would occur even without summer drawdowns. This influence on temperature is insignificant because bull trout do not use the reservoir during summer for FMO habitat when water temperatures exceed 15° C (Best 2012a, 2012b). From November through mid-May, Beulah Reservoir provides adequate water temperatures for bull trout foraging, rearing, and over-wintering.

The adfluvial life history strategy of bull trout allows them to leave inhospitable conditions in shallow lakes or reservoirs, and to return when water temperatures drop in the fall. Furthermore, the 2004 USFWS BiOp recognizes that bull trout are not present in the reservoir while the seasonal water quality barriers exist and the T&Cs focus on protecting the habitat to maintain the prey base rather than bull trout directly. The seasonal increase in water temperatures above those tolerable to bull trout will continue to occur; however, this temperature increase is unlikely to impair the function of PCE 5 because subadult and adult bull trout migrate out of Beulah Reservoir into the North Fork Malheur River and tributaries to over-summer and to spawn.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Beulah Reservoir has not been designated as spawning and rearing habitat (USFWS 2010a, pages 629, 641); therefore, the effects were not analyzed.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is not present in Beulah Reservoir; therefore, the effects were not analyzed.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The operation of Agency Valley Dam has seasonal adverse effects on PCE 8 from mid-May through October; however, these are insignificant because bull trout are not likely to be present during the time when adverse effects occur. Water quality conditions are good as described in the baseline conditions while bull trout are typically in the reservoir. Both life stages (adult and subadult) migrate out of the reservoir as water temperature and dissolved oxygen levels become unsuitable from mid-May through October. Reservoir operation influences water temperature and water quality conditions indirectly through a set of complex interactions with incoming water temperature, solar loading, release of cold water from the bottom of the reservoir, and the influence of reservoir elevation on thermal stratification. Although adverse effects seasonally occur, water quality conditions indicate a functional PCE for both bull trout and bull trout prey (PCE 3) when bull trout are known to be present. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 33).

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The operation of Beulah Reservoir will have an insignificant effect on PCE 9 in Beulah Reservoir. The proposed action provides an environment that allows the survival of nonnative fishes; however, ODFW exclusively manages the fisheries including stocking and regulations that favor the presence of individual species. The proposed action plays an insignificant role in the occurrence of nonnative fishes compared to variables (fish management and interbreeding) independent from the operation of Agency Valley Dam.

6.4.3 Summary of Effects of the Proposed Action

Under the proposed action conditions in the Vale Project in the Malheur River basin would continue to have an adverse effect on critical habitat. The operations of Beulah Reservoir affect several PCEs; in most instances, these effects are insignificant or discountable because the PCEs retained function when bull trout use the reservoir.

Table 17. Summary of the effects of the proposed action for Beulah Reservoir.

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
		Beulah Reservoir and North Fork Malheur River
1	Springs, seeps, groundwater sources	Discountable effect
2	Migration habitats with minimal impediments.	Insignificant effect
3	Abundant food base	Infrequent adverse effect when reservoir drawdowns drop to run-of-river, expected in 10 of 30 years
4	Complex river, stream, lake, and reservoir aquatic environments and process	Seasonal effects from mid-May through October, but insignificant because bull trout are not present
5	Water temps ranging from 2°-15 ^{o}C with adequate thermal refugia	Seasonal effects from mid-May through October, but insignificant because bull trout are not present

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
		Beulah Reservoir and North Fork Malheur River
6	Spawning/rearing substrate.	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present
8	Sufficient water quality and quantity	Seasonal adverse effects from mid-May through October, but insignificant because bull trout are not present
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

6.5 Cumulative Effects

Climate change may change aquatic habitat in the Malheur River basin directly and indirectly. Water yield, peak flows, and stream temperatures may change. Climate change projections indicate increased precipitation in the Pacific Northwest, but warming trends may result in shifting cool season precipitation from snow to more rain events. Warming is expected to reduce the snowpack from late fall through early spring, resulting in diminished runoff. Increasing water temperatures may reduce suitable cold water habitats for bull trout which can reduce connectivity and ultimately reduce population levels.

If climate changes progress as projected, warmer air temperatures will affect stream temperatures (Vliet et al. 2011), potentially limiting thermal refugia for biota living in areas near their thermal thresholds (Kaushal et al. 2010). Thermal refugia provide bull trout with patches of cold water habitats while allowing them to migrate through areas of suboptimal warm temperatures. As one of the southern-most population of bull trout, these climate-related stresses may limit the distribution of bull trout, in some cases making it difficult for the continued expression of certain life history strategies and in extreme cases, persistence of this species in certain drainages (Rieman et al. 2007).

Other factors not related to Beulah Reservoir operations may include increases in recreational fishing pressure which may result in incidental hook injury and mortalities; changes in watershed conditions such as from large wildfire events or mountain pine beetle infestations that increase erosion; or increased road construction/maintenance, grazing, or timber harvesting which is under the control of the Bureau of Land Management and USFS.

6.6 Determination

Reclamation has determined that future O&M in the Malheur River system **may affect and is likely to adversely affect** bull trout critical habitat in Beulah Reservoir. Adverse effects to bull trout occur in 10 of 30 years (2005 USFWS BiOp) when reservoir volume at Beulah Reservoir is reduced below the suggested pool volume of 2,000 acre-feet. This causes reductions in prey availability and increased competition for prey fish for bull trout returning to over-winter in the reservoir, affecting PCEs 3, 5, and 8.

7.0 POWDER RIVER SYSTEM

In 2005, bull trout were only known to exist in the headwater tributaries well above Reclamation facilities. Bull trout were not known to migrate down to Phillips Lake or Thief Valley Reservoir, and were not known to exist in the Powder River below these reservoirs. As a result, neither the 2004 Upper Snake BA nor the 2005 USFWS BiOp described effects to bull trout in the Powder River system. In 2011, ODFW sampled two bull trout in Phillips Lake. While the origin and life-history of these fish are unknown, their appearance in the reservoir suggests the potential for bull trout presence in Phillips Lake. Due to this new information, this section describes the effects of the future O&M in the upper and lower Powder River system on both bull trout and bull trout critical habitat.

7.1 Proposed Action

The proposed action for the future O&M of Reclamation facilities in the upper and lower Powder River system is detailed in the 2004 Upper Snake BA (Reclamation 2004a, page 25) and the 2004 Operations (Reclamation 2004b, pages 137-142). The proposed action is summarized as the continued O&M of the Upper and Lower Divisions of the Baker Project including Mason Dam and Phillips Lake; Savely Dam; Lilley Pumping Plant; and Thief Valley Dam and Reservoir. Since the 2004 Upper Snake BA, no new facilities have been constructed in the Powder River system. All features and O&M activities remain the same as presented in the 2004 Upper Snake BA. Effects to bull trout were not analyzed in the Powder River basin in the 2005 USFWS BiOp.

7.2 Action Area

The Baker Project action area is described in the 2004 Upper Snake BA (Reclamation 2004a, pages 25-27). Each proposed action is a distinct action area that begins at the location of the proposed action furthest upstream effect (i.e., the upper most extent of the storage reservoir or point of diversion) and continues to the location of its furthest downstream effect (Columbia River estuary). This chapter analyzes the effects to bull trout that occur in the Baker Project action area and effects to those portions of critical habitat that intersect this area (effects to the mainstem Snake and Columbia rivers are analyzed in Chapter 8). Areas analyzed in this chapter include:

- **Phillips Lake** (897 hectares [2216.5 surface acres]): This part of the Upper Powder River CHU provides potential FMO habitat and connectivity to the upper Powder River, Deer Creek, and Lake Creek populations (USFWS 2010a, Chapter 20). This area is referred to as the "Phillips Lake" section throughout this document.

- **Powder River - North Powder River**: The portion of the Powder River CHU from the confluence with Wolf Creek upstream 0.5 miles (0.8 kilometers) to the confluence with the North Powder River. This area provides potential FMO habitat between populations in the North Powder River and Wolf Creek, but the primary function is thought to be as a migratory corridor (USFWS 2010a, Chapter 20). This area is referred to as the "North Powder River" section throughout this document.

- **Powder River - Eagle Creek**: The portion of the Powder River CHU from the historic confluence with the Snake River (currently within Brownlee Reservoir) upstream 9.5 miles (15.3 kilometers) to the confluence with Eagle Creek. Less than a mile of this portion of the action area is currently upstream of the full pool elevation of Brownlee Reservoir. This area provides potential FMO habitat (USFWS 2010a, Chapter 20). This area is referred to as the "Eagle Creek" section throughout this document.

Bull trout in the Powder River system are part of the Mid-Columbia RU (USFWS 2002b). Current distribution of bull trout in the Powder River basin is in the headwater tributaries of the Powder River 8.0 to 17.0 miles (12.9 to 27.4 kilometers) upstream from Phillips Lake and 20.0 to 25.0 miles (32.2 to 40.2 kilometers) upstream from Thief Valley Reservoir in the Elkhorn Range. Figure 38 shows current distribution of known bull trout populations in the Powder River basin (headwater tributaries only).

Figure 38 also shows the designated critical habitat streams and reservoirs, and the proposed action project boundaries for the Baker Project. This section analyzes effects where the proposed action influences the hydrology in designated critical habitat (bold red lines show the area of overlap between the 2004 Upper Snake BA action area and designated critical habitat). Operation of the Powder River system also contributes to the aggregate effect of upper Snake River projects on designated critical habitat located on the mainstem Snake and Columbia rivers. Designated critical habitat on the mainstem Snake and Columbia rivers are part of the Mainstem Snake River CHU (CHU 23), Mainstem Upper Columbia River CHU (CHU 22), and the Mainstem Lower Columbia CHU (CHU 8) and these effects are analyzed in Section 8.

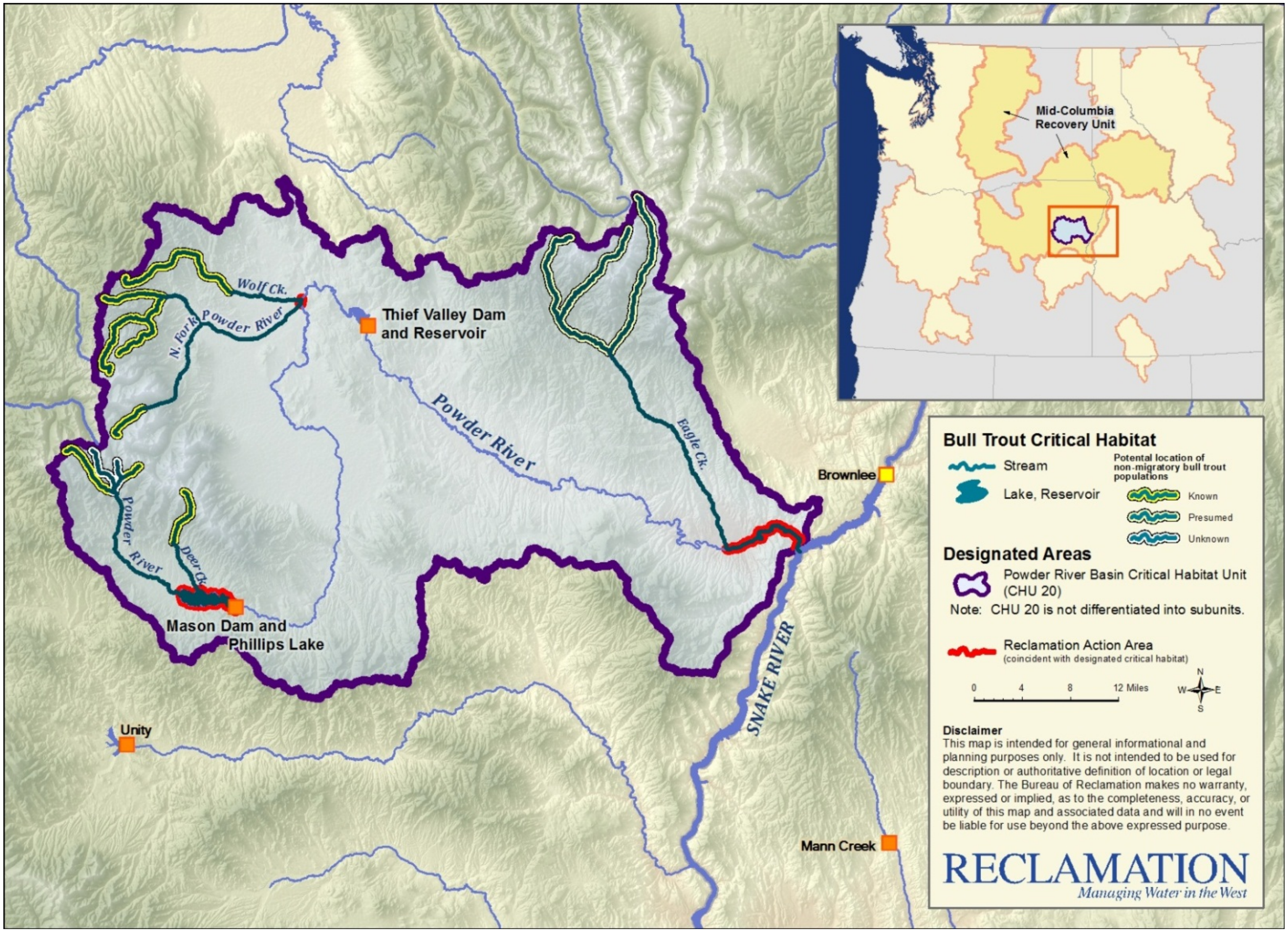

Figure 38. Powder River Basin Critical Habitat Unit 20 boundary. The action area described in Section 7.0 only includes Phillips Lake and portions of the Powder River at the confluence of the, North Powder River, and Eagle Creek.

All bull trout inhabiting the Powder River basin are thought to be resident fish (USFWS 2002b). Until 2011, no bull trout were documented in Phillips Lake. In 2011, ODFW documented two bull trout in Phillips Lake during perch removal operations. Historical dredge mining along most of the Powder River upstream from Phillips Lake severely degraded the habitat in these reaches and was thought to limit connectivity to Phillips Lake. The 2011 ODFW documentation raises speculation that bull trout may be using Phillips Lake; however, the best scientific information indicates they are not. More likely, individuals from the nonmigratory remnant headwater tributary populations of bull trout are occasionally washed into Phillips Lake during high runoff events (see baseline population status in Section 7.3.2).

Bull trout in the Powder River system are part of the Powder River CHU as defined in 75 FR 63896 and Chapter 20 of the *Bull Trout Final Critical Habitat Justification* (USFWS and IDFW 2010). The Powder River CHU is one of 12 CHUs that comprise the Mid-Columbia RU. The Powder River CHU has no subunits; however, nine tributaries are thought to support populations (Appendix A; USFWS 2010a, Chapter 20). The Upper Division of the Baker Project intersects portions of the Upper Powder River (Thief Valley Reservoir and upstream) and the Lower Division of the Baker Project intersects portions of the Lower Powder River (downstream of Thief Valley Reservoir). The Powder River CHU is considered essential to bull trout conservation because isolated populations represent a genetically distinct population in this part of the Hells Canyon reach of the Snake River (Table 18).

Table 18. Summary of stream miles, surface area, and volumes for Powder River Basin CHU 20 (CHU). Only Phillips Lake is considered reservoir habitat although the majority of critical habitat in the lower Powder River area is within Brownlee Reservoir.

Critical Habitat Unit	Critical Habitat Stream Miles (kilometers)	Critical Habitat Surface Area Acres (hectares)	Critical Habitat Storage (acre-feet)	Action Area
Powder River Basin, CHU 20 **1,095.6 total stream miles (1,763.1 kilometers)**	**184.2 (296.5)**	**2,216.5 (897.0)**	**73,000**	
Powder River CHU	19.9 (32.0)	2,216.5 (897.0)	73,000	73,000 acre-feet (reservoir); 19.9 miles (stream)

7.3 Environmental Baseline

7.3.1 Baseline Hydrology

The Powder River is roughly 153.0 miles (246.2 kilometers) long and is a tributary to the Snake River, with the confluence upstream of Brownlee Dam (Figure 38). The basin drains the eastern side of the Blue Mountains in northeastern Oregon and covers over 1,700 square miles (4,403 square kilometers) in area. The river initiates at an elevation of 4400 feet (1,341 meters) and drains into the Brownlee Reservoir at an elevation of 2064 feet (629 meters).

Historical data from multiple gages as shown in Figure 39 are used for the hydrologic analysis on the Powder River because it has not been modeled. Hydrologic graphics representing the 10 percent (wet), 50 percent (average), and 90 percent (dry) exceedances are provided in this section using the gaged datasets for the entire period of record available for each gage.

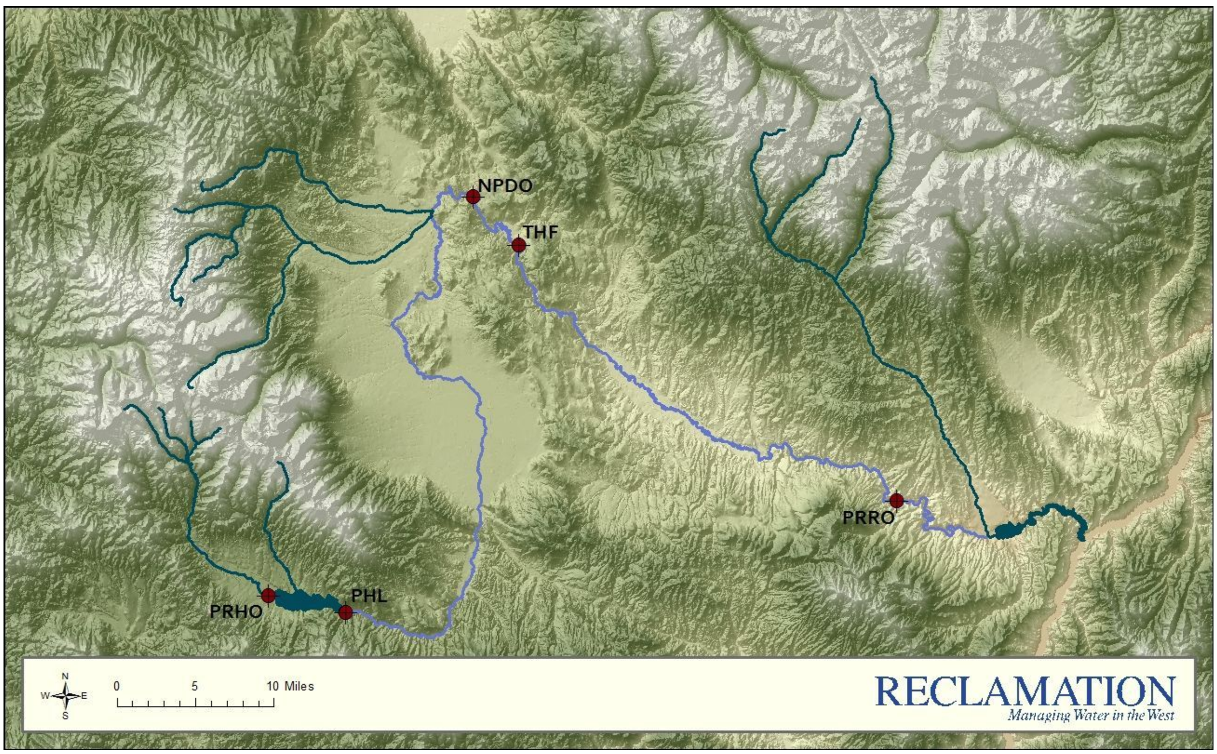

Figure 39. Locations of gages used in the Powder River analysis.

Inflow to Phillips Lake was determined using daily data for the gage at the Powder River at Hudspeth Lane above Phillips Lake (PRHO). Generally, all inflow to Phillips Lake is stored for irrigation except for flood control releases and a small 10 cfs release to maintain downstream flows. The Baker Irrigation District has an agreement with the ODFW to release enough water to meet a 10 cfs minimum instream flow at Smith Dam, about 10.0 miles (16.1

kilometers) below Mason Dam from October through January. Water is generally stored between October and March and released April through September. In an average year (50 percent exceedance), approximately 10 cfs are discharged from Mason Dam from October through January and approximately 20 to 50 cfs during February and March. From April through September of average years, approximately 100 to 200 cfs are released for irrigation diversions. Under flood control conditions, discharges up to 450 cfs would be released for short periods of time. See the 2004 Operations for a more detailed description of the operations (Reclamation 2004b, pages 137-142).

The end-of-month storage volume for Phillips Lake was determined by averaging the data on the last day of each month for the entire period of record from January 1968 through November 2011 (WY 1968-2012) (Figure 40). In general, refill begins in January or February depending on the water year type, but drafting normally begins in June. The drafting rate is consistent, regardless of water year type, until August at which time the rate slows. The storage volume in Figure 40 reflects active storage only; dead storage (3,510 acre-feet in Phillips Lake) is not reflected in the volume numbers in the figures. This dead storage volume of water may be available for in-reservoir fish use, but cannot be released downstream for instream use. Phillips Lake is also operated under formal flood control rules which dictate that an exclusive 17,000-acre-foot flood control space must be maintained at all times. The maximum storage line shown on Figure 40 reflects this flood control space; however, this space has never been fully used. If water is retained in the flood control space, it cannot be stored for irrigation and must be released as soon as possible at a rate not to exceed 450 cfs.

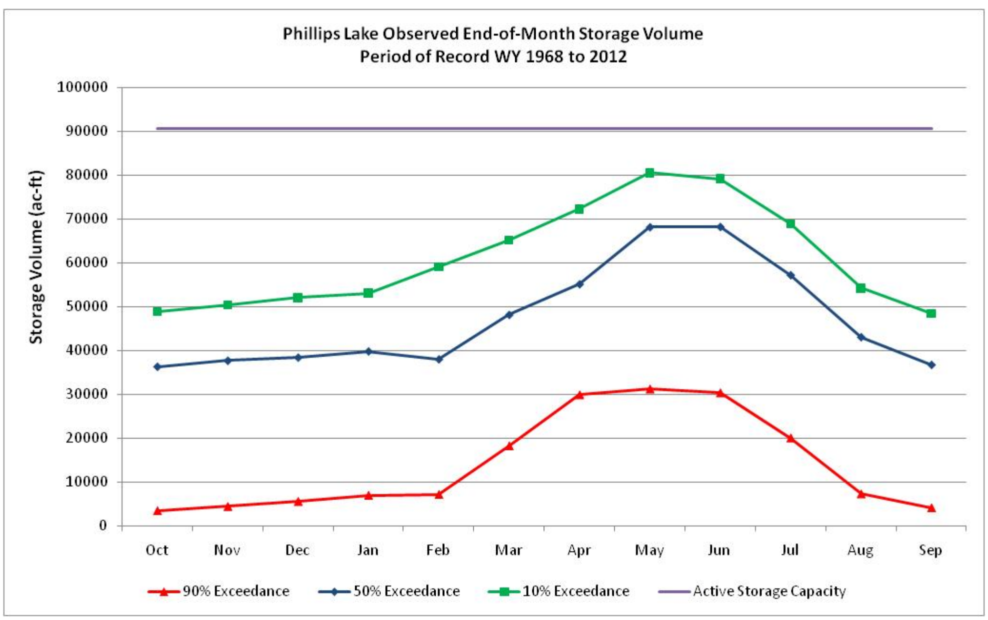

Figure 40. Phillips Lake observed 10%, 50%, and 90% end-of-month storage volume exceedance levels for the period of record (water years (WY) 1968 to 2012). Note that the active storage capacity includes 17,000 acre-feet of exclusive flood control space, which has never been fully used.

Mason Dam (Phillips Lake) discharge 10-percent, 50-percent, and 90-percent exceedance levels are plotted on Figure 41. Discharges from Mason Dam are less than 20 cfs during October, November, and December in all water year types. At the 10 percent exceedance level, outflow from the reservoir begins to increase in January and continues through June to meet flood control criteria. In average or dry years, outflow generally does not increase until March or April and peaks in May. Outflow generally begins in June and begins to taper off by the end of August.

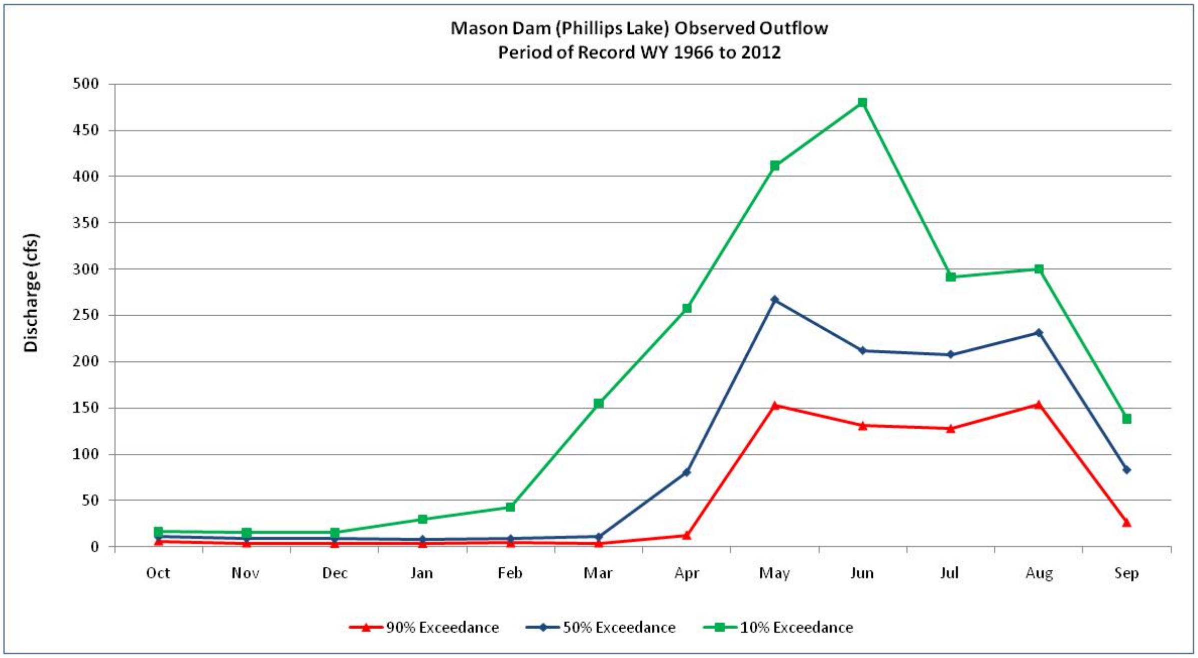

Figure 41. Monthly average observed 10%, 50%, and 90% outflow exceedance levels at Mason Dam (Phillips Lake) for period of record water years (WY) 1966 to 2012.

Thief Valley Reservoir exceedance plot of the end-of-month storage values are shown in Figure 42. Storage volume reflects active storage only; dead storage (170 acre-feet in Thief Valley Reservoir) is not shown in the volume numbers on the plots. This dead storage volume of water may be available for in-reservoir fish use, but cannot be released downstream for instream use.

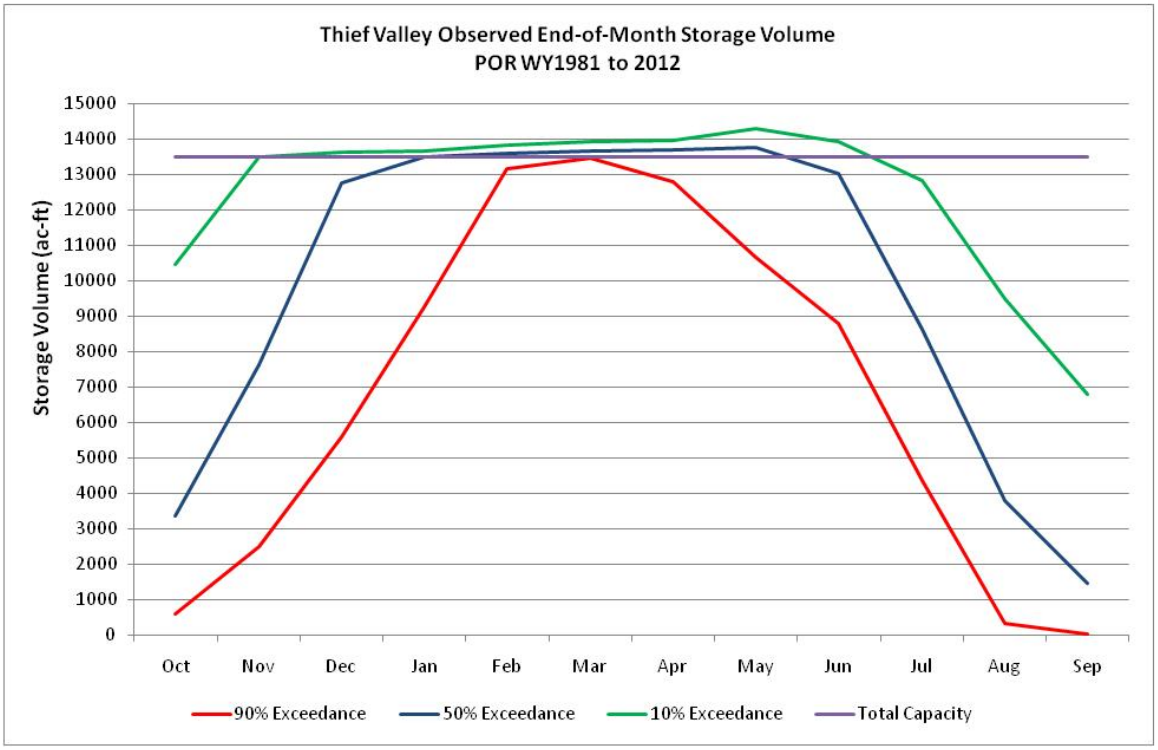

Figure 42. Observed 10%, 50%, 90% end-of-month storage volume exceedance levels for Thief Valley Reservoir for the period of record (POR) water years (WY) 1981 to 2012. Revised maximum storage volume capacity at dam crest (maximum volume revised down roughly 5,000 to 13,477 acre-feet in 2006 after a sediment study).

Thief Valley Reservoir stores all inflow to the reservoir during the late fall and winter primarily for irrigation. In most years, the reservoir fills completely in the late winter or early spring. After the reservoir is full, additional inflows will be discharged over the spillway. Figure 42 shows that at the 50- and 10-percent exceedance levels, the storage is higher than the full storage in the spring and early summer. This is due to the reservoir completely refilling and rising over the crest of the spillway to release the additional inflows. The maximum storage level on the graph is at the crest of the spillway. There are no formal flood control criteria, but some flood control space may be requested before refill in very high runoff years. See 2004 Operations for more details about the operations (Reclamation 2004b, page 142).

Figure 43 is the Thief Valley Reservoir observed outflow showing the 10-percent, 50-percent, and 90-percent exceedance levels. It indicates that releases from Thief Valley Reservoir reach almost 900 cfs in June during the wettest years, but generally peak below 400 cfs for the dry and average years. During the driest years, outflow from Thief Valley Reservoir generally does not exceed 100 cfs during any time of the year.

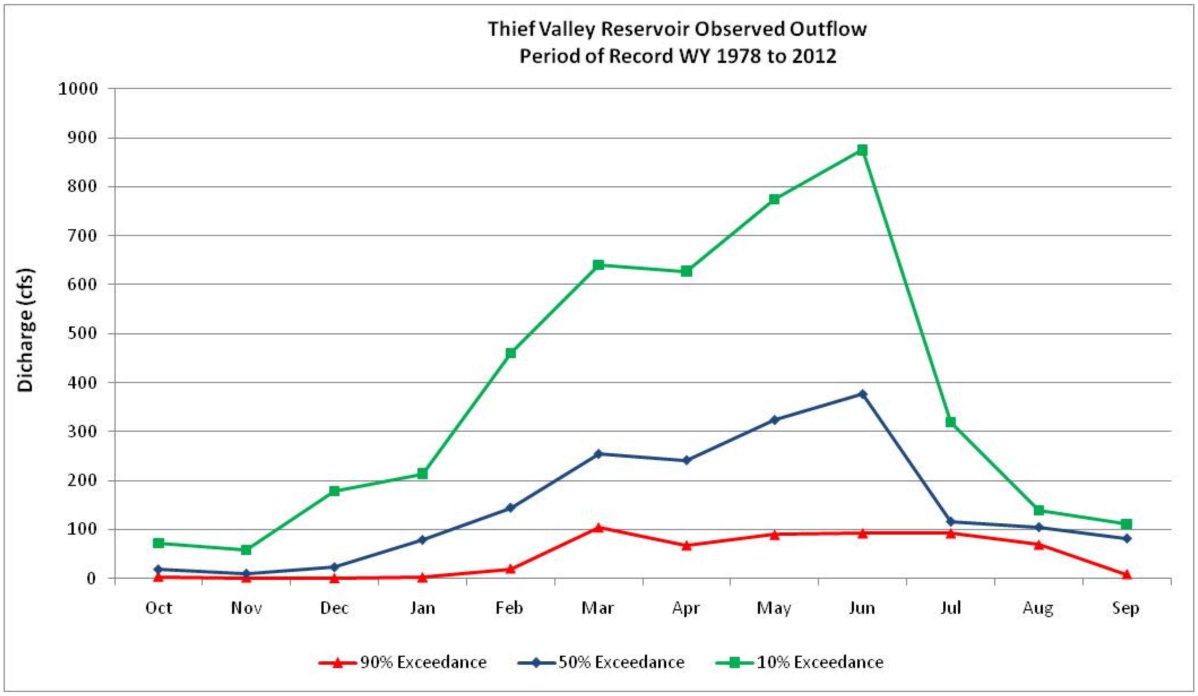

Figure 43. Thief Valley Reservoir 10%, 50%, and 90% observed outflow exceedance levels for period of record, water years (WY) 1978 to 2012.

Figure 44 depicts the exceedance levels for the Powder River near the Richland, Oregon gage (PRRO) just upstream from the mouth of the Powder River and Brownlee Reservoir showing the 10- percent, 50- percent, and 90-percent exceedance flow levels for the period of record from WY 1958 to 2012. This gage is in the Eagle Creek portion of the critical habitat action area and is presented here to show flows at that location and for comparative purposes to demonstrate the scale of effects of releases from Mason Dam on observed flows 124.1 miles (199.7 kilometers) downstream. Irrigation deliveries are released into the river channel and are diverted into various canals approximately 8.0 miles (12.9 kilometers) downstream from the dam. These low flow periods generally occur during late summer, with August generally being the lowest. Flows generally increase slowly from September through November. Flows during the summer irrigation season average about 50 cfs (Figure 44).

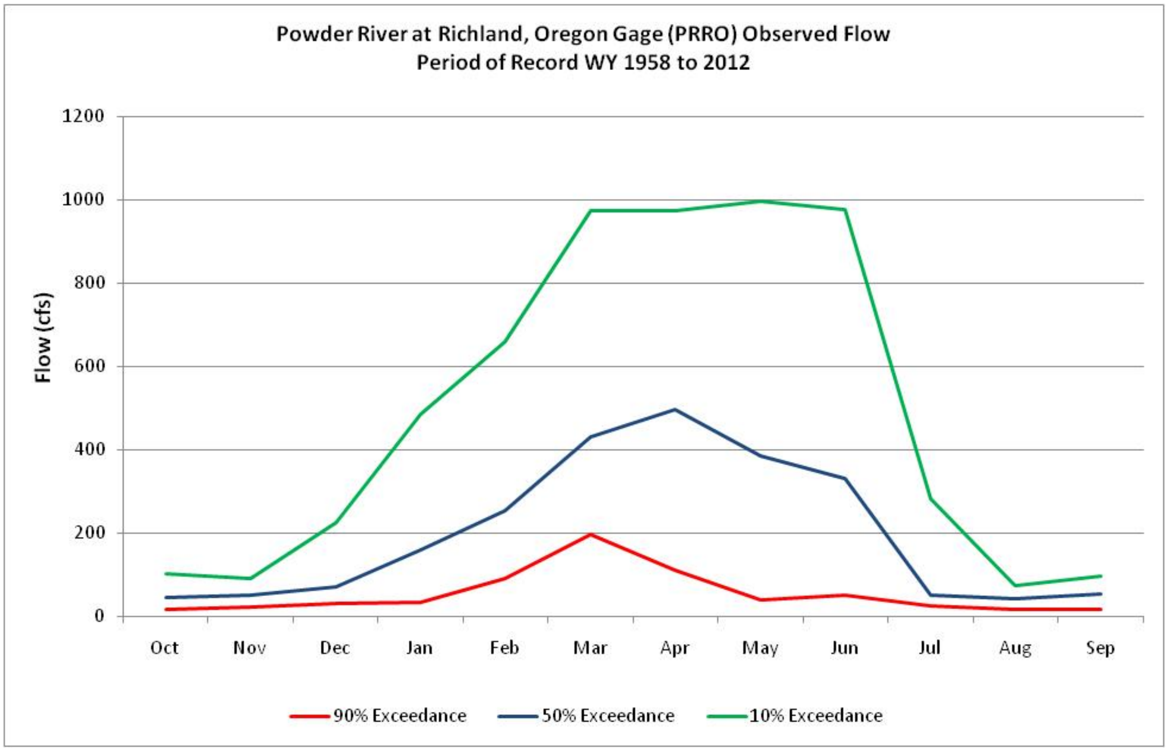

Figure 44. Observed 10%, 50%, and 90% monthly average flow exceedance levels at the Powder River at Richland, Oregon gage (PRRO) for the period of record water years (WY) 1958 to 2012.

Figure 45 shows an exceedance plot of observed flows for the Powder River near North Powder, Oregon (NPDO) for the period of record from WY 1998 to 2012. This gage is upstream of Thief Valley Reservoir and the plotted values reflect 10 percent, 50 percent, and 90 percent exceedance flows. These flows are after most of the water has been diverted for irrigation purposes above the gage. This gage is near the North Powder River portion of the critical habitat action area and is presented here to show flows at that location and for comparative purposes to demonstrate the scale of effects of releases from Mason Dam on observed flows 58.3 miles (93.8 kilometers) downstream. For this period of record, the 90-percent exceedance level flows show that during the months of July, August, and September are below 10 cfs. During August, monthly average flow was 0.8 cfs in 2005, which is the lowest monthly average flow recorded at that site.

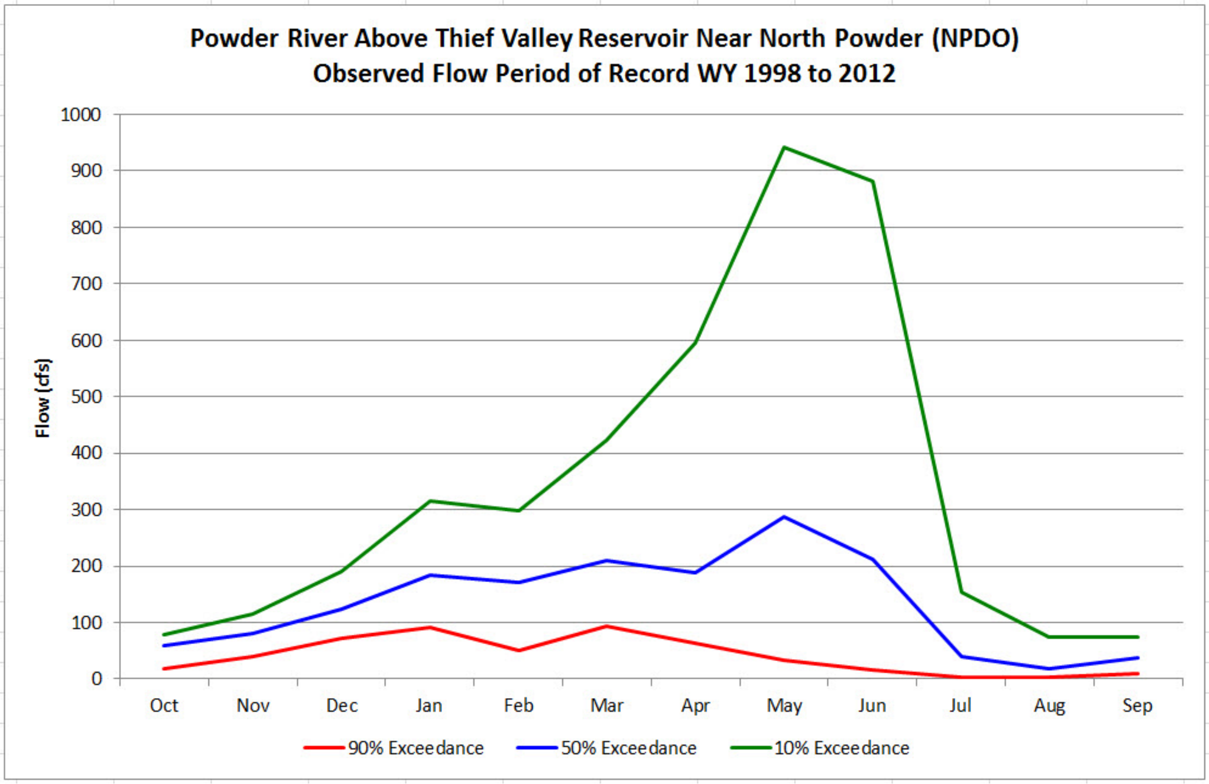

Figure 45. Powder River near North Powder (NPDO) observed 10%, 50%, and 90% monthly average flow exceedance levels (water years [WY] 1998 to 2012).

Future Hydrology with Climate Change

Currently there is no reservoir model constructed for the Powder River system so no modeled data were available. Hydroclimate Data Network sites are not present in the subbasin. Because of the lack of modeled data or processed climate change flow data, a qualitative description of the potential impacts of climate change on a basin with similar attributes as the Powder River basin is provided.

Basins that are similar to the Powder River basin may experience a greater increase in climate variability, which could mean an increase in change between wet and dry periods (Reclamation 2011d; OCCRI 2010). It is anticipated that the Powder River will reflect a similar pattern. Accompanied with the higher peaks is a possible shift in peak flow timing, which would indicate a greater likelihood of refill in the reservoirs earlier in the year with decreased inflows during the summer months. The end-of-month storage volume will likely be greater in the winter and spring due to earlier runoff and be lower in the summer and fall due to greater irrigation demand.

7.3.2 Baseline Population Status and Trends

Historical Distribution

The historical distribution of bull trout in the Powder River subbasin is unclear. Nowak (2004, page 52) stated that the species was thought to be widespread in the Powder River basin, with at least seasonal connections to the Snake River prior to 1960. Upstream fish passage above River Mile 70 on the Powder River was blocked in 1932 by the construction of Thief Valley Dam. Mason Dam, constructed in 1968, isolated bull trout in the upper Powder River from bull trout in the North Powder River and other tributaries downstream of Mason Dam. Phillips Lake was treated with rotenone in October of 1977, likely killing the native salmonid species present, and restocked in April 1978 with 150,000 hatchery rainbow trout and an undetermined number of largemouth bass, crappie, and coho salmon (PBWC 2001, page 129).

In 1998, ten local populations of bull trout in the Powder River core area were identified, but the status of some of these populations is unknown (USFWS 2002b, pages 11-14). Nine streams are currently occupied by bull trout: Lake Creek, upper Powder River, Big Muddy Creek, Salmon Creek, Pine Creek, North Powder River, Anthony Creek, Indian Creek, and Wolf Creek. Populations in these tributaries exhibit a resident life history, but passage barriers and habitat fragmentation limit the potential to migrate to the reservoir or return to their natal water except during periods of high water (USFWS 2002b, pages 15-16). The Lake Creek and upper Powder River populations are above Mason Dam, which demonstrates a resident life history, although the recent documentation of two bull trout in Phillips Lake (Bailey 2011a) might suggest that these local populations could develop a migratory life history over time if habitat conditions and connectivity were improved.

USFWS estimated a total of 250 to 1,000 individuals in all 10 local populations (USFWS 2008a, page 23), although the trend in bull trout populations in the Powder River basin is likely declining. All Powder River populations are likely affected by population fragmentation and low numbers of adults (Nowak 2004, page 48). Nowak (2004, page 48) reported that the upper Powder River populations were at moderate risk; the Indian Creek, Anthony Creek, North Powder River, and Muddy Creek populations were at high risk. The Eagle Creek population was downgraded from high risk to “probably extinct” (Nowak 2004, page 48).

Current Distribution

Presently, bull trout in the Powder River subbasin are restricted to tributary headwater areas where adequate water temperatures and habitat remain.

There is very little recent information on existing bull trout populations for the Powder River core area. Much of the data that exists was collected more than 14 years ago (USFWS 2002b, pages 11-12). According to Nowak (2004, page 48), bull trout in the Powder River basin are thought to be resident fish, as there were no documented observations of migratory bull trout in the reservoirs, including Phillips Lake, as well as the Powder River downstream of Mason Dam. However, ODFW documented two bull trout in Phillips Lake during perch removal operations in 2011. It is unknown at this time whether bull trout in Phillips Lake exhibit migratory tendencies or were moved downstream into the reservoir during spring runoff periods.

Factors Contributing to Species Decline

In general, both historical and current population data are sparse to nonexistent across much of the species range in the Powder River basin so that the degree of decline can only be qualitatively estimated. The 5-year bull trout status review found that the Powder River population was a population at high risk because of the geographical isolation of watershed subpopulations from each other, the low overall estimated population size, the limited amount of suitable habitat, and the presence of a single primary life history strategy (i.e., resident) (USFWS 2008a, pages 23, 26, 28, 30, 32). It is generally thought that at least 50 spawners are required in a local population to prevent inbreeding depression and 500 to 1,000 adults to prevent population loss through genetic drift (Rieman and McIntyre 1993, page 10). Presence of the migratory life history strategy provides a mechanism for the species to avoid catastrophic loss through adverse changes in any one habitat; however, there is no documentation of a current or historic migratory population in the Powder River basin (USFWS 2010a, page 513)

USFWS (FERC 2009, page 28) identified the primary factors for the bull trout decline in the Powder River basin as:

- Habitat fragmentation through dams, other physical impediments to passage such as roads, water withdrawals/diversions, and thermal or flow barriers to movements, noting that improperly constructed stream crossings may act as barriers to bull trout movement either constantly or under certain conditions, which prevents bull trout access to suitable habitats and increases isolation of bull trout populations. Habitat fragmentation has occurred at both a large scale within the Hells Canyon Complex, isolating local populations from each other and, at a smaller scale, within local populations.

- Nonnative fish species introductions such as lake and brook trout which can compete with or hybridize with bull trout and predatory fish such as yellow perch and brown trout.

- Habitat degradation through increased water temperature, sedimentation, and loss of stream and floodplain complexity.

Current Conditions

Phillips Lake

Fish species in Phillips Lake include rainbow trout, crappie, smallmouth and largemouth bass, yellow perch, walleye, and tiger trout (Nowak 2004, page 38). Yellow perch and walleye were introduced in the 1980s and yellow perch have dominated the lake fishery.

ODFW has sampled nonnative yellow perch in Phillips Lake since 1991 (ODFW 2000, page ii). Sampling occurred in 1991, 1994, and 1999 to investigate the impact of yellow perch on zooplankton and game fish (smallmouth bass, black crappie, and rainbow trout). ODFW (2000, page ii) concluded from the 1994 investigation that "if yellow perch became abundant, they could potentially cause a shift in the zooplankton community structure and size distribution and reduce warm-water game fish production." ODFW (2000, page 15) later concluded that the zooplankton population experienced a marked change following the 1994 study. The selection of larger zooplankton by yellow perch drove the zooplankton towards smaller species and individuals that cannot be utilized by young-of-year and juvenile bass and crappie. This change in food web structure complicated management of the Phillips Lake fishery.

ODFW began trapping yellow perch to reduce its population (Bailey 2012a, page 1) and with the objectives of increasing trout growth and survival and increasing yellow perch growth. Trapping operations took place in 2009 (51,574 perch removed), 2010 (360,629), 2011 (354,468), and 2012 (343,000) (Bailey 2012a, page 5). The estimated yellow perch abundance in the reservoir at the time of the 2011 removal effort was 1,636,575 (Bailey 2012a, page 6). Annual yellow perch removals are scheduled to continue through 2013.

In spring 2011, ODFW sampled two bull trout in Phillips Lake for the first time during yellow perch removal operations. It is unknown whether these fish were adfluvial in nature or had simply been flushed downstream from upper reaches of the Powder River. No bull trout were observed during similar perch removal operations conducted at Phillips Lake in 2012 (Bailey 2012b).

In September 2011, ODFW released about 1,600 sterile tiger trout into Phillips Lake in an effort to control yellow perch (Bailey 2011b). Tiger trout are known to be highly piscivorous and long lived (12 to 17 years). ODFW believe they will be a good control against perch populations in Phillips Lake.

In spring 2013, ODFW will start a tiger muskie stocking plan, calling for 36,000 fingerling size tiger muskie to be released annually for a period of at least 5 years to control against the expanding perch population (ODFW 2012).

Upstream of Phillips Lake

Nearly all streams in the upper Powder River drainage upstream of Phillips Lake contain signs of past mining activities. The most noticeable area is the 6-mile reach of the Powder River between Sumpter and Phillips Lake that was dredged, resulting in straightened stream channels and the destruction of meadow areas and riparian vegetation (Nowak 2004, Chapter 3.1.1.6). The dredge operations turned the riparian area and floodplain over which created tailings piles, many of which cross the valley floor (Figure 46). Some riparian vegetation has reestablished, but the tailings piles have constricted the river channel and simplified the channel, disconnecting the river from its floodplain. Dredging activities caused damage to the floodplain function, habitat complexity, pool quality and quantity, riparian vegetation, stream shading, and instream channel function.

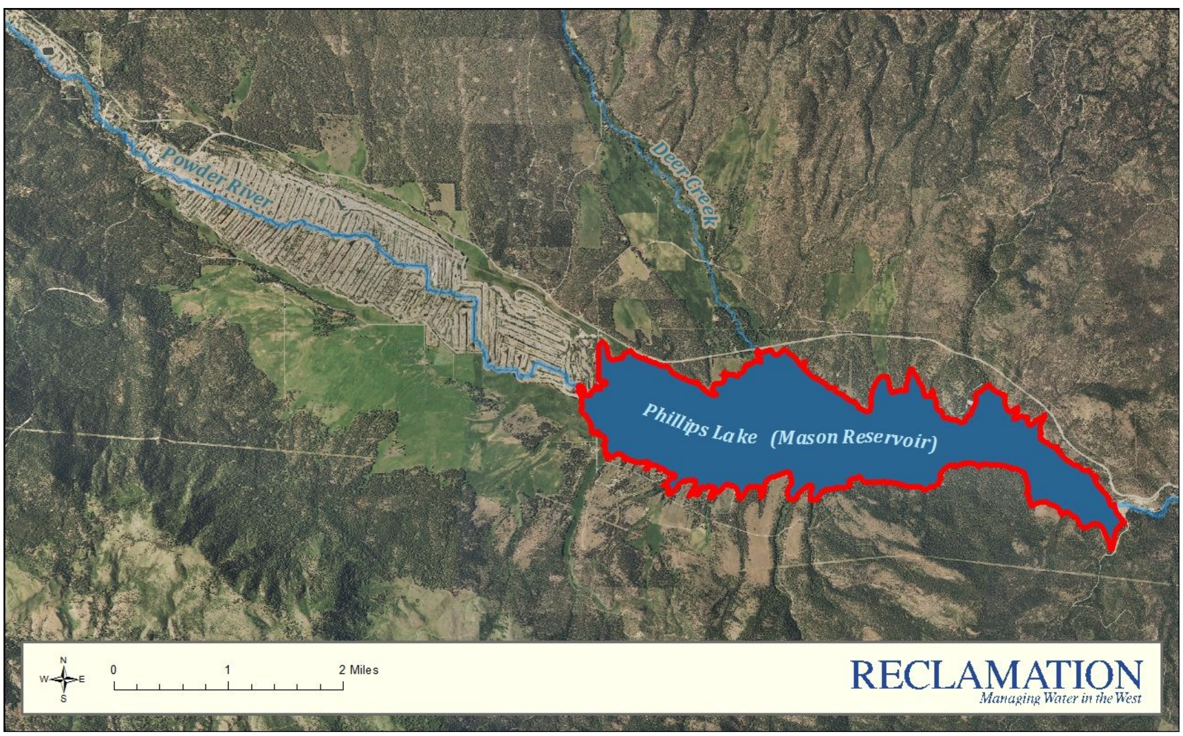

Figure 46. Aerial photograph showing the extensive tailings piles left by dredge mining above Phillips Lake.

Lake Creek is a tributary to Deer Creek; the confluence of the two is approximately 5.0 miles (8.0 kilometers) upstream of where Deer Creek enters Phillips Lake. Bull trout are known to occur in Lake Creek approximately 1.5 miles (2.4 kilometers) upstream from the confluence with Deer Creek (about 6.5 miles [10.5 kilometers] upstream of Phillips Lake) (USFWS 2009, page 253). Suitable spawning and juvenile rearing habitat generally occurs farther upstream and outside of waters affected by the Baker Project. Habitat fragmentation, nonnative fish species introductions, and habitat degradation have resulted in a significant reduction in bull trout habitat in the Powder River basin including Lake Creek.

Powder River below Mason Dam

Habitat conditions in the Powder River below Mason Dam are poor from Baker City to Thief Valley Dam. Loss of habitat diversity is due to a number of factors including confinement by roads and railroads, diking, straightening, and the loss of riparian vegetation due to agricultural activities (Nowak 2004, chapter 3.1.3.4). Many riparian areas along the mainstem Powder River have been reduced or removed due to agricultural/grazing practices similar to the portion of Powder River shown in Figure 47. These practices have resulted in reduced instream and streambank cover, reduced streambank stability, and increased stream temperatures (HCCRUT 2003). In an attempt to improve these degraded conditions, the Oregon Watershed Enhancement Board funded projects, including riparian restoration, on 10.0 miles (16.1 kilometers) of the Powder River below Baker City (USFWS 2010a, page 514). Although this habitat is identified as potential FMO habitat, the functional value may be limited to a seasonal migration corridor between headwater populations.

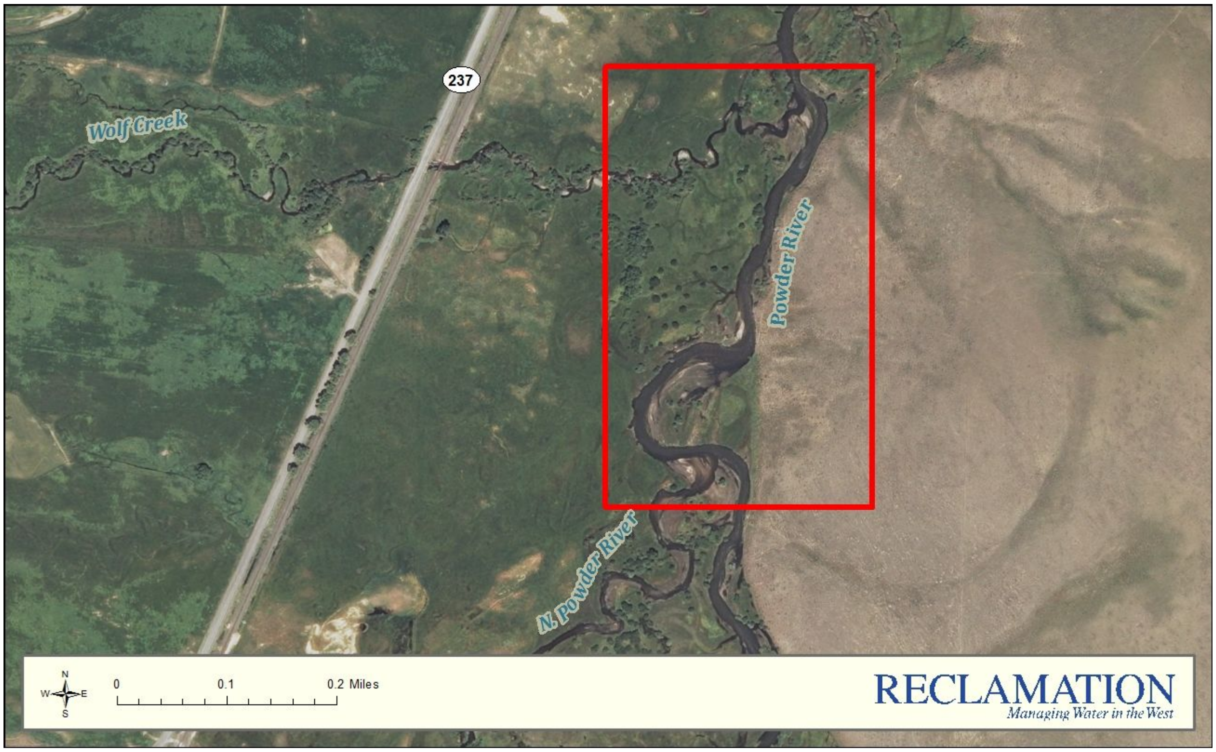

Figure 47. Aerial photograph showing the action area in the Powder River between mouth of Wolf Creek and North Powder River.

Eagle Creek

Little to no water is released from Thief Valley Reservoir during the winter. ODFW filed for instream water rights on the Powder River and its tributaries in 1991 for fish habitat purposes. Instream flow rights at specific river reaches in the river and its tributaries range from 1.8 to 60.0 cfs. These minimum flows currently are not always met because of natural flow fluctuations or stream depletion by higher-priority water rights. This is particularly true of the larger 50-cfs instream flow immediately below Thief Valley Reservoir to Goose Creek.

The Powder River basin includes numerous ditches, both active and inactive (Nowak 2004, chapter 3.1.3.3). Constructed for use in mining and irrigation, it is not known how many of the historic ditches are currently in use or how much water they carry. Screening of diversions has been minimal and of low priority.

Major anthropogenic activities have resulted in changes to the Powder River, including logging; fire suppression; grazing, cultivation, and other agricultural development; draining of wetlands; ditching and diking of streams; water withdrawal; and the introduction of exotic plant and animal species (Nowak 2004, chapter 3.1.3.4; see Figure 48). Although this habitat is identified as potential FMO habitat, the functional value may be limited to a seasonal migration corridor between headwater populations.

Figure 48. Aerial photograph showing the action area downstream of the mouth of Eagle Creek and within Brownlee Reservoir.

7.3.3 Baseline Critical Habitat Conditions

Phillips Lake provides FMO habitat during the fall, winter, and spring for connectivity to the upper Powder River populations of bull trout and Deer Creek/Lake Creek population (75 FR 63898, page 63907). Suitable spawning and juvenile rearing habitat generally occurs farther upstream and outside of waters affected by the Baker Project. Habitat fragmentation, nonnative fish species introductions, and habitat degradation have resulted in a significant reduction in bull trout habitat in the Powder River basin. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant in the Powder River basin and have resulted in a legacy of degraded habitat conditions include:

- Fragmentation and isolation of local populations due to dams and water diversions that have eliminated habitat; altered water flow and temperature regimes; and impeded migratory movements.

- Degradation of spawning and rearing habitat and upper watershed areas, particularly alterations of streambed habitat by mining activities in the upper Powder River basin.

- The introduction and spread of nonnative fish species as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources.

- Degradation of FMO habitat resulting from reduced prey bases, roads, agriculture, and dams.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Phillips Lake

PCE 1 is present, but provides a limited contribution to potential FMO habitat in Phillips Lake. The Powder River is the main source of water and nutrients to the reservoir followed by Deer Creek. Phillips Lake provides FMO habitat (fall, winter, and spring). The primary drivers of water quality, temperature, and thermal refugia at Phillips are inflows from the Powder River and Deer Creek and the operation of Mason Dam. Groundwater is not a significant factor. Small areas of wetlands and riparian zones are present, associated with the mouth of the Powder River and Deer Creek. These wetlands and riparian areas appear to be maintained by flow from the river and not by groundwater. High to full pool levels in the reservoir result in groundwater recharge that is later released as reservoir levels drop during irrigation water withdrawals. Generally, this groundwater release does not play a significant role in contributing to cold water refugia within the reservoir.

Subsurface connectivity between cold water refugia in the reservoir and tributary habitats may be limited by the condition of tributaries outside the action area rather than the proposed action. Many tributaries in the Powder River basin exceed cold water biota standards during summer months (ODEQ 2013b, page 98). The role of springs, seeps, or groundwater from these unmanaged tributaries on cold water refugia in the reservoir is unknown. Generally, the significance of spring seeps and groundwater sources are greater in the headwater areas where they have more contribution to the total flow than further downstream (Wehrly et al. 2006).

North Powder River

The presence of PCE 1 in the North Powder portion of the Powder River is unknown, but likely immeasurable. Little or no data regarding groundwater within the North Powder section is available because land bordering this portion of the action area is privately owned and inaccessible. There are multiple land uses identified in both the Core Area Assessment (USFWS 2005b) and the ODEQ Draft Powder Basin Status Report (ODEQ 2013b) that influence the baseline condition in this area including grazing, farming, and water diversions. If PCE 1 is present, it does not have a significant contribution to the function of the PCE.

Eagle Creek

The presence of PCE 1 in the Eagle Creek portion of the Powder River is unknown, but likely immeasurable. A portion of this area (approximately 1 mile) is within the Daly Wildlife Habitat Management Area owned and managed by Idaho Power.[5] The remaining portion (approximately 8.5 miles [13.7 kilometers]) is within the Brownlee Reservoir pool. Management of the Daly Wildlife Habitat Management Area likely has the most potential to influence the condition of this PCE in this part of the action area. Planned management for the area is expected to include riparian enhancement; these efforts will likely improve the FMO habitat. Brownlee Reservoir operations will influence the rest of the action area similarly to the influence described for Phillips Lake. If PCE 1 is present, it does not have a significant contribution to the function of the PCE.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Phillips Lake

PCE 2 is present in and contributes to potential FMO habitat in Phillips Lake for bull trout that may be present. It is difficult to assess this PCE because little is known regarding when bull trout might migrate to or from the reservoir. Since ODFW began intensive fish sampling in 1991, they have found only two bull trout in Phillips Lake. It is unlikely that bull trout that are present represent a migratory form. If a migratory form were to develop, it is likely they would have similar characteristics to the bull trout in Beulah Reservoir because of the similarities in geography, climate, reservoir operations, and conditions between the two reservoirs. Bull trout in Beulah Reservoir migrate out of the reservoir in mid-May and do not return until late October.

Bull trout migration to and from the reservoir may be limited by three factors: temperature and dissolved oxygen conditions; an infrequent migration barrier in the varial zone of Deer Creek; and entrainment of fish from the reservoir.

First, seasonal water temperature and dissolved oxygen effects occur in September as a result of thermal loading both in the reservoir and from tributaries outside the action area and bacterial respiration in the hypolimnion. Most streams in the Powder River basin, including the Powder River above Phillips Lake, exceed biologically based criteria for cold water biota (ODEQ 2013a). Bull trout are not likely to be present in the reservoir during this time.

[5] See http://www.idahopower.com/OurEnvironment/WildlifeHabitat/Daly/.

Second, a seasonal physical migration barrier exists in the varial zone of Deer Creek due to the presence of two abandoned road beds in close proximity to one another within the full pool margin. Portions of the old highway cause Deer Creek to split and braid within the varial zone. Deer Creek intersects the abandoned road beds at an approximate elevation of 4048 feet, a point that is reached during most years. Access to Phillips Lake on the Powder River is severely impacted by dredge mine tailings upstream from the reservoir (Figure 46). The presence of the dredge mine tailings creates partial physical and biological barriers to migration above the action area between over-wintering habitat in Phillips Lake and spawning and rearing habitat in the Powder River. Barriers do not occur when bull trout would be likely to be present in the reservoir.

Third, the extent of entrainment and resulting effects on bull trout is unknown at this time; however, it is unlikely that if bull trout were present they could be entrained at Mason Dam. Releases from Mason Dam occur exclusively through the outlet works located near the bottom of the dam and not the spillway, eliminating the possibility of entraining bull trout in the spring that may be present in the upper water column of Phillips Lake. Entrainment has been identified as occurring in other systems mostly associated with spillway releases during the spring season when bull trout are likely to be in the upper water column feeding. No entrainment has been documented from the outlets works close to the bottom of the dam and no recent documentation of bull trout in the Powder River below Mason Dam exists.

North Powder River

PCE 2 is present, but provides a limited contribution to potential FMO habitat in the Powder River. Degraded baseline conditions are present in the North Powder portion of the Powder River that could limit migration between resident populations of bull trout that are present in headwater locations. Physical barriers due to dewatering occur in the North Powder River and Wolf Creek (USFWS 2005b) causing potential migration limitations out of the action area into these areas. The North Powder River is one of the highest priorities for flow restoration in the Powder River basin (ODEQ 2013a). Wolf Creek also has numerous seasonal impediments including Wolf Creek Dam (a non-Reclamation project). Furthermore, natural thermal loading in most tributaries and the mainstem Powder River exceed biologically-based criteria for cold water biota (ODEQ 2013a). Bull trout use of this area as a migration corridor is unlikely; however, migration to headwater tributary locations does not typically occur during the time when the barriers described above would be present.

Eagle Creek

PCE 2 is present, but provides a limited contribution to potential FMO habitat in the Powder River. Degraded baseline conditions (e.g., low flow, lack of screened diversions, high temperatures) are present in the Eagle Creek portion of the Powder River; however, in 2008, Idaho Power purchased the land bordering the upper portion of this area and is currently developing a comprehensive management plan for habitat enhancement in consultation with State and Federal resource agencies. Approximately 1.0 mile (1.6 kilometers) of the action area is owned and managed by Idaho Power as the Daly Wildlife Habitat Management Area. Habitat improvements include revegetation projects and irrigation improvements that will maintain more water in the Powder River. These efforts will improve FMO habitat. The remaining portion of this section in the action area is within the Brownlee Reservoir pool which is operated by Idaho Power.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Phillips Lake

PCE 3 is present in and contributes to potential FMO habitat in Phillips Lake. Baseline condition is functional with adequate forage available from native and nonnative prey species in the reservoir (PCE 9). Species encountered during ODFW fish sampling include an abundant prey base of forage fishes for bull trout. An expanding perch population has altered the food web dynamics in the reservoir, potentially limiting the diversity, but not the abundance of prey items for bull trout that could be seasonally present (ODFW 2012).

The proposed action includes inactive storage in Phillips Lake; the presence of this pool contributes to the conditions that allow the current abundance of prey fishes that are available to bull trout that could use the reservoir as over-wintering habitat.

North Powder River and Eagle Creek

The function of PCE 3 in the North Powder River and Eagle Creek portions of the Powder River are unknown.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes, that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths gradients velocities and structure.

Phillips Lake

PCE 4 is present, but provides a limited contribution to potential FMO habitat in Phillips Lake. Reservoir depth and shallow shoreline habitat provides the most significant habitat complexity and contribution toward FMO habitat. Depth allows temperature (PCE 5) and water quality conditions (PCE 8) to support at least minimal benefits throughout the year. Shallow shoreline habitat allows increased primary productivity (PCE 3) that supports a diversity of prey fishes.

Habitat conditions of the watersheds that enter Phillips Lake have been impacted by mining, floods, and cattle grazing (USFWS 2005b), contributing to a decreased complexity of reservoir habitat during drawdown conditions. Drawdowns expose the varial zone of the Powder River within the Phillips Lake pool. Habitat complexity is affected by changing the habitat features from a reservoir environment to a river type environment. A habitat survey was conducted in 2011 to quantify habitat variables in the varial zone within the reservoir (Prisciandaro 2012). Although the river habitats in the varial zone are different from those in the reservoir and degraded from unregulated systems, they still offer a variety of environments that could be used by bull trout.

In dry years, the inactive pool of 3,510 acre-feet prevents the reservoir from going completely empty, protecting the habitat diversity at low pool elevations. Since 1968, Phillips Lake has only dropped below 5,000 acre-feet three times.

North Powder River

PCE 4 is present, but provides a limited contribution to potential FMO habitat in the Powder River. Conditions in the Powder River are generally degraded. The river lacks recruitment of sediment and large woody material from sources upstream of Mason Dam. Baseline conditions of the watershed have been impacted by multiple land uses including mining, agriculture, and grazing practices (USFWS 2005b). These events have caused sediment transport above levels naturally expected into the Powder River and reduced instream and riparian cover and streambank stability. The results of these uses have reduced riparian habitat complexity and limited the functional use of the Powder River as potential FMO habitat to periods of higher flow.

Eagle Creek

PCE 4 is present, but provides a limited contribution to potential FMO habitat in the Powder River. Conditions are similar to those described for the North Powder River reach. However, the management plan being developed for the Daly Wildlife Habitat Management Area (action area) may improve conditions over those currently observed.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Phillips Lake

PCE 5 is present, but provides a limited contribution to potential FMO habitat in Phillips Lake. Phillips Lake provides adequate water temperatures for potential FMO habitat

November through July, a period when migratory bull trout, if present in the basin, would likely be in the reservoir (Figure 49). Water temperatures and dissolved oxygen levels become unsuitable for bull trout beginning in mid- to late July through October, forcing any bull trout in the reservoir to migrate into the Powder River. However, based on the migration of adfluvial adults in other systems, bull trout would typically leave the reservoir during this time anyway for spawning migrations to the headwater tributaries.

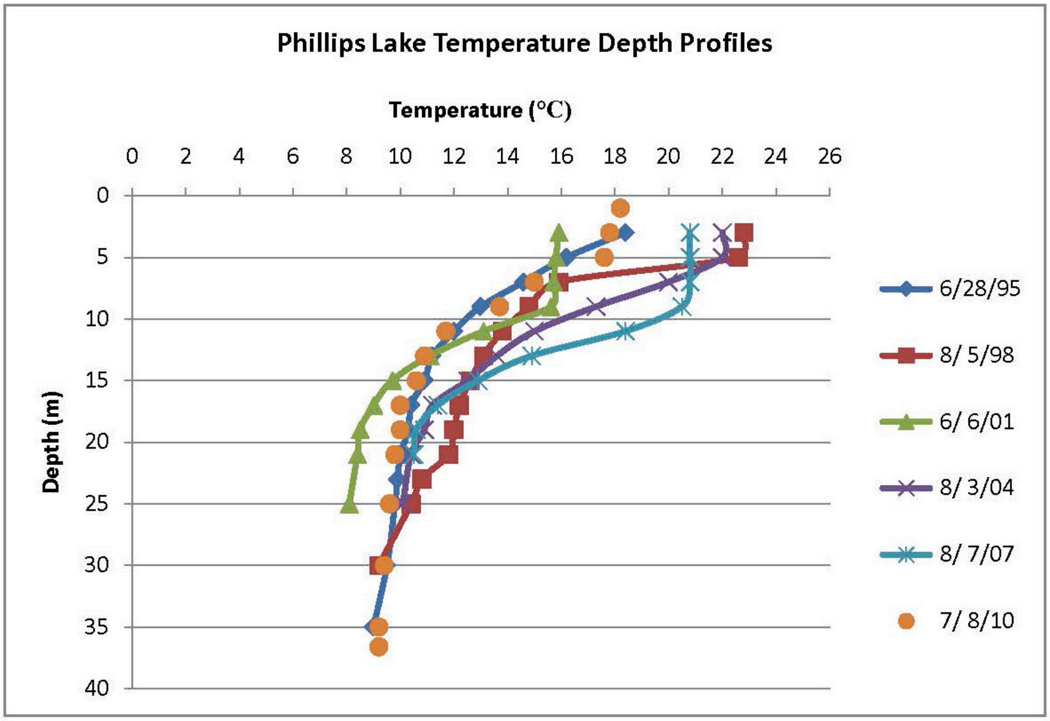

Figure 49. Monthly average temperature profiles in Phillips Lake.

The functionality of PCE 5 in Phillips Lake is partially affected by conditions outside the action area. Water temperatures in many portions of the Powder River basin including the Powder River upstream of the action area exceed 15° C from July through September exceeding biologically based cold water criteria (Figure 50; ODEQ 2013a). According to the USFS, 7-day maximum temperatures exceeding 18° C have been recorded at the Deer Creek temperature gage located near the mouth of Deer Creek and the full pool elevation of Phillips Lake (FERC 2009, page 20). Conditions in the Powder River and tributaries may deteriorate, but thermal refugia at higher elevations and in springs in headwaters tributaries are available to all life stages of bull trout.

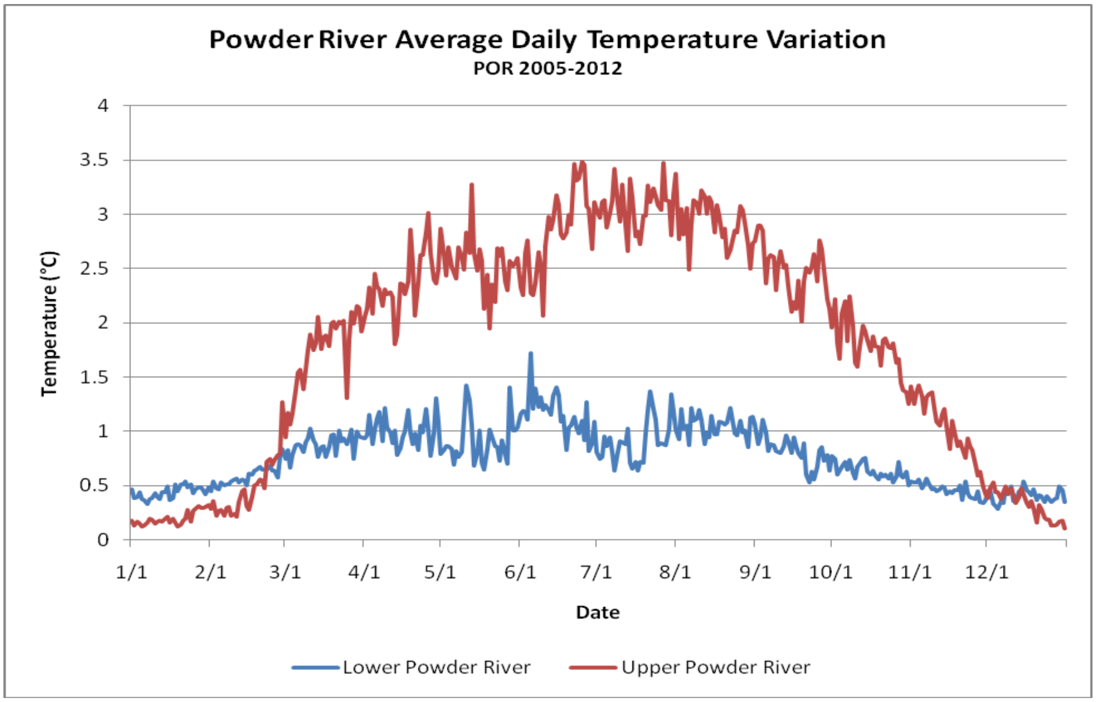

Figure 50. Powder River average daily temperature variation (maximum - minimum) for the period of record (POR) 2005-2012; Upper Powder River (gage PRHO) represents stream temperatures entering Phillips Lake and Lower Powder River (gage PHL) represents stream temperatures leaving Phillips Lake.

North Powder River

PCE 5 is present, but provides a limited contribution to potential FMO habitat in the Powder River below Phillips Lake. Generally, the water temperature immediately below Phillips Lake is within 2° to 15° C in most months (Figure 49). However, water temperature monitoring performed for the Powder/Brownlee Agriculture Water Quality Management Area Plan and ODEQ recorded that water temperatures were influenced by multiple causes and usually exceeded 15° C during the summer throughout the action area in the North Powder River (52.7 miles downstream from Mason Dam) (SWCD 2007). Natural thermal loading causes most waters in the basin to exceed biologically based cold water biota standards partially exacerbated by land uses reducing riparian cover. Additionally, wastewater treatment facilities in both Baker City and North Powder are point sources for elevated water temperature and have permits to exceed State standards (ODEQ 2013b, page 30).

The proposed action has a limited contribution to water temperatures in the North Powder portion of the action area because of the multiple other causes (described earlier) that have a greater effect on this PCE. During most of the year, releases from Mason Dam could help to ameliorate the nonproject effects to this PCE by reducing water temperatures in the Powder River, but not enough to reach PCE targets.

The function of the Powder River is primarily to provide a seasonal migration corridor between areas that are capable of supporting bull trout critical habitat year-round. Periods when water temperatures exceed targets are seasonal and do not occur during times when bull trout are expected to be present.

Eagle Creek

PCE 5 is present, but provides a limited contribution to potential FMO habitat in the Powder River below Phillips Lake. Conditions are similar to those described for the North Powder reach above. A wastewater treatment facility in the city of Richland causes the same temperature concerns as described above. The management plan being developed for the Daly Wildlife Habitat Management Area (within the action area) may improve conditions over those currently observed. Furthermore, the operation of Brownlee Reservoir (managed by Idaho Power) has a greater influence on water temperatures within the 8.5 miles (13.7 kilometers) of the action area that is within the Brownlee Reservoir pool than the proposed action.

The proposed action has a limited contribution to water temperatures in the Eagle Creek portion of the action area (124 miles [199 kilometers] downstream from Mason Dam) because of the multiple other causes described earlier that have a greater effect on this PCE.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present in the areas analyzed in this chapter. Neither Phillips Lake nor the North Powder and Eagle Creek portions of the Powder River were designated as spawning and rearing habitat (USFWS 2010a, page 629, 641).

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

Phillips Lake

PCE 7 is not present in Phillips Lake. PCE 7 refers to "a natural hydrograph including peak, high, low and base flows, or if flows are controlled minimal flow departure from a natural hydrograph." Accordingly, PCE 7 addresses the timing and amount and timing of stream flow, a characteristic that is by definition not present in a reservoir environment.

North Powder River

PCE 7 is present, but provides a limited contribution to potential FMO habitat in the Powder River below Phillips Lake. The hydrograph in the Powder River is altered and does not follow the natural daily and seasonal fluctuations of unregulated systems. The hydrograph in this portion of the action area is characterized by flows that are higher in the winter, a lower spring peak, and higher during the summer when flows are held artificially high from irrigation deliveries (Figure 41). A 10-cfs minimum instream flow agreement between ODFW and the Baker Irrigation District maintains water in the channel immediately below Mason Dam from October through January; however, benefits of this flow are not noticed in the North Powder River portion of the action area as a result of water withdrawals (section 7.3.1).

Mason Dam is approximately 40.0 river miles (64.4 kilometers) from the North Powder River portion of the action area. The hydrograph for this area is depicted in Figure 45 (gage NPDO). Releases from Mason Dam (Figure 41) have little influence on the shape of the hydrograph in this area as a result of the many nonproject land management uses including water diversions.

The function of this PCE in the Powder River is to provide a migration corridor between areas that are capable of supporting bull trout critical habitat year-round. Because of the conditions outside the action areas, this function is likely limited to periods of high flow.

Eagle Creek

PCE 7 is present, but provides a limited contribution to potential FMO habitat in the Eagle Creek portion of the action area. The hydrograph in the Powder River is altered and does not follow the natural daily and seasonal fluctuations of nearby systems.

Mason Dam is approximately 124.1 river miles (199.7 kilometers; extracted from the medium resolution national Hydrographic Dataset) from this portion of the action area. The hydrograph in this portion of the action area is depicted in Figure 41. Releases from Mason Dam have little influence on the shape of the hydrograph in this area as a result of the many nonproject land management uses including water diversions. Management of Thief Valley Reservoir approximately 47.8 river miles (76.9 kilometers) from this portion of the action area has more potential than Mason Dam to affect this area, but even the operation of Thief Valley Dam does not shape the hydrograph at gage PRRO (Figure 44).

The function of this PCE in the Powder River is to provide a migration corridor between areas that are capable of supporting bull trout critical habitat year-round. Because of the conditions (i.e., land management activities, water withdrawals) outside the action areas, this function is likely limited to periods of high flow.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Phillips Lake

PCE 8 is present in and contributes to potential FMO habitat in this area. Water quality and quantity data is limited, but indicate water quality conditions in Phillips Lake are good (Nowak 2004) and habitat for bull trout would likely be available through most of the year with the exception of July through October, allowing bull trout, if present, to over-winter successfully in Phillips Lake. The reservoir is classified as oligotrophic, indicating that a nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir. Water temperatures and dissolved oxygen levels show seasonal limitations in September; however, bull trout are not thought to be present during this time. Sediment and turbidity levels are typically very low and should not impact sight foraging fishes or cause gill abrasions or other secondary or delayed mortality issues associated with high suspended solids or turbidity. Water quality and quantity are adequate to allow the prey base (fish, aquatic invertebrates, and zooplankton) to remain at sufficient levels to support bull trout. The TN:TP ratios indicate that blue green algae and other unpalatable forms of nitrogen-fixing algae should not dominate the reservoir as nitrogen is common. Furthermore, the types of algae that are often associated with the observed TN:TP ratios should provide suitable forage for zooplankton and other aquatic invertebrates.

North Powder River

PCE 8 is present in and contributes to potential FMO habitat in the Powder River. Degraded baseline conditions exist seasonally as a result of both point and nonpoint sources. Water quality is limited from Mason Dam to Brownlee Reservoir pool with some water quality standards being exceeded during both irrigation and nonirrigation seasons (ODEQ 2013b, page 74). Wastewater treatment facilities in both Baker City and North Powder are point sources for temperature and nutrients into the Powder River, including a permit to exceed State standards (ODEQ 2013b, page 30). Additionally groundwater contamination occurs from nonpoint sources including arsenic, nitrate, *E. coli*, and sodium (ODEQ 2013b, page 17).

The proposed action has a limited contribution to water quality in the North Powder River portion of the action area because of the multiple other causes described earlier that have greater effects on this PCE.

Eagle Creek

PCE 8 is present in and contributes to potential FMO habitat in the Powder River. Conditions are similar to those described for the North Powder River reach. A wastewater treatment facility in the city of Richland causes the same water quality concerns as previously described. The management plan being developed for the Daly Wildlife Habitat Management

Area (within the action area) may improve conditions over those currently observed. Furthermore, the operation of Brownlee Reservoir (managed by Idaho Power) has a greater influence on water quality within the 8.5 miles (13.7 kilometers) of the action area that is within the Brownlee Reservoir pool than the proposed action.

The proposed action has a limited contribution to water quality in the Eagle Creek portion of the action area because of the multiple other causes described earlier that have greater effects on this PCE.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Phillips Lake

PCE 9 is present, but provides a limited contribution to potential FMO habitat in Phillips Lake. The proposed action provides an environment that allows the survival of nonnative fishes; however, ODFW exclusively manages the fisheries including stocking and regulations that favor the presence of individual species.

Nonnative fish are present in Phillips Lake (stocked rainbow trout, crappie, smallmouth and largemouth bass, yellow perch, walleye, tiger trout, and tiger muskie). Juvenile nonnative fish may comprise part of the bull trout prey base in Phillips Lake. Tiger trout and tiger muskie could prey on smaller-sized bull trout.

North Powder River and Eagle Creek

PCE 9 is present, but provides a limited contribution to potential FMO habitat in the Powder River. Because of the proximity to Thief Valley and Brownlee reservoirs, the fish assemblages in each reservoir are also likely to use portions of the action area that are upstream of the reservoirs. Altered flow and temperature regimes below the dams and irrigation diversions have likely increased the abundance and productivity of nonnative predatory and competing fish species in bull trout critical habitat. These conditions are not likely to influence the function of this area as a migration corridor.

7.4 Effects of the Proposed Actions

7.4.1 Effects of the Proposed Action on Bull Trout

Phillips Lake

A migratory population of bull trout in Phillips Lake is not likely present. Since 1991, sampling by ODFW has only documented two bull trout (in 2011); those individuals were likely washed into the reservoir from high flows higher in the basin. There is no existing information on bull trout in Phillips Lake; however, assumptions on the behavior of potential migratory bull trout in Phillips Lake can be made using Beulah Reservoir as a comparison. Beulah Reservoir (Chapter 6) has similar water temperature and water quality effects as Phillips Lake and the behavior of adfluvial bull trout limits their presence in the reservoir to late fall through early spring. Bull trout use of Phillips Lake would likely be limited to over-wintering periods. Adfluvial bull trout typically leave lakes or reservoirs in the spring, migrating to spawning locations in headwater tributaries and returning in the fall. This behavior would limit effects of the proposed action to the late fall through early spring season periods when bull trout could be present. Water quality conditions including temperature (PCE 5) and water quality (PCE 8) exceed targets identified by the PCEs from July through October; however, bull trout are not likely to be present during these times.

The proposed action results in effects to the migration corridor in the fall when reservoir levels are low, leaving areas of the tributary varial zones exposed. The varial zone of the Powder River does not act as a barrier, but Deer Creek has a seasonal barrier (abandoned roadbed) to bull trout that could migrate to and from the reservoir in the spring or fall before pool elevations return to a level that covers the abandoned road beds (PCE 2). This condition occurs annually, during both the fall and spring migration periods.

Entrainment is not likely to adversely affect bull trout in Phillips Lake. While there has been no recent documentation of bull trout in the Powder River below Mason Dam, the extent of entrainment and resulting effects on bull trout is unknown at this time. Entrainment has been identified as occurring in other systems mostly associated with spillway releases during the spring season when bull trout are likely to be in the upper water column feeding. Releases from Mason Dam occur exclusively through the outlet works and not the spillway, thereby eliminating the possibility of entraining bull trout in the spring that are in the upper water column of Phillips Lake.

For these reasons, the proposed action **may affect and is likely to adversely affect** migratory bull trout populations above Mason Dam.

Powder River North Powder and Eagle Creek

The operation of Mason and Thief Valley dams **may affect, but are not likely to adversely affect** bull trout where they are likely to occur. Presently, bull trout in the Powder River subbasin are restricted to headwater areas where adequate instream temperatures and habitat remain. Nowak (2004, page 52) states that the historic distribution of bull trout in the Powder River is unknown. Bull trout were likely seasonally connected to the Snake River until the construction of Thief Valley Dam, which has no upstream fish passage. Construction of Mason Dam in 1968 isolated bull trout in the upper Powder River from bull trout in the North Powder River and other Powder River tributaries. Although there has been no documentation of bull trout in the Powder River downstream of Mason Dam, there is still the possibility that bull trout could enter the Powder River from tributaries such as the North Powder River and Wolf Creek.

7.4.2 Effects of the Proposed Action on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Phillips Lake

The operation of Mason Dam will have discountable effects on PCE 1 within Phillips Lake. As noted previously, springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quantity or water quality in Phillips Lake. Although reservoir operation may influence shallow groundwater exchange, the influence of this exchange is not of sufficient scale to influence thermal refugia in the reservoir as a whole.

North Powder River and Eagle Creek

The operation of Mason Dam will have a discountable effect on PCE 1 in the Powder River. The presence of PCE 1 in the North Powder and Eagle Creek portions of the Powder River is unknown, although hyporheic influence is thought to persist under baseline conditions. The effects of operations are reduced as the downstream distance increases, with the small effects from the proposed action becoming indistinguishable from the multiple other nonproject variables described in baseline section that have a greater effect on this PCE.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Phillips Lake

The operation of Mason Dam has an adverse seasonal effect on PCE 2 in Phillips Lake. Possible biological barriers include water quality and increased risk of predation with the increased length of varial zone. There is a seasonal water quality barrier that occurs in Phillips Lake when bull trout are not present in August and September. Water temperatures and low dissolved oxygen exceed bull trout tolerances. Bull trout in Phillips Lake would likely behave as they do in Beulah Reservoir when all adult and subadult bull trout leave the reservoir and do not return until temperatures and dissolved oxygen reach tolerable levels in late October (see the Beulah Reservoir discussion).

Habitat surveys performed on the Powder River and Deer Creek in the fall of 2011 and 2012 by Reclamation compared habitat between the varial zone and immediately upstream and found no physical barriers to migration in the Powder River, but did find physical barriers to migration in Deer Creek when pool elevations drop below two abandoned road beds (old highway). The approximate elevation where Deer Creek first intersects each road bed is at 4009 and 3993 feet. Varial zone lengths vary depending on the tributary, the reservoir, and the season. During the study, the varial zone length averaged 1.3 miles (2.1 kilometers) at the Powder River and 0.9 mile (1.4 kilometers) at Deer Creek; however, a split channel at Deer Creek, caused by abandoned road beds, may block the fall return migration until the reservoir levels rise above this location. The proposed action will continue to adversely affect fall migration from lower Deer Creek when the Phillips Lake elevation is below the abandoned roadbeds.

Phillips Lake isolates resident populations of bull trout and would be a barrier to upstream migration for bull trout entrained out of the reservoir. While there has been no recent documentation of bull trout in the Powder River below Mason Dam, the extent of entrainment and resulting effects on bull trout is unknown at this time. Entrainment has been identified as occurring in other systems mostly associated with spillway releases during the spring season when bull trout are likely to be in the upper water column feeding. Releases from Mason Dam occur exclusively through the outlet works and not the spillway, eliminating the possibility of entraining bull trout in the spring that are in the upper water column of Phillips Lake.

North Powder River and Eagle Creek

Operation of Mason Dam will have insignificant effects on PCE 2 in the Powder River. Generally, operation of Mason Dam reduces flow in the winter and increases flow in the summer. Under both winter and summer operations, Reclamation has observed no physical, biological, or water quality impediments that could affect bull trout migration in the Powder River due to the proposed action. Bull trout are not known to exist below Mason Dam and the effects of the proposed action are reduced as the downstream distance increases from Mason Dam. Variables independent from the proposed action play a more dominant role in the availability of a migration corridor.

Warm-water winter releases have been associated with intermittent ice barriers in other systems, but no similar ice dams have been observed in the Powder River. Climate change forecasts suggest baseline conditions will maintain flows within the range of conditions analyzed in the proposed action.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Phillips Lake

The operation of Mason Dam will have insignificant effects on PCE 3 within Phillips Lake. Reservoir operation can influence primary production through the impact of water quality (PCE 8) and in turn, influence the food web including aquatic invertebrates and forage fishes. However, the inactive pool maintains storage that protects the prey base at sufficient levels to maintain prey diversity for migratory bull trout that may use the reservoir to over-winter. Abundant numbers of prey fishes have been sampled annually during ODFW perch removal efforts.

The proposed action includes inactive storage in Phillips Lake; the presence of the dead pool contributes to the habitat complexity and water quality and quantity that allow the current abundance of prey fishes that are available to bull trout that could use the reservoir as over-wintering habitat.

North Powder River and Eagle Creek

Operation of Mason Dam will have insignificant effects on PCE 3 in the Powder River. Reservoir operation can affect prey base through the impact of water quality and primary productivity; however, no bull trout are known to exist in this reach of the Powder River and effects of the proposed action for bull trout migrating through the action area are insignificant. The dam is located 57.2 miles upstream from North Powder and 124.0 miles upstream from Eagle Creek; therefore, variables independent from the operation of Mason Dam play a more dominant role in the availability of habitat to support a food base (PCEs 4, 5, 7, and 8) for bull trout that use the action area as a migration corridor.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Phillips Lake

The operation of Mason Dam will have insignificant effects on PCE 4 within Phillips Lake. In general, reservoir operation in nondrought years provide a diversity of habitat including bays where tributaries enter the reservoir, a shallow more productive transition area near the mouth of the Powder River (PCE 3), and depth refuge. In dry years, reduced storage volumes may limit depth refuge; however, an inactive storage pool of 3,500 acre-feet prevents the reservoir from being completely evacuated, preserving the function of this PCE.

In most years, operation of Phillips Lake can also influence shoreline complexity by affecting the interface with shoreline vegetation and the exposure of low-complexity varial zones; however, bull trout are not likely to be present at this time. Further, in a reservoir environment, shoreline complexity plays a limited contribution to the role of the reservoir in providing complex environments both in the reservoir and at the CHSU scale. Accordingly, reservoir operations are not likely to significantly reduce the overall function of PCE 4 in Phillips Lake. The deposition of sediment and presence of mine tailings will continue to limit lacustrine habitat complexity, potentially increase length of the varial zones, and contribute to water quality (PCE 8), although measurable effects within the duration of the 2005 USFWS BiOp are not anticipated.

Powder River North Fork Powder and Eagle Creek

The operation of Mason Dam will have insignificant effects on PCE 4 in the Powder River. Discharge from Mason Dam does not affect the habitat complexity within these areas. Although consistent summer flows have allowed a better established riparian zone in the area immediately downstream of the dam, no bull trout are known to exist below Mason Dam and effects of the proposed action for bull trout migrating through the action area are insignificant. Benefits of the proposed action are reduced as the downstream distance increases from Mason Dam. Variables independent from the operation of Mason Dam (e.g., water withdrawals, land management practices) play a more dominant role in the availability of habitat complexity (PCEs 4, 5, 7, and 8).

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Phillips Lake

Operation of Mason Dam has an effect on PCE 5 from mid-July through October. However, these effects are insignificant because bull trout are not present. In most years, water temperatures exceed 15° C with little to no thermal refugia in Phillips Lake. This is due to summer drawdowns and warm water entering Phillips Lake from tributaries. During the remainder of the year, the reservoir provides adequate water temperatures for bull trout that could be present for foraging, rearing, and over-wintering from November through mid-July.

The warm summer water temperatures will not affect prey base because native aquatic biota found within the core area, including many of the prey species, have a tolerance for higher water temperatures and lower dissolved oxygen levels than bull trout. During periods when PCE 5 targets are exceeded for bull trout, conditions would be favorable for prey species, allowing for the presence of an established prey fish population (PCE 3) during seasons when bull trout may be present in the reservoir (November through June).

North Powder River and Eagle Creek

The operation of Mason Dam has an insignificant effect on PCE 5 in the Powder River. Hypolimnetic releases from Mason Dam maintain suitable water temperatures throughout most of the year. Benefits of the proposed action are quickly reduced as the downstream distance increases from Mason Dam, variables independent from the operation of Mason Dam (e.g., water withdrawals, land management practices) play a more dominant role in the availability of habitat complexity (PCEs 4, 5, 7, and 8).

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Phillips Lake and the Powder River downstream of Mason Dam have not been designated as spawning and rearing habitat (USFWS 2010a, pages 629, 641); therefore, the effects were not analyzed.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

Phillips Lake

PCE 7 is not present in Phillips Lake; therefore, the effects were not analyzed.

North Powder River and Eagle Creek

The operation of Mason Dam has seasonal adverse effects on PCE 7 in the lower Powder River throughout the year; however, the PCE remains functional and provides beneficial effects to other PCEs as a result of being altered (PCE 4 and 5). Typically, spring migration coincides with periods of higher flow when effects of the proposed action would be insignificant. Seasonal adverse effects could occur during the fall when irrigation flows are reduced and discharge is less than unregulated flows. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 40).

The influence of Mason Dam operations is seasonally adverse because typical fall migration coincides with periods of low flows when reservoir operations regulate the hydrograph characterized by flows that are lower than unregulated hydrograph. In general, reservoir operations regulate the hydrograph characterized by flows that are lower in the winter and spring, lower during the spring peak, and higher in the summer with irrigation deliveries. Due to the regulation of flows out of Phillips Lake, the descending hydrograph does not follow daily and seasonal fluctuations of nearby unregulated systems. Bull trout are not known to exist in these portions of the action area; however, if they were present they would likely only use these areas during migration periods.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Phillips Lake

The operation of Phillips Lake has an effect on PCE 8 from July through October; however, these effects are insignificant because bull trout are not likely to be present during the time when the effects occur. Water quality conditions are good as described in the baseline conditions while bull trout would typically be in the reservoir. Although data on bull trout behavior in Phillips Lake does not exist, comparisons can be made to Beulah Reservoir where similar PCE characteristics are present. Based on information from Beulah Reservoir, bull trout would likely migrate out of the reservoir as water temperature and dissolved oxygen levels become unsuitable from July through October. Reservoir operations influence water temperature and water quality conditions indirectly through a set of complex interactions with incoming water temperature, solar loading, release of cold water from the bottom of the reservoir, and the influence of reservoir elevation on thermal stratification. Although adverse effects seasonally occur, water quality conditions indicate a functional PCE for both bull trout and bull trout prey (PCE 3) when bull trout are thought to be present. Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Figure 40).

The operation of Mason Dam will continue to provide functional water quality and quantity conditions sufficient to maintain an adequate prey base (PCE 3) and to support normal growth for bull trout that may over-winter in Phillips Lake. The proposed action maintains an inactive storage pool that benefits the prey base (water quantity) during dry years.

North Powder River

Operation of Mason Dam will have an insignificant effect on PCE 8 in the North Powder River portion of the Powder River action area. The influence of Mason Dam on PCE 8 is insignificant for two reasons. First, levels of measured constituents in the Powder River immediately below Mason Dam are very low, indicating in most cases, lower loading and less degradation of water quality as compared to nearby rivers. Total dissolved gas concentrations have been monitored in the past and generally dissolved gas concentrations in the Powder River are within ODEQ standards throughout the year (Appendix B). These data for both water quality constituents and dissolved gas concentrations suggests few, if any, direct water quality effects on bull trout. Second, the influence of the proposed action on PCE 8 is attenuated by independent variables as the downstream distance from Mason Dam increases. In this area, these independent variables play a more dominant role in the water quality and quantity. The baseline sections for PCEs 4, 5, 7, and 8 provide more detailed discussion of these independent variables. Reclamation anticipates effects similar to those observed under the environmental baseline will continue.

Eagle Creek

Operation of Mason and Thief Valley dams will have an insignificant effect on PCE 8. The Eagle Creek critical habitat subunit is 47.8 miles downstream from Thief Valley Dam. As a result, the influence of Thief Valley operations is reduced as independent variables play a more dominant role in the water quality and quantity in this reach. For example, most of the Powder River within the Eagle Creek CHSU is part of Brownlee Reservoir, which plays a large role in determining the water quality in this reach. To the extent that Thief Valley influences water quality in non-critical habitat portions of the Powder River, Reclamation advises operations for Thief Valley Dam (operated by the Lower Powder River Irrigation District) to minimize the release of sediment to maintain downstream water quality (Reclamation 2004b).

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Phillips Lake

The operation of Mason Dam will have an insignificant effect on PCE 9 within Phillips Lake. The proposed action provides an environment that allows the survival of nonnative fishes; however, ODFW exclusively manages the fisheries including stocking and regulations that favor the presence of individual species. The proposed action plays an insignificant role in the occurrence of nonnative fishes compared to variables (fish management and interbreeding) independent from the operation of Mason Dam.

Powder River - North Powder & Eagle Creek

The operation of Mason Dam will have an insignificant effect on PCE 9 within North Powder River and Eagle Creek. The proposed action provides an environment that allows the survival of nonnative fishes; however, ODFW exclusively manages the fisheries including stocking and regulations that favor the presence of individual species. The proposed action plays an insignificant role in the occurrence of nonnative fishes compared to variables (fish management and interbreeding) independent from the operation of Mason Dam.

7.4.3 Summary of the Effects of the Proposed Action

Under the proposed action, conditions in Phillips Lake and the Powder River throughout the year will maintain the majority of PCEs in their current condition. In general, only headwater tributaries provide ideal habitat conditions for bull trout throughout the year where resident populations of bull trout currently exist. The proposed action provides habitat that allows the survival of predatory and competitive nonnative fish species that are stocked and managed by ODFW. Currently, there are no population estimates for bull trout in Phillips Lake or the Powder River downstream of Mason Dam.

Table 19. Summary of the effects of the proposed action for Phillips Lake, North Powder River, and Eagle Creek.

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action	
		Phillips Lake	North Powder and Eagle Creek
1	Springs, seeps, groundwater sources	Discountable effect	Discountable effect
2	Migration habitats with minimal impediments.	Seasonal adverse effect: an exposed varial zone may cause a migration barrier during both spring and fall migration periods	Insignificant effect
3	Abundant food base	Insignificant effect	Insignificant effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect	Insignificant effect
5	Water temps ranging from 2°-15^{o} C with adequate thermal refugia	Insignificant effect: water temperatures rise above PCE targets from July through October when bull trout are not present.	Insignificant effect
6	Spawning/rearing substrate.	Not present	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present	Seasonal adverse effect: low flows after irrigation season
8	Sufficient water quality and quantity	Insignificant effect: water quality conditions are degraded; however, bull trout are not present during this period.	Insignificant effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect	Insignificant effect

7.5 Cumulative Effects

In the Powder River Basin, bull trout are primarily thought to be distributed on Federal land, but private and State activities and management programs may affect bull trout and critical habitat. Other factors not related to the proposed action may include increases in recreational fishing pressure which may result in incidental hook injury and mortalities or changes in watershed conditions from increased agriculture, irrigation diversions, grazing, mining activities, or timber harvesting which is under the control of the Bureau of Land Management and USFS. The effects of these actions will continue into the future and contribute to cumulative effects. The specific impacts of these activities on bull trout and critical habitat are unknown at this time.

7.5.1 Effects of Climate Change on Bull Trout

USFWS (2011, pages 40-41) stated that "bull trout rely on cold water throughout their various life stages and increasing air temperatures likely will cause a reduction in the availability of suitable cold water habitat." The effects of climate change on Phillips Lake are likely to limit the ability of a migratory life history to form. Migratory forms of bull trout could include either: 1) adfluvial fish that over-winter in Phillips Lake; 2) fluvial forms that use Phillips Lake as a migration corridor; or 3) migratory pioneers from established resident headwater tributary populations that use Phillips Lake as a migration corridor to establish new headwater tributary populations. Climate-related warming of lakes will likely lead to longer periods of thermal stratification, forcing cold-water fish such as bull trout to be restricted to the bottom layers for greater periods of time (USFWS 2011, page 41). Because migratory bull trout are not known to exist in Phillips Lake, this would further inhibit the potential for development of a migratory life history.

Thermal refugia are important for providing bull trout with patches of suitable habitat while allowing them to migrate through or to make foraging forays into areas with above optimal temperatures (Howell et al. 2010). ODEQ cool water (not cold water) aquatic life criteria apply to lower elevation areas of major valleys throughout the Powder River basin (ODEQ 2013b, page 83). These conditions could be exacerbated by climate change and cause populations that are currently connected to become thermally isolated accelerating the rate of local extinction (USFWS 2011, page 41).

The Powder River below Mason Dam is currently not cold enough for bull trout spawning, incubation, and juvenile rearing. In areas such as the Powder River basin that already have degraded water temperatures and are at the southern edge of the bull trout's range, bull trout may already be at risk of impacts from current as well as future climate changes.

Climate change may alter aquatic habitat in the Powder River basin directly and indirectly. Water yield, peak flows, and stream temperatures may change. Climate change modeling indicates increased precipitation in the Pacific Northwest, but warming trends may result in shifting cool season precipitation from snow to more rain events. Warming is expected to reduce the snowpack from late fall through early spring, resulting in diminished runoff. Increasing water temperatures may reduce suitable cold water habitats for bull trout which can reduce connectivity and ultimately reduce population levels.

7.5.2 Effects of Climate Change on Bull Trout Critical Habitat

Climate change may change the function of critical habitat in the Powder River basin directly and indirectly in the same ways as described above for bull trout.

If climate changes progress as projected, warmer air temperatures will affect stream temperatures (Vliet et al. 2011), potentially limiting thermal refugia for biota living in areas near their thermal thresholds (Kaushal et al. 2010). Thermal refugia provide bull trout with patches of cold water habitats while allowing them to migrate through areas of suboptimal warm temperatures. As one of the southern-most population of bull trout, these climate-related stresses may limit the distribution of bull trout and the function of critical habitat. In some cases, it may be difficult for the continued expression of certain life history strategies and in extreme cases, it may be difficult for the persistence of this species in certain drainages (Rieman et al. 2007).

7.6 Determination

Reclamation has determined that future O&M in the Powder River system **may affect and is likely to adversely affect** bull trout and bull trout critical habitat in Phillips Lake. Future O&M does not significantly affect bull trout critical habitat in Eagle Creek and the Powder River. The operation of Mason Dam has an adverse seasonal (July through October) effect on PCE 2 within Phillips Lake. An exposed varial zone as a result of drawdown may cause migration barriers during both spring and fall migration periods. Water temperatures may rise above PCE targets and reduced water quality conditions (PCEs 5 and 8) may occur; however, bull trout are not present at the same time and effects to the prey base are insignificant.

The operation of Mason Dam could have an adverse seasonal effect on PCE 7 in the Powder River during the fall caused by reduced flows from a natural hydrograph; however, bull trout are not known to exist in this area.

8.0 MAINSTEM SNAKE/COLUMBIA RIVER SYSTEM

8.1 Proposed Actions

This section considers the collective hydrologic effect of the several actions described in Section 1 and focuses on how the operation of the upper Snake River projects influences hydrology downstream of Brownlee Reservoir. No new facilities that would affect the downstream hydrology have been constructed in the Snake River system and operations have not changed since the 2004 Upper Snake BA, as amended by the 2007 Upper Snake BA (2004/2007 Upper Snake BA). No T&Cs were included in the 2005 USFWS BiOp specifically for the mainstem Snake and Columbia rivers. The action area was limited to the operation of the Federal projects in the upper Snake River basin above Brownlee Reservoir (Figure 1).

8.2 Action Area

This section evaluates effects of the proposed actions on bull trout designated critical habitat in the Snake River downstream from Brownlee Dam to its confluence with the Columbia River, and in the Columbia River from its confluence with the Snake River to the Columbia River estuary. The analysis in this section focuses on those locations where designated critical habitat overlaps with the action area described above:

- The **mainstem Snake River** includes the mainstem Snake River CHU (CHU 23) and extends from Brownlee Dam downstream 280.6 miles (451.7 kilometers) to the confluence with the Columbia River.

- The **mainstem Columbia River** includes portions of the upper mainstem Columbia River CHU (323.3miles [520.1 kilometers]; CHU 22) from the confluence of the Snake and Columbia rivers to John Day Dam, and the entire Lower Columbia CHU (211.5 miles [340.4 kilometers]; CHU 8) from John Day Dam to the mouth of the Columbia River (see Appendix A).

The mainstem Snake River and Upper Columbia River CHUs provide feeding, migratory, and/or over-wintering habitat and connectivity (Table 20). The mainstem Snake River provides connectivity for bull trout in the Hells Canyon Complex CHU and tributaries to the Snake River (i.e., Sheep and Granite creeks). The mainstem Upper Columbia River CHU provides only connectivity between the mainstem CHUs and to numerous CHSUs associated with tributary systems of the Columbia River. None of the units addressed in this section support spawning and rearing habitat.

Table 20. Critical habitat stream miles, surface area and storage within the Middle Columbia Critical Habitat Unit (CHU) 22 and CHU 23 and Coastal Critical Habitat Unit (CHU) 8.

Critical Habitat Unit or Subunit	Total Stream Miles (kilometers)	Critical Habitat, Stream Miles (kilometers)	Critical Habitat, Surface Area Acres (hectares)	Critical Habitat, Water Storage (in acre-feet)	Action Area in Miles (in kilometers)
Mainstem Columbia River CHU 22	323.2 (520.1)	323.3 (520.1)	0	0	103 (165.8)
Mainstem Columbia River CHU 8	215.6 (347.0)	211.5 (340.4)	0	0	211.5 (340.4)
Snake River CHU 23	280.6 (451.7)	280.6 (451.7)	0	0	280.6 (451.7)

Bull trout in the mainstem Snake and Columbia rivers are part of the Middle Columbia River RU Coastal RU (Figure 51).

Figure 51 shows the mainstem Snake and Columbia river basins bull trout RUs coincident with the designated critical habitat rivers and reservoirs. Effects where the proposed action influences the hydrology in designated critical habitat are analyzed in this section.

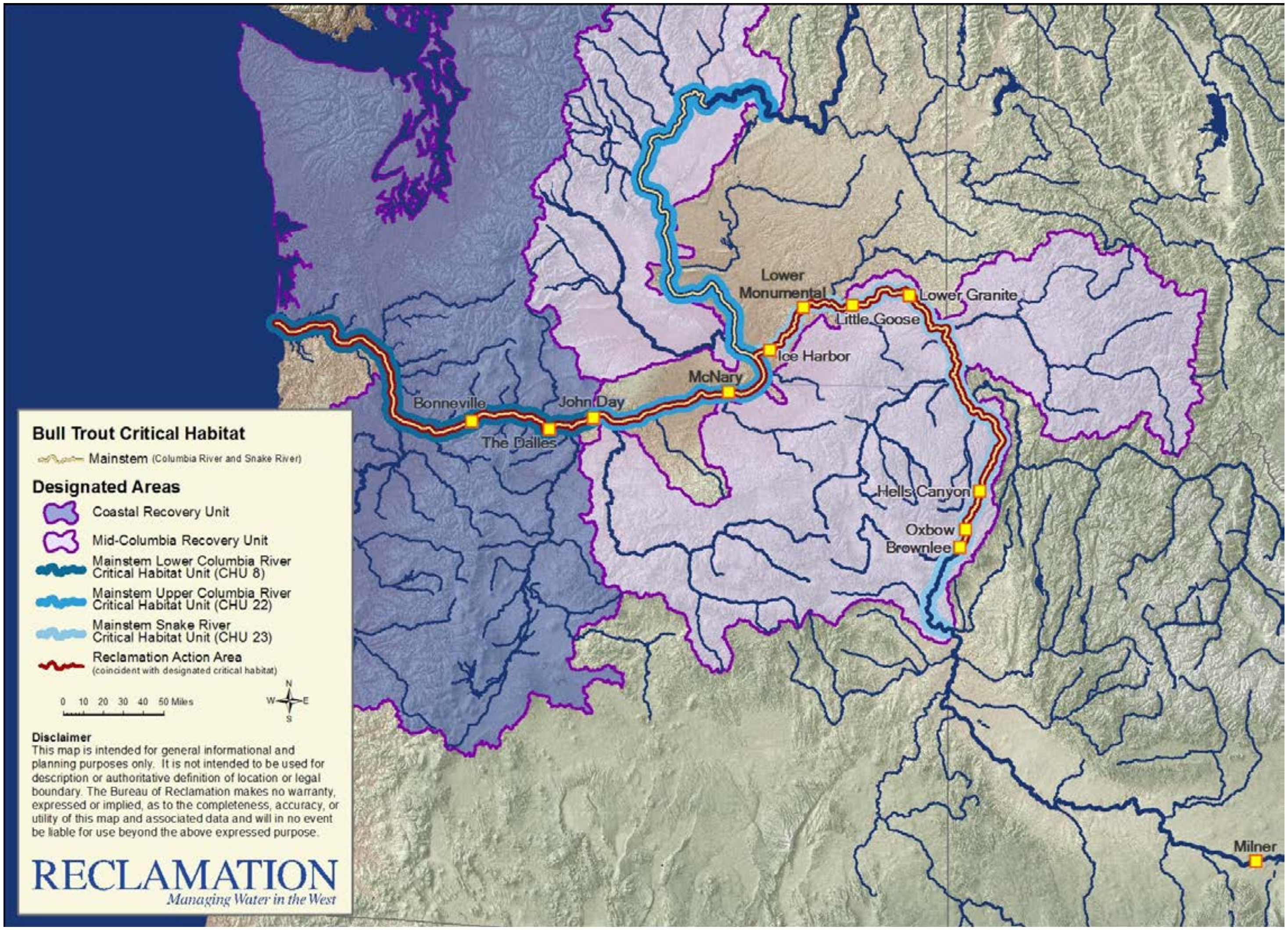

Figure 51. Dams on the mainstem of the Columbia River in the United States. Mainstem Lower Columbia River, Mainstem Upper Columbia River, and Mainstem Snake River Critical Habitat Units (CHUs 8, 22 and 23, respectively) are displayed. The action area described in Section 8.0 only includes the mainstem Snake River below Brownlee Dam and the mainstem Columbia River below the confluence with the Snake River. Refer to Figure 1 for full extent of the action area.

8.3 Environmental Baseline

8.3.1 Baseline Hydrology

Current hydrologic conditions in the mainstem Snake and Columbia rivers are the result of numerous upstream water development activities including, but not limited to, hydropower development; private and Federal irrigation and flood control projects; and municipal and industrial diversions and discharges. Reclamation's O&M activities have influenced the hydrologic conditions in the Snake River for over a century beginning with the construction of the Minidoka Project. All facilities associated with the proposed actions have been operating for at least 40 years. Current flow conditions are consistent with those modeled in the analyses for the 2007 Upper Snake BA and are extensively discussed in Chapter 3 of that document (Reclamation 2007, pages 25-47). The hydrologic effect of the Upper Snake projects is discussed thoroughly in Chapter 5 of the 2008 NOAA Fisheries BiOp (NOAA Fisheries Service 2008b).

In addition, salmon flow augmentation is described in detail on pages 35-39 of the 2007 Upper Snake BA, incorporated by reference (Reclamation 2007), and discussed in Section 2.2.5. Generally, these salmon flow augmentation activities can be delivered from April through August, augmenting natural flows to meet flow targets for salmon at Lower Granite Dam.

The 2008 NOAA Fisheries BiOp HYDSIM analysis illustrates the relative influence of the Upper Snake projects on the hydrology of the lower Snake and Columbia rivers. Under this analysis, Reclamation compared current hydrologic conditions with upper Snake River operations, including salmon flow augmentation, to a “without projects” case where Reclamation projects pass all inflow downstream. While this method effectively illustrates the causal influence and scale of upper Snake River operations on mainstem hydrology, it should not be used as a quantitative indicator of effects to bull trout or critical habitat. There are two reasons for this. First, this method assumes downstream hydropower operators would adjust operations in proportion to the influence of the upper Snake River projects. In reality, this overstates Reclamation’s ability to influence flows at particular times without the cooperation of downstream operators. Second, because operations are ongoing, future biological conditions are a function of changes in operations or changes in species or habitat response under future conditions. Nonetheless, a with/without comparison remains a useful tool in understanding the scale and ability of Reclamation to influence biological and habitat conditions downstream.

Generally, Reclamation's operations have reduced the inflows to Brownlee Reservoir by about 2.2 million acre-feet annually. Due to tributary inflows and systematic Federal Columbia River Power System (FCRPS) operations, the hydrologic effects of the upper Snake River projects are greatest immediately below Hells Canyon Dam and diminish farther downstream. The critical habitat units addressed in this section all occur downstream of Brownlee Dam. The remainder of this section discusses the influence of Upper Snake operations in sections of the mainstem Snake and Columbia rivers.

Mainstem Snake River

This section evaluates the relative influence of Upper Snake operations at two locations in the mainstem Snake River: below Brownlee Dam in the Hells Canyon Complex, and below Lower Granite Dam. Figure 52 and Figure 53 illustrate the inflows to Brownlee Reservoir with and without Reclamation projects and the proportional influence of the Upper Snake projects. In the Hells Canyon Complex, Reclamation generally decreases inflow from October through June, with the greatest decreases in May and June (-30 to -31 percent). Upper Snake operations and salmon flow augmentation increase flows from July through September by between 40 and 88 percent. Discharge at Hells Canyon Dam runs a very similar pattern and magnitude of influence.

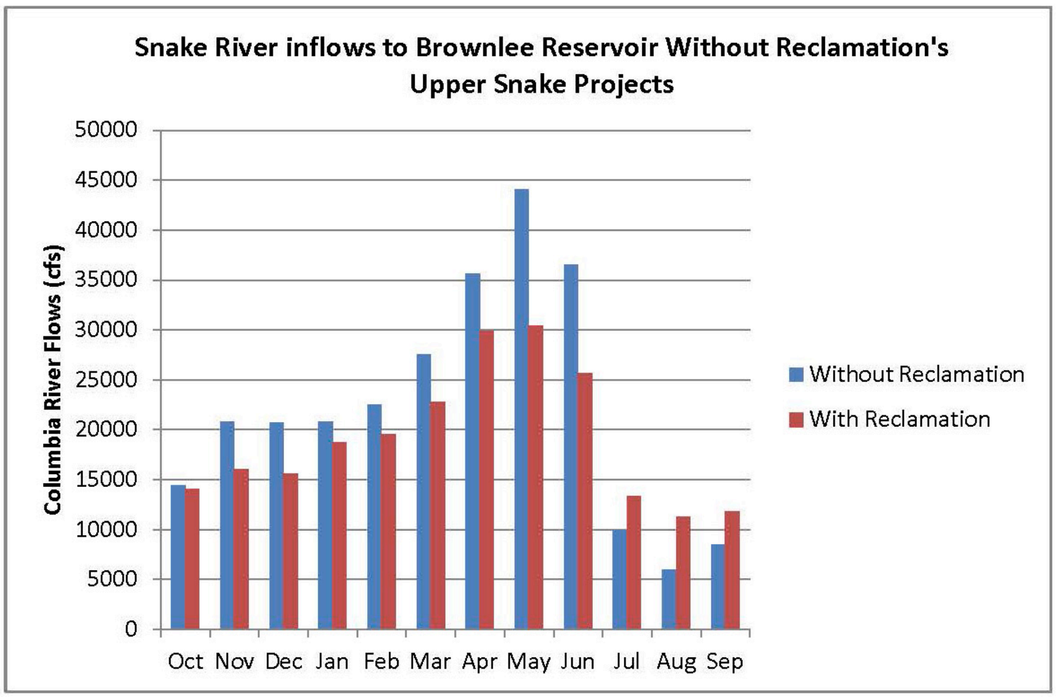

Figure 52. Snake River inflows into Brownlee Reservoir with and without Reclamation's Upper Snake projects for the period of record of 1928-2000. July through September flows include Salmon Augmentation contributions as required in NOAA 2008.

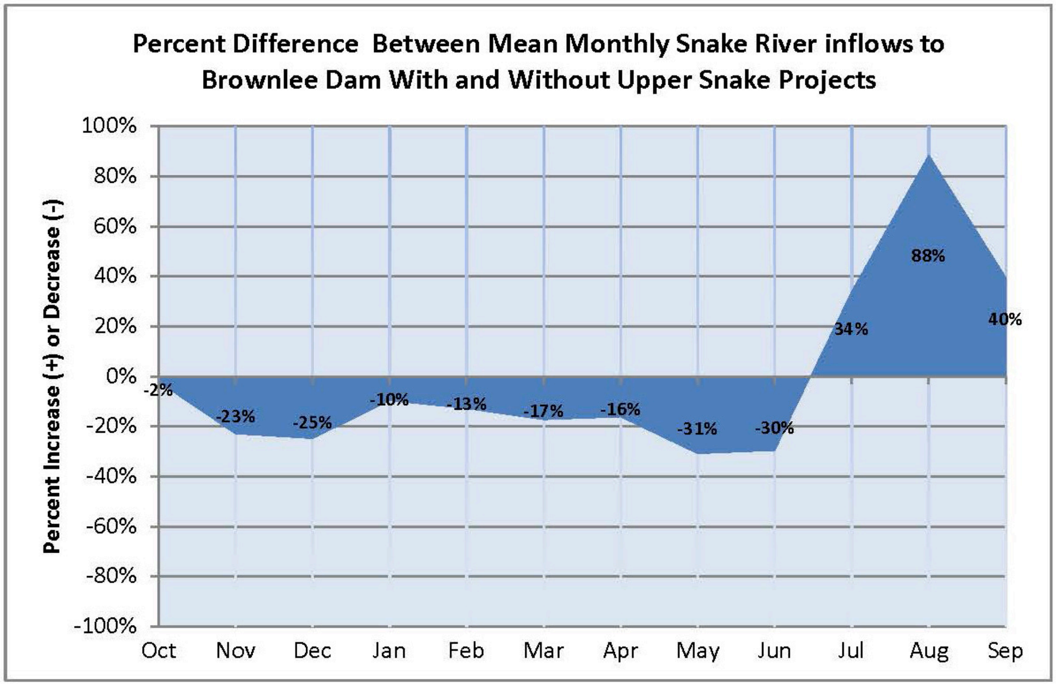

Figure 53. Percent difference between mean monthly Snake River inflows to Brownlee Dam with and without Upper Snake projects expressed as a percentage of the baseline flows.

Inflow to Lower Granite Dam (Figure 54 and Figure 55) shows that the influences of the upper Snake River projects follow a similar pattern as observed at Brownlee Reservoir, but on a smaller scale due to the attenuating effect of additional inflow. Again, Upper Snake operations generally decrease flows from October through June and increase flows from July through September. The timing of the greatest influence, however, shifts towards November and December (-14 to -15 percent) with lesser influence during the spring runoff in May and June (-10 to -11 percent) than observed upstream. The relative influence of salmon flow augmentation releases in August and September falls to between 15 and 21 percent.

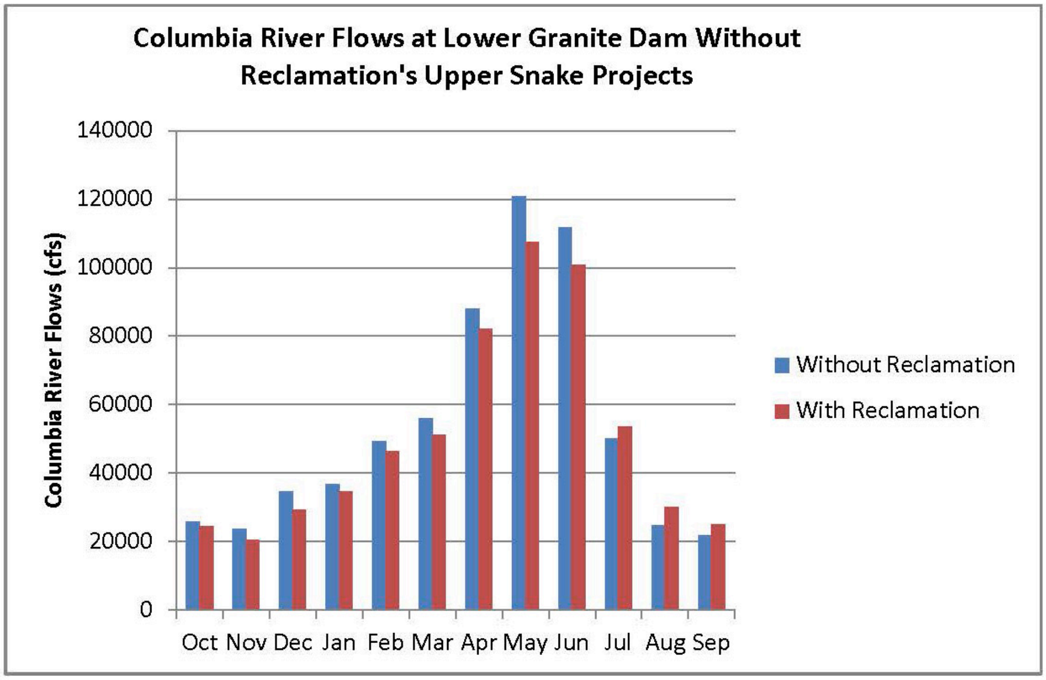

Figure 54. Columbia River flows at Lower Granite Dam with and without Reclamation's Upper Snake projects for the period of record of 1928-2000.

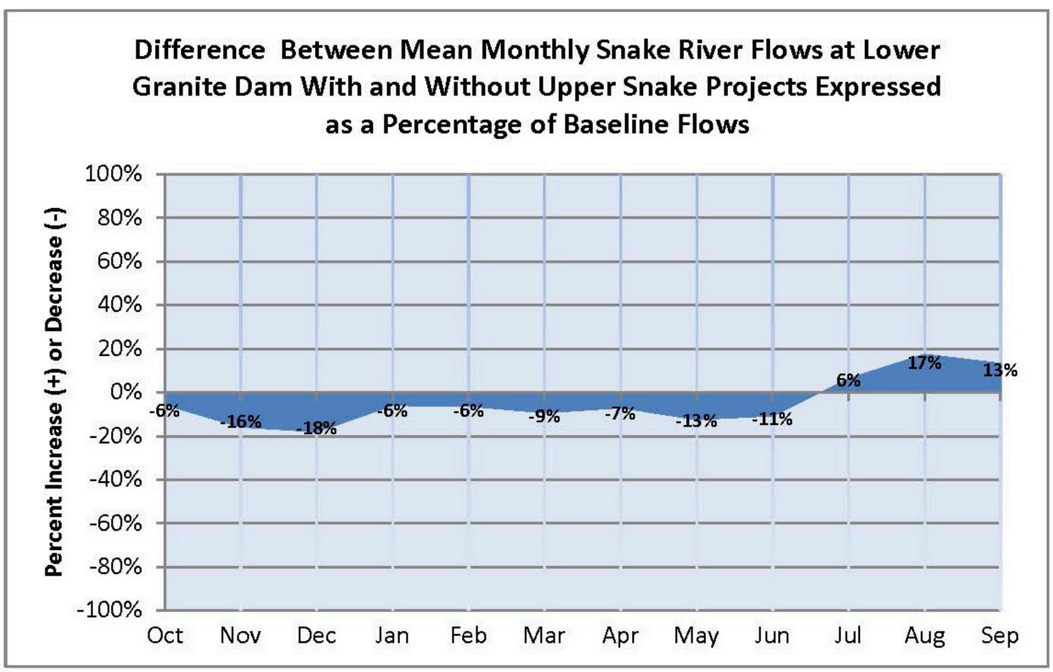

Figure 55. Percent difference between mean monthly Snake River flows at Lower Granite Dam with and without Reclamation's Upper Snake projects expressed as a percentage of baseline flows.

Mainstem Columbia River

This section describes the influence of Upper Snake operations on two sections in the mainstem Columbia River as measured by the inflow to McNary and Bonneville dams (Figure 56 through Figure 59). Generally, both reaches reflect a similar timing and degree of influence, with generally small decreases from October through June and similarly small increases from July through September. In most months, this influence is very small (less than 5 percent). In December and August, the upper Snake River projects have a greater, yet still slight, degree of influence. This influence diminishes substantially farther downstream due to inflows from Willamette River about 101.0 miles (162.5 kilometers) above the mouth of the Columbia River. Consequently, influence of upper Snake project operations in the lower 100.0 miles (160.9 kilometers) of the Columbia River, the estuary, and the plume are an even smaller portion of the overall comprehensive effects on those species found in this section of the Columbia River.

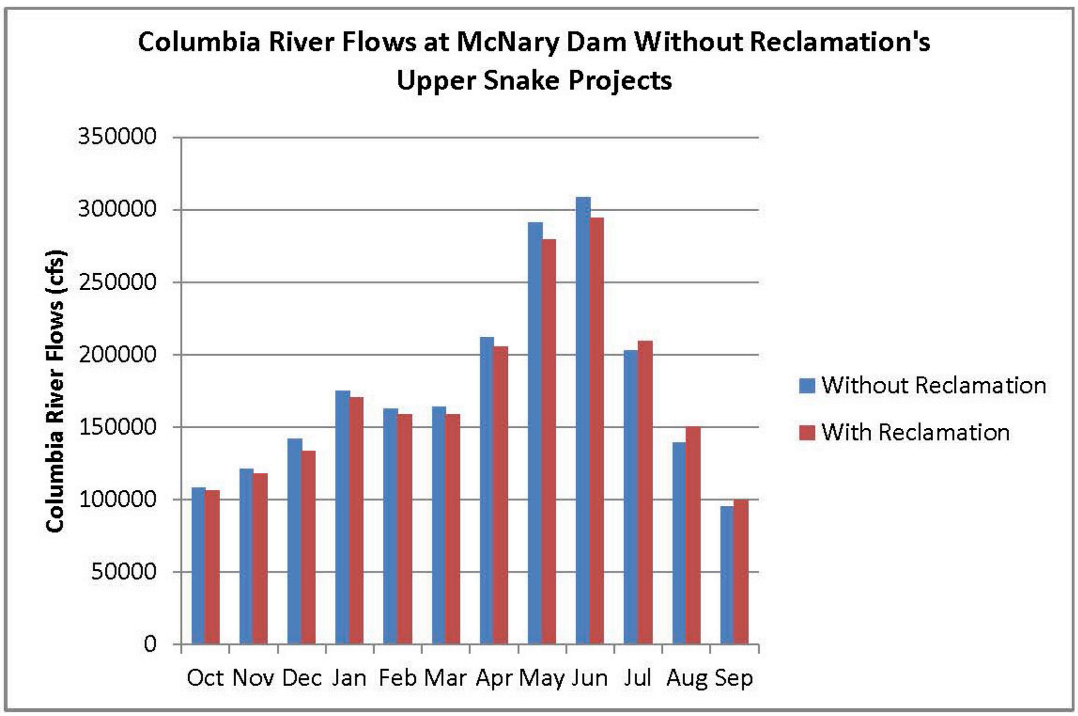

Figure 56. Columbia River flows at McNary Dam with and without Reclamation's Upper Snake projects for the period of record of 1928-2000.

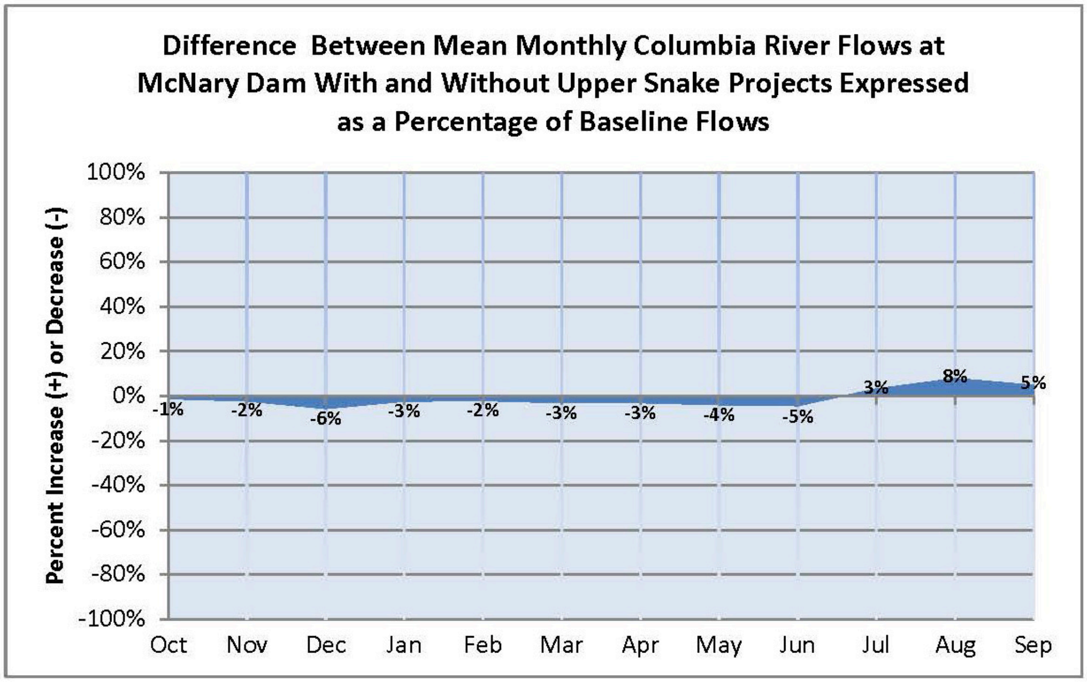

Figure 57. Percent difference between mean monthly Columbia River flows at McNary Dam with and without Reclamation's Upper Snake River projects.

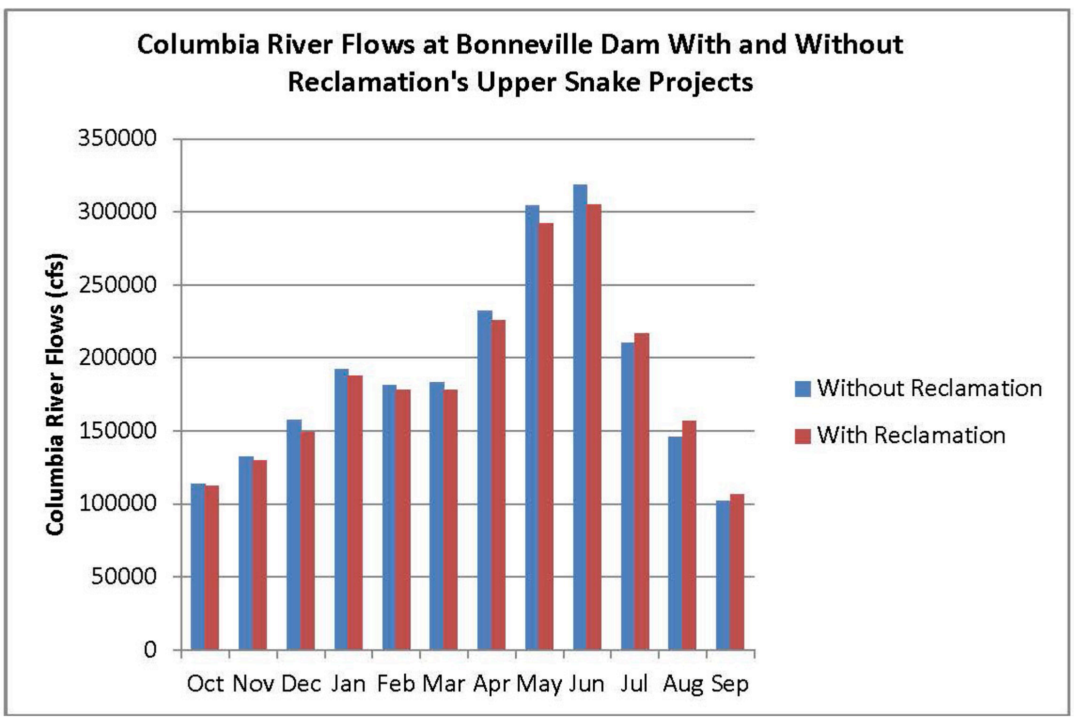

Figure 58. Columbia River flows at Bonneville Dam with and without Reclamation's Upper Snake projects for the period of record of 1928-2000.

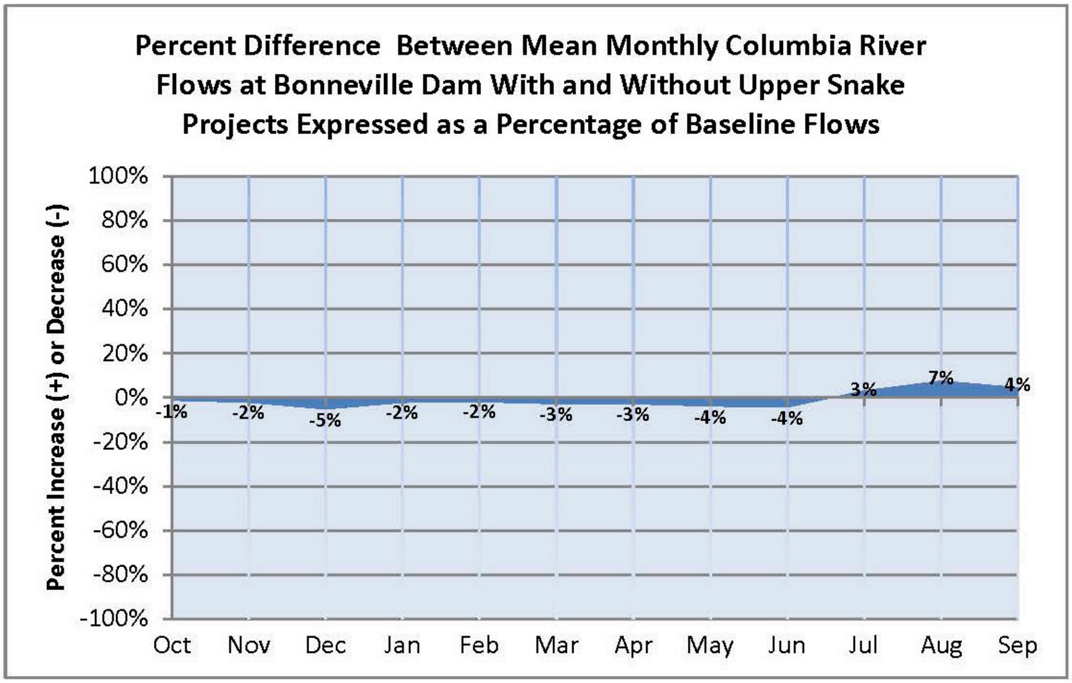

Figure 59. Percent difference between mean monthly Columbia River flows at Bonneville Dam with and without Reclamation's Upper Snake projects.

In summary, the hydrologic effects of the Upper Snake projects have a moderate influence on the flows in the mainstem Snake River, and a very minor effect on Columbia River flows. This influence varies throughout the year and from year-to-year with varying water conditions. Analysis in the 2007 Upper Snake BA found the influence of the Upper Snake projects on mainstem hydrology was not likely to have any measurable effect on bull trout and their prey base in the Hells Canyon Complex and downstream areas. The influence on Brownlee Reservoir inflows are relatively minor compared to existing inflows, and Brownlee Reservoir elevations (as well as Oxbow and Hells Canyon) are not likely to be affected at all since salmon flow augmentation is passed through the three reservoirs. The project also would not be likely to have a measureable effect on bull trout, their prey base, and bull trout accessibility to critical habitat and spawning tributaries in the reaches below Hells Canyon.

Future Hydrology with Climate Change

In the 2011, RMJOC Climate Change Study, Reclamation evaluated climate change impacts on the upper Snake River basin using MODSIM (Reclamation et al. 2010). The results of these analyses are reported in their appropriate sections in this document. No additional modeling by Reclamation was conducted below Brownlee Reservoir. In general, higher flows during the winter to early spring and lower late summer flows are likely. Reservoirs would likely refill earlier in the spring and be drawn down more in the winters to make room for the increased spring flows (BPA and Corps 2011).

8.3.2 Baseline Population Status and Trends

The Columbia River Basin bull trout Distinct Population Segment was listed in 1998 as a threatened species. Their range includes nearly the entire Columbia Basin in higher elevation tributaries in Washington, Oregon, Idaho, Montana, and a small part of Nevada. Most bull trout populations are found in higher elevation tributaries of the Columbia River and its major tributaries, due primarily to their requirements for cold water spawning and juvenile rearing.

A number of non-Reclamation Federal and private projects may affect bull trout effects analysis in this section so a brief description is provided here. The Snake and Columbia river systems have been extensively developed for many additional uses including flood control, irrigation, navigation, recreation, and water supply. Multiple dams have been constructed on the mainstem Snake and Columbia rivers, largely for hydroelectric power development, including FCRPS projects and other privately-owned facilities. The hydroelectric dams in the Columbia River Basin are the foundation of the Pacific Northwest's power supply and have a maximum capacity of 22,500 megawatts.

As shown on Figure 51, there are three Idaho Power dams, collectively known as the Hells Canyon Complex (Brownlee, Oxbow, and Hells Canyon), on the mainstem Snake River. There are four FCRPS dams on the mainstem of the Snake River below the Hells Canyon Complex (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). There are four FCRPS dams on the mainstem Columbia River below the confluence of the Snake River (McNary, John Day, The Dalles, and Bonneville).

Bull trout have been documented in the mainstem Columbia River to varying degrees between Chief Joseph and Bonneville dams. Chief Joseph Dam, operated by the Corps of Engineers, marks the upstream boundary of the Mainstem Upper Columbia River CHU, but is upstream of the action area. Very few observations have been made for bull trout presence at lower and middle Columbia River dams including Bonneville, John Day, The Dalles, McNary, Priest Rapids, and Wanapum dams on the mainstem Columbia River or at the four mainstem Snake River dams in southeastern Washington and Idaho. Information on adult, subadult, and juvenile bull trout presence indicates that adults are more frequently observed using the upper mainstem Columbia River dams that are outside of the action area. Although bull trout are observed in the mainstem Columbia River, they were probably never abundant there (Mongillo 1993). Bull trout tagged in the Tucannon River were found to infrequently use the mainstem Snake River for over-wintering habitat, but their movements within the mainstem Snake River could not be tracked by the methods used (Faler et al. 2008).

Columbia River dams downstream from Chief Joseph Dam have fish passage facilities that were designed for upstream passage of migrating anadromous fish, primarily for salmon and steelhead. Records at lower Columbia River dams may not accurately represent bull trout passage because adult fish counts and juvenile anadromous fish monitoring cease after

October 31, and fish counters have not always recorded bull trout sightings. It is uncertain if the juvenile fish facilities are effectively passing bull trout because these structures were designed for juvenile anadromous salmon and steelhead. Only three bull trout have been officially recorded at the juvenile fish facilities at the lower Columbia River dams: one at McNary Dam on December 21, 2004; one at the John Day Dam Smolt Monitoring Facility in May 2002 (FPC 2012); and one at the Bonneville Powerhouse #2 on March 21, 2005 (FPC 2012).

Adult fish passage is also monitored at these mainstem dams (Table 21). Monitoring of fish ladders at The Dalles, John Day, McNary, and Priest Rapids by the Corps of Engineers has revealed only three bull trout detections (two at McNary Dam and one at John Day) between 2006 and 2008 (Corps 2012). Fish passage monitoring at Corp of Engineers dams on the Snake River (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams) has seen a slight increase in the number of bull trout; however, only between two and eight fish were observed passing Snake River dams during the 2006 and 2010 monitoring periods (Corps 2012).

Table 21. Studies, monitoring, or reports that have been completed since the 2005 USFWS BiOp that pertain to the mainstem Columbia River or Snake River core areas.

Date	Reference	Title
2008	Faler et al. 2008	Evaluation of Bull Trout Movements in the Tucannon and Lower Snake Rivers, Project Completion Summary (2002-2006).
2012	Corps 2012	Walla Walla District, Fish Counts and Reports
2013	Corps 2013	Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers
2010	USFWS 2010a	Bull Trout Proposed Critical Habitat Justification: Rationale for Why Habitat is Essential, and Documentation of Occupancy
2010	Howell et al. 2010	Relationships between water temperatures and upstream migration, cold water refuge use, and spawning of adult bull trout from the Lostine River, Oregon, USA
2012	FPC 2012	Fish Passage Center. http://www.fpc.org accessed on September 20, 2012.

8.3.3 Baseline Critical Habitat Conditions

The mainstem river units do not support the PCEs typically associated with spawning habitats such as water temperatures ranging from 2° to 15° C with adequate thermal refugia (PCE 5), and spawning/rearing areas (PCE 6) (75 FR 63898). Other PCEs (those that refer to FMO habitat) where baseline conditions are typically a function of geography includes springs seeps and groundwater sources (PCE 1) and complex habitats (PCE 4). Reservoirs in the mainstem Snake and Columbia rivers do not support these PCEs (75 FR 63898, page 63934), and they are typically considered "degraded" for bull trout critical habitat PCE definitions in the riverine environments, although in some cases of these mainstem rivers, this is the natural condition and can be either exacerbated or improved by hydrologic effects of dam operations. The construction and operation of dams has homogenized habitat conditions throughout the mainstem reaches. Water temperatures are typically within the range for bull trout in the fall, winter, and spring, while frequently exceeding 15° C in the summer months.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 1 is not present in lakes and reservoirs in the Snake and Columbia River CHUs (75 FR 63898, page 63934). Some groundwater influence may occur in riverine areas not dominated by bedrock or immediately below dams, although little is known regarding the ecological significance of this exchange (Corps 2013).

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

PCE 2 is present, but provides a limited contribution to FMO habitat and connectivity in the mainstem Snake and Columbia rivers. Physical barriers (dams), water temperature and water quality (PCE 8) pose impediments to bull trout migration. Generally, the mainstem Snake and Columbia rivers provide limited migration habitat for fluvial bull trout between tributary spawning and rearing habitat and mainstem FMO habitat in the mainstem. Such behaviors have been observed in the lower Columbia River (USFWS 2002b), upper Columbia River (75 FR 63898, page 63940), and mainstem Snake River (Chandler et al. 2003, USFWS 2010b); however, bull trout found in the Oxbow Reach and Hells Canyon Reservoir in the Snake River appear to be extremely low in abundance.

Water temperature impediments may present seasonal barriers to fluvial bull trout migration between the mainstem rivers and tributary habitat; however, bull trout are not likely to be present in the mainstem rivers while impediments exist (Chandler et al. 2003). Additionally, if areas of thermal refugia exist, bull trout have been documented using habitat with temperatures that exceed the PCE target within the migration corridor (Howell et al. 2010). Average daily winter (January through March) temperatures throughout the Columbia River are relatively low, ranging from 3° to 6° C from the forebay of Grand Coulee Dam to the Camas/Washougal monitoring location below Bonneville Dam. Most of the reservoirs and impoundments are likely isothermal with relatively constant temperatures. The river begins to warm during August and September, exceeding bull trout tolerance levels as early as June 5 at the lowermost monitoring location and throughout the whole mainstem Columbia River by July 11. The tributaries entering the Columbia River below Priest Rapids clearly change the temperature regime in the river with much warmer temperatures than the upper reaches of the river.

Connectivity between tributary populations to the Snake and Columbia rivers is more limited. Although many mainstem dams below Brownlee Dam have adult fish passage, physical or water quality impediments to inter-tributary connectivity persist. Within the mainstem Columbia River, connectivity may occur in isolated reaches including the upper Columbia between the Yakima and John Day rivers (75 FR 63898, page 63940) and the lower Columbia River between the Hood River and portions of the lower Columbia River Basins CHU (USFWS 2002b). In the mainstem Snake River, only five bull trout have been observed passing lower Granite Dam since 1998 (FPC 2012). Likewise, the three dams of the Hells Canyon Complex limit connectivity between tributaries to the complex and tributaries downstream (USFWS 2002b, pages 15-16)

Upstream of Lower Granite Dam, fluvial bull trout have been observed using the mainstem of the Snake River to migrate between FMO habitat in the Snake River and spawning and rearing habitat in tributaries (Chandler et al. 2003, USFWS 2010b). Chandler et al. (2003), however, reported that bull trout found in the Oxbow Bypass reach and Hells Canyon Reservoir of the Snake River appeared to be extremely low in abundance.

Reclamation delivers salmon flow augmentation (increased flows) from April through August, augmenting natural flows to meet flow targets for salmon at Lower Granite Dam (Figure 56 through Figure 59). Increased flows also provide a small benefit to bull trout that could be in these reaches by slightly improving water temperatures, dissolved oxygen levels, and reducing the potential of migration impediments at the mouth of tributaries during the summer months when those parameters could fall below target values. However, it is unlikely that bull trout would be present during these times.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

PCE 3 is present in and contributes to FMO habitat in the mainstem Snake and Columbia rivers. While altered flow and temperature regimes below dams have significantly impacted the productivity of native species, increases in nonnative fish production provide an abundant prey base for bull trout (USFWS 2010b). Thirty-four different species of resident fishes have been collected from the lower Snake River reservoirs during fisheries studies conducted from 1979 through 1993 (USFWS 2002b). Forage fish such as juvenile salmon and steelhead, whitefish, sculpins (family *Cottidae*), suckers (family *Catostomidae*), and minnows (family *Cyprinidae*) are present throughout the mainstem rivers.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

PCE 4 may provide a limited contribution to FMO habitat in the mainstem Snake and Columbia rivers. Generally, PCE 4 is not present in Snake and Columbia River reservoirs (75 FR 63898, page 63934). While some portions of the mainstem Snake and Columbia rivers may exhibit complex processes, it is unlikely these processes provide a significant contribution to bull trout use of these habitats.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

PCE 5 is not present in the mainstem Columbia or Snake River CHUs (75 FR 63898, page 63934) and will not be analyzed further in this chapter.

PCE 6: In spawning/rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present in the mainstem Columbia or Snake rivers (75 FR 63898, page 63934) and will not be analyzed further in this chapter.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is present, but provides a limited contribution to FMO habitat in the mainstem Snake and Columbia rivers. Generally, the hydrograph of the mainstem Snake and Columbia rivers is highly regulated. The effects of a natural hydrograph on bull trout in the action area have not been intensively studied because of the small numbers of bull trout that use these areas. Current hydrology conditions support the mainstem local population of bull trout and provide adequate connectivity between core areas in the upper and mid-Columbia River (see additional hydrology discussion in Section 8.3.1).

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

PCE 8, at times, provides a limited contribution to FMO habitat in the mainstem Snake and Columbia rivers. Generally, water quality in the mainstem Snake and Columbia rivers is limited by several pollutants including sediment, bacteria, dissolved oxygen, nutrients, pH, mercury, pesticides, total dissolved gas, and temperature in the Snake River; and bacteria, mercury, pesticides, pH, toxics, total dissolved gas, and temperature in the lower Columbia River (WDOE 2013, ODEQ 2013a, IDEQ 2013, and Reclamation 2004a).

The primary water quality constituent affecting bull trout use of the mainstem Snake and Columbia rivers is temperature. Typically, temperatures exceed PCE targets for bull trout by mid-June. Chandler et al. (2003) suggests bull trout in the mainstem Snake River exhibit "classic fluvial migrations," over-wintering in the mainstem rivers and departing for tributaries in April through June, suggesting migrations are, at least in part, due to water temperature conditions in the mainstem rivers. Previous modeled analyses described in the 2005 USFWS BiOp indicated that although slight increases in summer water temperatures might occur with the 2004/2007 Upper Snake BA's proposed actions in place, in most years the resulting temperatures did not exceed 20° C at Lower Granite Reservoir (NOAA Fisheries Service 2005, Tables 6-10 and 6-11). If areas of thermal refugia exist, bull trout have been documented using habitat with temperatures that exceed the PCE target within the migration corridor (Howell et al. 2010). Dissolved oxygen levels below the minimum criterion of 6.5 milligrams per liter are most likely a secondary water quality condition attributable to excessive algal production associated with high nutrient levels entering the Hells Canyon Complex reservoirs.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

PCE 9 is present, but provides no measurable contribution to FMO habitat in the mainstem Snake and Columbia rivers. Altered flow and temperature regimes below dams (and associated habitat effects) along with reservoir habitat above dams, have significantly increased the abundance and productivity of nonnative predatory and competing fish species within bull trout critical habitat. Conditions in reservoir reaches typically favor nonnative species and these are prevalent in the mainstem Snake and Columbia rivers. A significant number of bull trout captured in Oxbow and Hells Canyon Reservoirs showed signs of hybridization with brook trout, a result of bull trout and brook trout being present in the tributaries (Chandler et al. 2003). Below the Hells Canyon Complex, bull trout do not show any signs of hybridization with brook trout (Chandler et al. 2003).

8.4 Effects of the Proposed Actions

The upper Snake River projects are not physically present in this area; therefore, the possible effect of the proposed action is limited to the hydrology of the Snake and Columbia rivers. That is, there is no direct contact between any upper Snake project facilities and the mainstem Snake and Columbia rivers. The hydrologic effect is not direct, occurs downstream from upper Snake project operations, and is offset, exacerbated, or masked by numerous factors. These factors include tributary inflows downstream of the upper Snake River projects; FCRPS, Hells Canyon, and other project operations; consumptive and non-consumptive uses throughout the Columbia River Basin; and climate changes. Rather, operation of the Upper Snake projects affects the supply of water downstream (below Hells Canyon Dam), although this effect is attenuated as flows move downstream. In the modeling analysis for the biological opinion *Federal Columbia River Power System Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Consultation for the Operation and Maintenance of 10 U.S. Bureau of Reclamation Projects and 2 Related Action in the Upper Snake River Basin above Brownlee Reservoir*, the hydrologic effect of the upper Snake River projects was integrated into the hydrologic effects related to the FCRPS (NOAA Fisheries Service 2008b). This hydrologic modeling exercise incorporated flow effects from all sources, not just the FCRPS and upper Snake River projects. In this sense, the flow effects attributed to both the upper Snake River projects and the FCRPS are overstated, offering a “worst case scenario” on which to analyze effects. Actual project effects are likely less.

8.4.1 Proposed Action Effects on Bull Trout

Reclamation has considered new information relevant to bull trout use of the mainstem Snake and Columbia rivers that has become available since the 2007 Upper Snake BA. Though there is additional data supporting occasional use of these mainstem rivers as feeding, migratory, and over-wintering habitat, no new information exists that would indicate an effect of a different degree or nature than was previously considered. Therefore, Reclamation has determined that the previous finding in the 2004 Upper Snake BA (Reclamation 2004a) that the proposed action would be not likely to adversely affect bull trout in the mainstem Snake and Columbia rivers is still appropriate and there is no need to reinitiate consultation at this time for the species in this section.

8.4.2 Effects of the Proposed Action on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The operation of the dams and reservoirs in the upper Snake River basin will have discountable effects on PCE 1 within mainstem Snake and Columbia rivers. As noted previously, springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quantity or water quality in the reservoirs in the upper Snake River basin. Although, reservoir operations may influence shallow groundwater exchange, the influence of this exchange is not of sufficient scale to influence thermal refugia in the reservoirs as a whole.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The operation of the upper Snake River projects will have an insignificant effect on PCE 2 in the mainstem Snake and Columbia rivers. There are no project facilities in the mainstem Snake or Columbia rivers, so there would be no physical effects on migration habitats or impediments. The small portion of hydrologic effects that could be attributable to the upper Snake River projects would not be measurable in terms of the ability of bull trout to migrate through the mainstem rivers. Under current conditions, water quality is sufficient at times when bull trout would be likely to use the action area for FMO habitat. Accordingly, the operation of the upper Snake River projects does not appear to have a significant effect on migration between tributary and mainstem habitats. The continued augmentation of flows for salmon under the proposed action would continue to provide slight benefits to bull trout by improving water temperatures, dissolved oxygen levels, and potential physical impediments at the mouths of tributaries during the summer months when those parameters could fall below target values. Migration habitats would remain fragmented or impounded by dams as described in environmental baseline.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The operation of the Upper Snake projects will have insignificant effects on PCE 3 in the mainstem Snake and Columbia rivers. Upper Snake project operational changes are not likely to have any measurable effect on bull trout prey base in the Hells Canyon Complex and downstream areas (USFWS 2005a). Operation of the upper Snake River projects may increase inflows to Brownlee Reservoir as much as 1,100 cfs in July (at the 90 percent exceedance level) with salmon flow augmentation. The changes in Brownlee Reservoir inflows, as a result of the upper Snake River projects, are relatively minor compared to existing inflows and Brownlee Reservoir elevations (as well as Oxbow and Hells Canyon) are not likely to be affected at all since salmon flow augmentation is passed through the three reservoirs. Changes in flows below Hells Canyon Dam would also be unlikely to have a measurable effect on bull trout prey base. Conditions favoring nonnative species would continue to provide a prey base. Brownlee Reservoir inflows are decreased in winter and increased in spring and summer.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Operation of the upper Snake River projects will have an insignificant effect on PCE 4. Generally, PCE 4 is not present in Snake and Columbia river reservoirs (75 FR 63898, page 63934). While some portions of the mainstem Snake and Columbia rivers may exhibit complex processes, it is unlikely these processes provide a significant contribution to bull trout use of these habitats. Throughout most of the year, the variability associated with upper Snake project operations is subsumed by the operation of mainstem dams, making the influence of upper Snake River projects on river elevation nearly immeasurable in much of the Snake and Columbia rivers. In August and September, salmon flow augmentation releases may temporarily ameliorate low summer flow conditions although the scope of these benefits to habitat complexity is unknown.

PCE 5: Water temperatures ranging from 2° to 15° C (36° to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

PCE 5 is not present in the mainstem Snake River and Columbia River; therefore, the effects were not analyzed.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present in the mainstem Snake and Columbia rivers. The lakes, reservoirs, mainstem Snake River, and mainstem Columbia River have not been designated as spawning and rearing habitat (USFWS 2010a, pages 629, 641); therefore, the effects were not analyzed.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

The operation of the upper Snake River projects will have an insignificant effect on the function of PCE 7 on the mainstem Snake and Columbia rivers. Generally, the operation of the upper Snake River projects reduces inflow to Brownlee Reservoir from October through June, with the most substantial influence in May and June. Reclamation anticipates hydrologic conditions similar to those observed under the environmental baseline will continue. Salmon flow augmentation releases from the upper Snake River projects increase flows in August and September. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Section 2.2).

This influence is insignificant for two reasons. First, the intermediating influence operation of downstream dams, particularly those of the Hells Canyon Complex, overwhelm the influence of the Upper Snake River projects at time scales necessary to control the magnitude, duration or stability of the peak, high, low and base flows that make up a natural hydrograph. In other words, while the operations of the Upper Snake River projects influence the context in which downstream management actions occur, this influence is not sufficient to overcome the impacts of baseline regulation downstream and restore characteristics of a natural hydrograph.

Second, what influence the Upper Snake River projects may have on mainstem hydrology, this influence has insignificant effects on the function of this habitat for FMO use. Generally, the primary benefit of a natural hydrograph for FMO habitat is in providing stable flows to avoid impacting foraging and over-wintering behaviors (75 FR 63898, page 63931). Under baseline conditions, base flows remain sufficiently stable to support bull trout feeding, migration, and over-wintering. Chandler et al. (2003) found that bull trout use the Oxbow Bypass reach and Hells Canyon Reservoir primarily during late fall and winter. While peak spring flows have been reduced from a natural hydrograph, it is unclear whether this has any effect on bull trout migration from the mainstem rivers to tributary habitats. Typically, water temperature and tributary hydrology are the primary triggers for migratory behavior.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The operation of the upper Snake River projects will have an insignificant effect on PCE 8 in the mainstem Snake and Columbia rivers. Generally, adequate water quantity exists within the mainstem rivers to support migration habitats (PCE 2) and bull trout prey base (PCE 3). A slight beneficial effect to summer water quantity may occur as a result of salmon flow augmentation, although these benefits diminish below Lower Granite Dam. The operation of the upper Snake River projects influences water quality in the mainstem Snake River by temperature regimes, suspended sediment, and nutrient transport dynamics (Reclamation 2007); however, these effects are insignificant and do not affect the function of the PCE. Incoming water temperatures to Brownlee Reservoir are primarily a function of baseline meteorologic functions rather than upper Snake operations. The volume of water could influence temperature gradients within the reservoirs and the temperature of water released downstream, but the degree of this influence is largely determined by the operations of the Hells Canyon Complex facilities. From November through mid-June, water temperatures are suitable for bull trout through much of the Snake River below Brownlee Reservoir. This suggests that flow reductions attributable to upper Snake River project operations do not have a significant influence on water temperature. In the summer, the influence of salmon flow augmentation releases depends on the operation of Snake River facilities. When passed over the top of dams, salmon flow augmentation releases may increase water temperatures, although salmon flow augmentation is generally associated with a slight reduction in temperatures below Lower Granite Dam (Corps 2013). Reclamation anticipates effects similar to those observed under the environmental baseline will continue. Climate change forecasts suggest baseline conditions will maintain storage levels within the range of observed conditions (Section 2.2).

The delivery of water for agricultural use can also influence sediment transport regimes. Project reservoirs trap sediment loads from upstream tributaries, while water deliveries can indirectly increase loads due to agricultural practices. Reclamation anticipates that continued implementation of sediment TMDLs will reduce sediment loads from those observed under the environmental baseline. To the extent that operations may increase sediment transport in the upper Snake River, these effects are not anticipated to have a significant effect on PCE 8 below Brownlee Reservoir because the reservoir traps much of the incoming sediment.

Similarly, water deliveries can influence nutrient loads within the upper Snake River. Generally, nutrients are deposited within Brownlee Reservoir where they affect nutrient dynamics within the reservoir. As summer water temperatures rise, this may increase nutrient consumption within the reservoir and cause dissolved oxygen levels both within the reservoir and downstream to decrease. Once dissolved oxygen is depleted, the reservoir becomes anoxic and a portion of incoming nutrient loads are bypassed downstream. Generally, these effects diminish with each reservoir downstream. Reclamation does not anticipate this influence to have a significant effect on the function of PCE 8 because bull trout are not present at times when water temperature causes downstream dissolved oxygen and nutrient loading issues.

Below Lower Granite Dam, the influence of upper Snake operations on water quality and quantity becomes immeasurable; therefore, no significant effects are anticipated for the lower Snake River below Lower Granite Dam and the mainstem Columbia River.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The operation of upper Snake River projects will have an insignificant effect on PCE 9 within mainstem Snake and Columbia rivers. The proposed action provides an environment that allows the survival of nonnative fishes; however, state fish and game departments exclusively manage the fisheries including stocking and regulations that favor the presence of individual species. The proposed action plays an insignificant role in the occurrence of nonnative fishes compared to variables (fish management and interbreeding) independent from the operation of the upper Snake River projects.

8.4.3 Summary of the Effects of the Proposed Action

Hydrologic effects to PCEs in the mainstem Snake and Columbia River CHUs are summarized in and detailed in the following paragraphs. PCEs 5 and 6 are excluded from analysis because they are not present in these CHUs (75 FR 63898, page 63934).

Table 22. Summary of the effects of the proposed action for the mainstem Snake/Columbia River system.

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	Springs, seeps, groundwater sources	Discountable effect
2	Migration habitats with minimal impediments.	Insignificant effect
3	Abundant food base	Insignificant effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
5	Water temps ranging from 2°-15 °C with adequate thermal refugia	Not present
6	Spawning/rearing substrate.	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Insignificant effect
8	Sufficient water quality and quantity	Insignificant effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

8.5 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 considered in this biological assessment. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

Cumulative effects from a variety of activities are likely to continue to affect bull trout and their critical habitat. These actions include, but are not limited to, industrial and residential development, road construction and maintenance, mining, forest activities, fish management activities, agriculture and grazing, and fire management. Continued operation and maintenance of non-Federal Idaho Power dams in the Hells Canyon complex would continue to contribute to degradation of critical habitat elements as described in environmental baseline. The state fish and wildlife agencies exclusively manage the fisheries within the action area including the stocking and regulations that favor the presence of individual species. Effects from stocking of nonnative species throughout the mainstem rivers and from angling activities would continue to affect bull trout and their critical habitat through direct competition, hybridization, and predation.

Watershed assessments and other education programs may reduce these adverse effects by continuing to raise public awareness about the potentially detrimental effects of residential development and recreation on salmonid habitats and by presenting ways in which a growing human population and healthy fish populations can co-exist.

Water discharge and temperatures are impacted by changes and variability in regional climate across the Columbia River basin. Seasonal variation in the Columbia River discharge is impacted by winter precipitation amounts and snowpack depths in higher elevation areas throughout the basin. Possible future climate warming across the basin has anticipated impacts on snowpack and runoff patterns.

8.6 Determination

In summary, considering the small influence of the upper Snake River project operations on mainstem Snake and Columbia River flows, the effects of the upper Snake River projects on bull trout designated critical habitat are found to be insignificant, discountable, and/or beneficial. The changes in Brownlee Reservoir inflows are relatively minor compared to existing inflows, and Brownlee Reservoir elevations (as well as Oxbow and Hells Canyon) are not likely to be affected at all since salmon flow augmentation is passed through the three reservoirs. Several PCEs (PCEs 1, 4, 5, and 6) are not supported by the mainstem reservoirs, and habitat use of the riverine system is limited to FMO. Migration habitats are not affected physically in this area and would continue to benefit from salmon augmentation flows. No measurable effect on prey base of bull trout, or influence of nonnative completion/predation would be expected in the Snake or Columbia rivers habitats. Hydrological manipulation of the mainstem Snake and Columbia rivers from a number of Federal and non-Federal projects would continue to alter the natural hydrograph and water quality as in baseline. The portion of these effects attributable to the upper Snake River projects, coupled with the consideration of the transitory nature of the bull trout's use of this habitat and that migration is supported by this hydrologic regime, lead to the conclusion that these effects are highly unlikely to rise to the level of adverse.

Reclamation has determined that future O&M in the upper Snake River projects **may affect, but is not likely to adversely affect** bull trout and bull trout critical habitat in the mainstem Snake and Columbia river basins.

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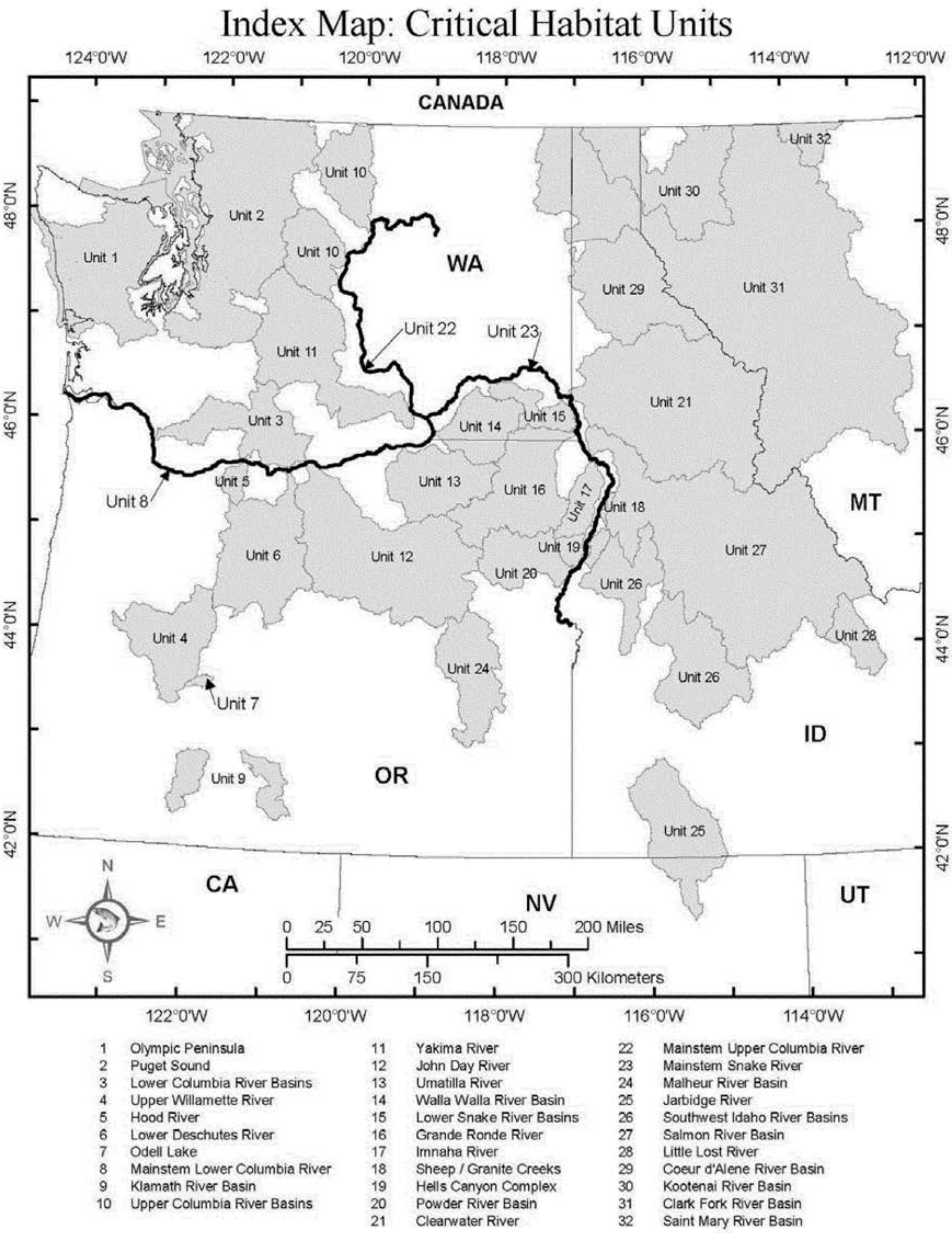
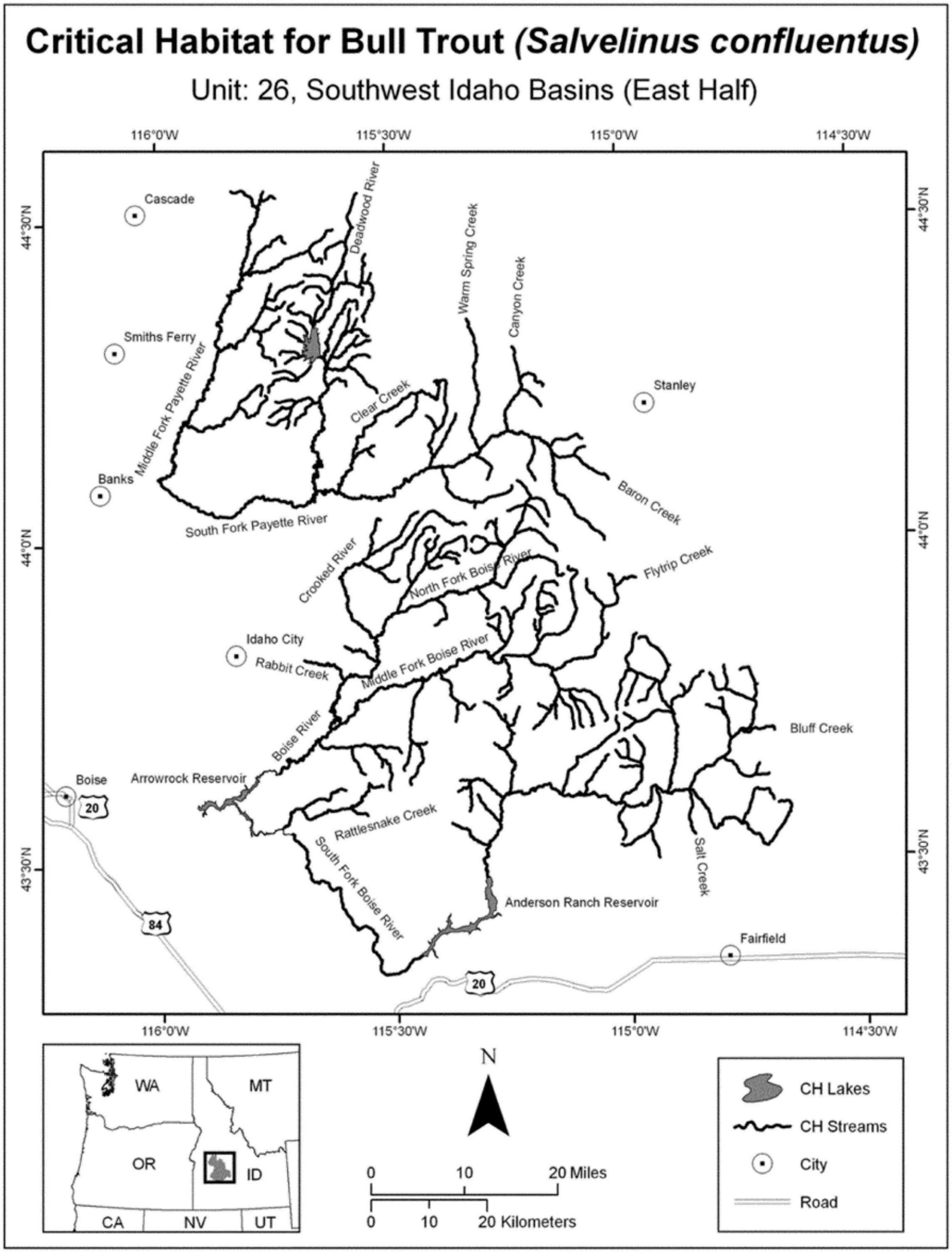
APPENDICES

APPENDIX A

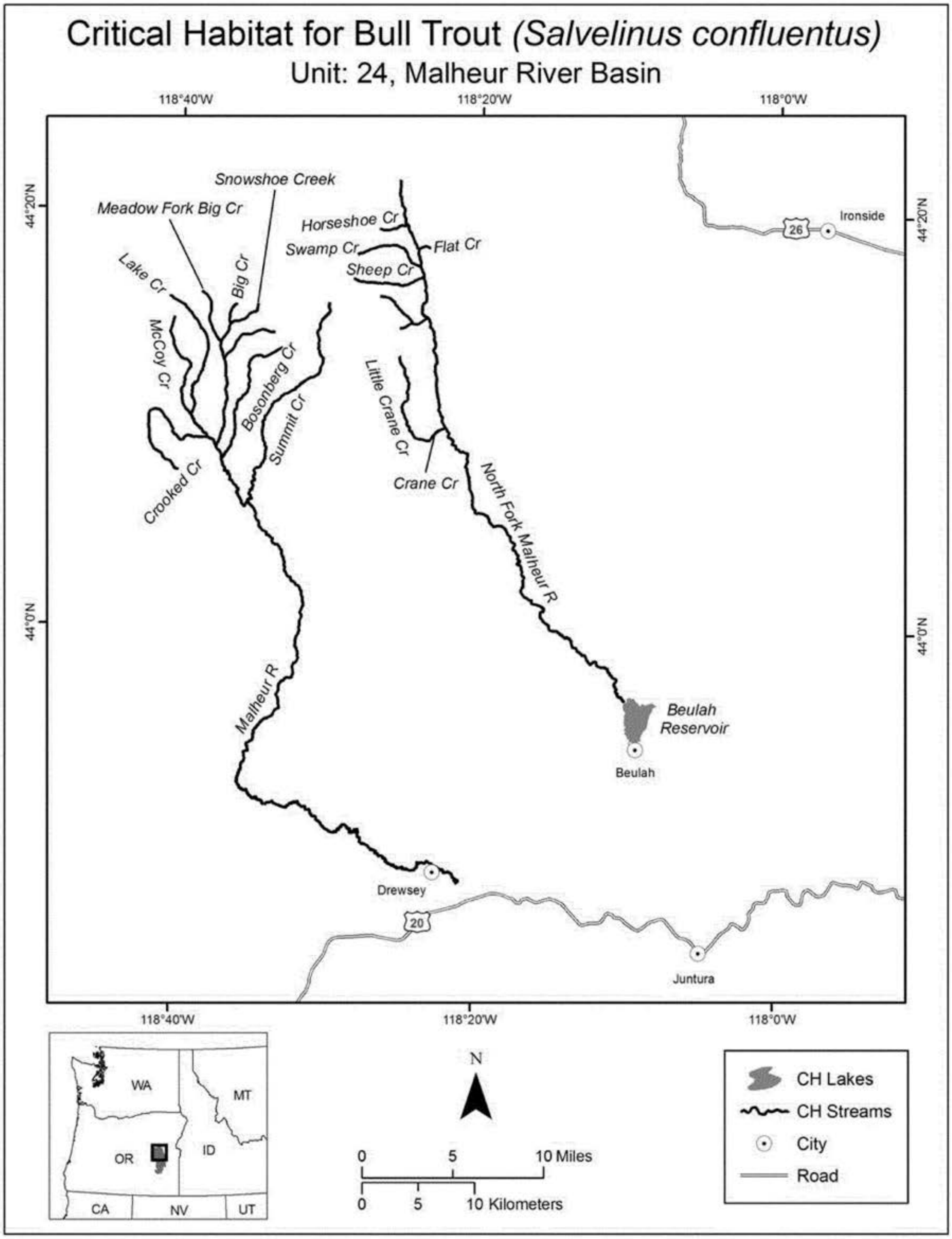
Maps of Designated Critical Habitat Areas



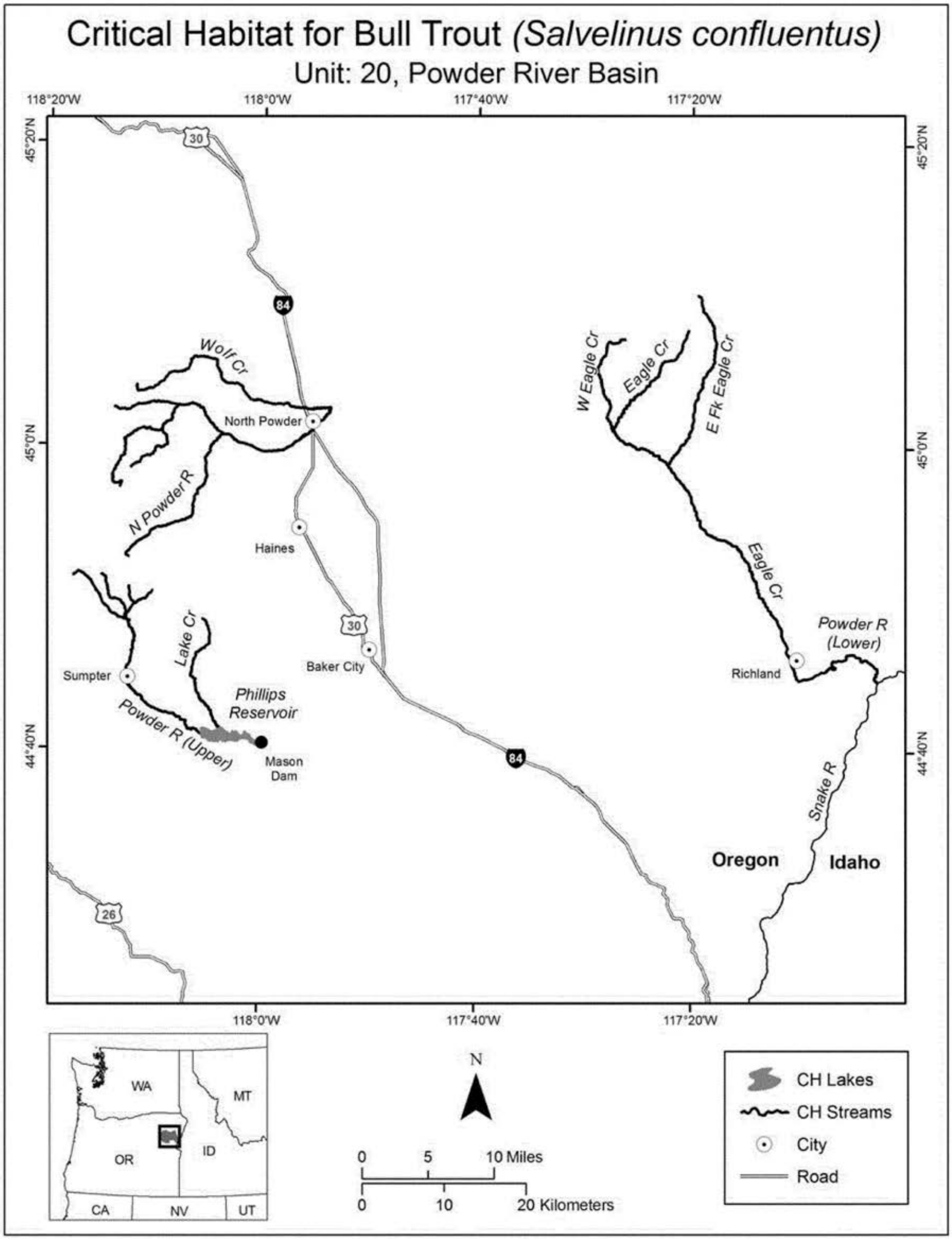
Appendix Figure 1. Map of the critical habitat units as designated by USFWS (75 FR 63898). This document covers Units 8, 20, 23, 24, and 26.



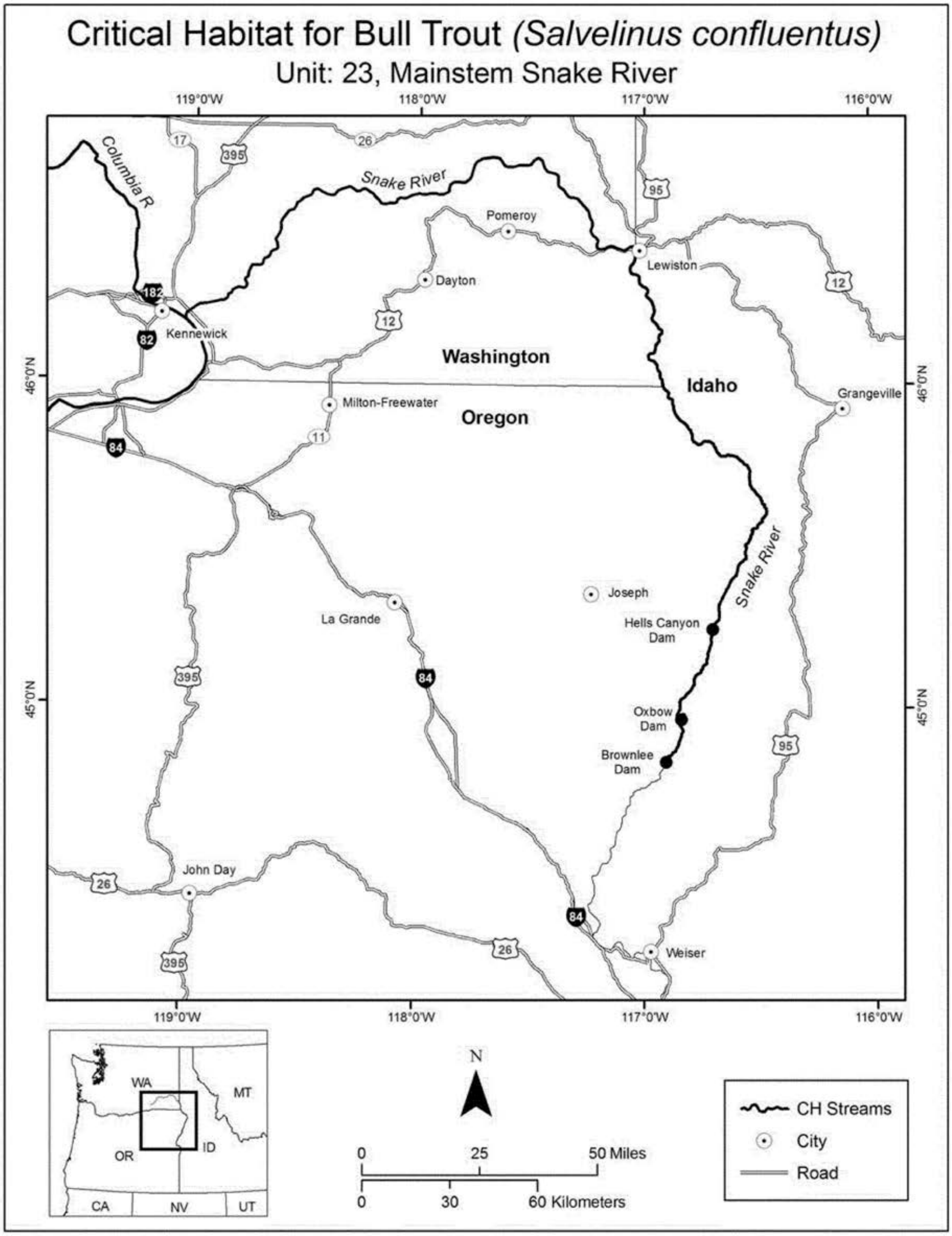
Appendix Figure 2. Map of the critical habitat areas in the Boise, Payette, and Deadwood River basins as designated by USFWS (75 FR 63898).



Appendix Figure 3. Map of the critical habitat areas in the Malheur River basin as designated by USFWS (75 FR 63898).



Appendix Figure 4. Map of the critical habitat areas in the Powder River basin as designated by USFWS (75 FR 63898).



Appendix Figure 5. Map of the critical habitat areas of the Lower Snake River basin as designated by USFWS (75 FR 63898).

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APPENDIX B

Water Quality Analysis

Water Quality Analysis

For

Biological Assessment for Bull Trout Critical Habitat in the Upper Snake River Basin

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WATER QUALITY

While no explicit pollutant reduction requirements are assigned to the Bureau of Reclamation (Reclamation) in any of the upper Snake River basin Total Maximum Daily Loads (TMDLs), Reclamation has consistently provided technical and financial assistance to the States of Idaho and Oregon (States) 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,[1] 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 operation and maintenance (O&M) associated with the continued operations of Reclamation's projects, and therefore, are incorporated into Reclamation's proposed actions in this consultation (Reclamation 2007, p. 54).

Staff from Reclamation's Snake River Area Office and Pacific Northwest Regional Office 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 (Reclamation 2007, p. 54).

IDEQ and ODEQ jointly developed the TMDL for the Snake River on the Idaho-Oregon border to the confluence with the Salmon River which describes current water quality concerns for this reach (IDEQ and ODEQ 2003). Primary water quality problems identified in that reach 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

[1] These programs partner with States and local water users to identify solutions to water and related natural resource problems

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). The non-point source tributaries included in that TMDL are the Snake River inflow (1,912 kilograms per day [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) (USFWS 2002). 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.

Little Wood River System

The Little Wood River subbasin lies in south central Idaho and is the main water body that drains the subbasin. The headwaters of the river originate in the Pioneer Mountains of the Sawtooth National Forest and discharge in the desert plains at the Big Wood River. Reclamation operates a small irrigation storage reservoir on the Little Wood River. This reservoir was listed as water quality impaired in 1998 by the State of Idaho for bacteria, low dissolved oxygen, excess nutrients, and excess sediment. In August 2005, the reservoir water quality was assessed by the IDEQ and they determined that the water quality at the time was meeting all water quality standards and subsequently delisted the water body (IDEQ 2005). The Little Wood River upstream from the reservoir was listed for temperature violations and a temperature TMDL was developed. Allocations for temperature reductions were based upon riparian shade curves and differences between natural shade potential (IDEQ 2005).

Owyhee River System

ODEQ has not yet begun to work on the TMDLs for the Owyhee River basin (ODEQ 2012) and no timeframe has been indicated for when the TMDLs will be started. In the meantime, Reclamation provides financial assistance for laboratory services to the Malheur County Soil and Water Conservation District for pre-TMDL development monitoring (Reclamation 2007, p. 56).

Boise River System

The South Fork Boise River subbasin is located in southwestern Idaho and includes the South Fork Boise River upstream of Arrowrock Reservoir, Anderson Ranch Reservoir, and all South Fork Boise River tributaries upstream to the headwaters. IDEQ completed temperature TMDLs for five tributaries of the South Fork Boise River in March 2009 and an implementation plan for those tributaries in October 2009 (IDEQ 2008). Reclamation continues to participate in the watershed advisory group to ensure that TMDL development integrates the known operational flexibilities at Anderson Ranch Dam.

The lower Boise River sediment and bacteria TMDLs were approved by the Environmental Protection Agency (EPA) in January 2000. Nutrient allocations for the lower Boise subbasin were incorporated into the Snake River Hells Canyon TMDL (IDEQ and ODEQ 2003). The lower Boise River was added to the State's integrated report (303[d] list) in 2010 and will be scheduled for TMDL development at a later date. Reclamation provides financial assistance for laboratory services to IDEQ, Boise City, and U.S. Geological Survey (USGS) for TMDL development and implementation monitoring. Reclamation also regularly participates in watershed advisory group meetings (Reclamation 2007, p. 56).

Payette River System

The Cascade Reservoir TMDL was developed in two phases and 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 (Reclamation 2007, p. 56).

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 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 (Reclamation 2007, p. 56).

At Black Canyon Park on Black Canyon Reservoir, Reclamation installed riprap to protect the shoreline from erosion (Reclamation 2007, p. 56).

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 (Reclamation 2007, p. 56).

Malheur River System

ODEQ completed TMDLs for the Malheur River subbasin in 2010. Reclamation is cooperating with ODEQ on temperature monitoring activities related to TMDL development. The Malheur River basin TMDLs included chlorophyll a reductions, bacteria reductions, and temperature reductions and required Reclamation to eliminate excessive temperature increases downstream from Beulah and Warm Springs reservoirs. In addition, the TMDL required that Reclamation evaluate managed flows required for the survival of downstream riparian communities (ODEQ 2010). Reclamation also regularly participates in the Malheur Watershed Council meetings (Reclamation 2007, p. 57).

Mann Creek System

The Weiser River subbasin is located in southwestern Idaho. Twelve stream segments were originally listed on Idaho's 1998 303(d) list. EPA added streams to Idaho's 1998 303(d) list of impaired waters that exceeded Idaho's temperature criteria. In 2006, Idaho developed temperature TMDLs for these EPA additions to the Idaho 303(d) list, as well as for the Weiser River and ten of its major tributaries, including Mann Creek and Mann Creek Reservoir. Allocations for temperature reductions were based on riparian shade curves and differences between natural shade potential (IDEQ 2006).

Burnt River System

ODEQ initiated the TMDL processes for the Burnt River, but there is no schedule for completing TMDLs needed for the Burnt River system. Currently, ODEQ is conducting initial scoping and preliminary data collection efforts (ODEQ 2012). Reclamation will cooperate as needed with ODEQ on water quality monitoring in the basin and participate in public outreach meetings.

Powder River System

ODEQ has initiated the TMDL processes for the Powder River, but there is no schedule for completing TMDLs needed for the Powder River system. Currently, ODEQ is conducting initial scoping and preliminary data collection efforts (ODEQ 2012). Reclamation will cooperate as needed with ODEQ on water quality monitoring in the basin and participate in public outreach meetings.

Snake River from Salmon River Confluence to the Columbia River

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;

Reclamation 2007, p. 57) 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 (Reclamation 2007, p. 57). 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 (Reclamation 2007, p. 57). 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 (Reclamation 2007, p. 57).

According to the States 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, work on the TMDL was not completed for various reasons. Currently, Reclamation, Army Corp of Engineers, States, and Tribes are collaborating on developing hydrology and temperature models for the entire Columbia River. The models will assess potential changes in the Columbia River operations from changes in the Columbia River 2024 treaty negotiations.

Columbia River from the Snake River Confluence to the Columbia River Mouth

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. 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 (Reclamation 2007, p. 58). The TMDL may be reinitiated following development of models for much of the Columbia River for the Columbia River Treaty 2014/2024 investigations.

BOISE RIVER SYSTEM

Anderson Ranch Reservoir Water Quality Conditions

Temperature

Reclamation has collected temperature profiles periodically over the past 16 years at up to three reservoir locations. These temperature profiles indicate the annual progression of stratification and thermocline breakdown. No profiles were collected during the ice-covered period; however, lakes and reservoirs are typically inversely stratified with colder water next to the ice and slightly warmer more dense water near the bottom of the reservoir.

April profiles indicate that the reservoir is isothermal with temperatures between 4 and 6° C. Warming of the epilimnion begins in May, building a weak stratification (Figure 1). The epilimnion is not well defined, with a nearly linear temperature transition through the thermocline to the hypolimnion. This stratification remains in place through July, with a weakly developed epilimnion, a large and deep thermocline, and stable and cold hypolimnion. Average epilimnion depth at this time is approximately 4 meters. The temperature difference between the surface waters and bottom waters increased to 17° C by July with maximum epilimnetic temperatures reaching 22+° C while the temperatures near the bottom of the reservoir remain relatively constant between 4 and 5° C. The average epilimnetic temperature during the summer was 21.5° C, above bull trout temperature tolerances. During this time, the epilimnion remained between 5 and 6 meters deep. In August through October, the reservoir begins to cool and the thermocline begins to erode, developing a strongly defined epilimnion (Figure 2). The reservoir quickly cools and is again isothermal by December, prior to ice formation. Due to the depth of the reservoir, it is highly likely that the reservoir would stratify in most years. It appears that during the critical summer months, the epilimnion will warm above bull trout temperature tolerances, while temperatures below 30 meters remain below 10° C.

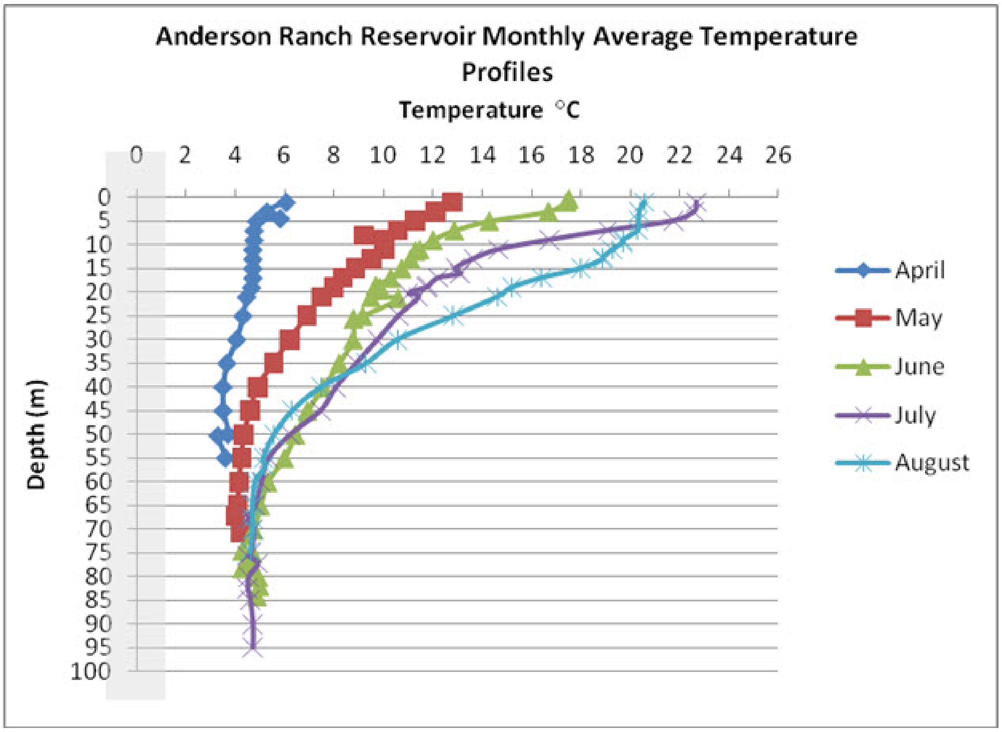

Figure 1. Monthly average temperatures of Anderson Ranch Reservoir, April through August.

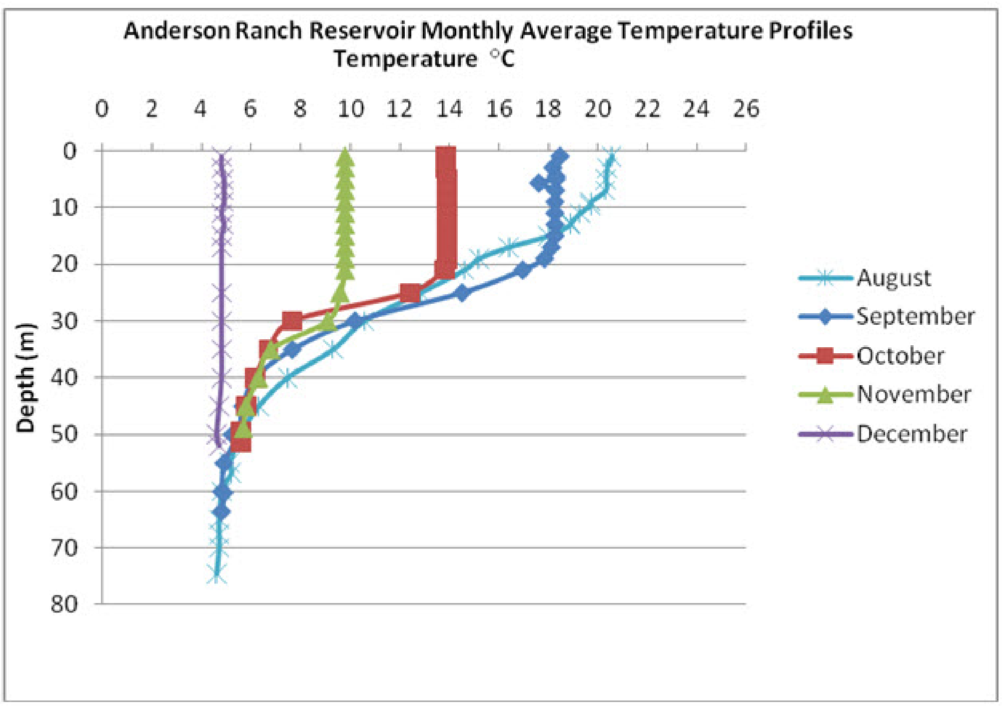

Figure 2. Monthly average temperatures of Anderson Ranch Reservoir, August through December.

Dissolved Oxygen

Dissolved oxygen profiles were also collected along with the temperature profiles and similar situations were observed. Throughout the year, dissolved oxygen levels were suitable for bull trout through the top portion of the water column. Oxygen depletion became evident only after the reservoir began to strongly stratify following the summer months, likely due to the isolation of the hypolimnion and the increased respiration of the growing seasons carbon load (Figure 3). Bacterial respiration and sediment oxygen demand in the hypolimnion in deep hypolimnetic waters often removes dissolved oxygen. Due to the various locations monitored with variable depths, the average dissolved oxygen profiles are more erratic than expected, but are indicative of dissolved oxygen depletion at depth. Oxygen depletion was noted below the thermocline and oxygen was depleted below 7 milligrams per liter (mg/L) beginning in July at 10 meters through October throughout the water column (Figure 2 and Figure 3). This leaves a thermal and oxygen refugia in the reservoir during the summer critical period between 5 and 10 meters. Oxygen depletion reaches its maximum extent in September through November with the hypolimnion dissolved oxygen depleted to near anoxic conditions near the bottom (Figure 4).

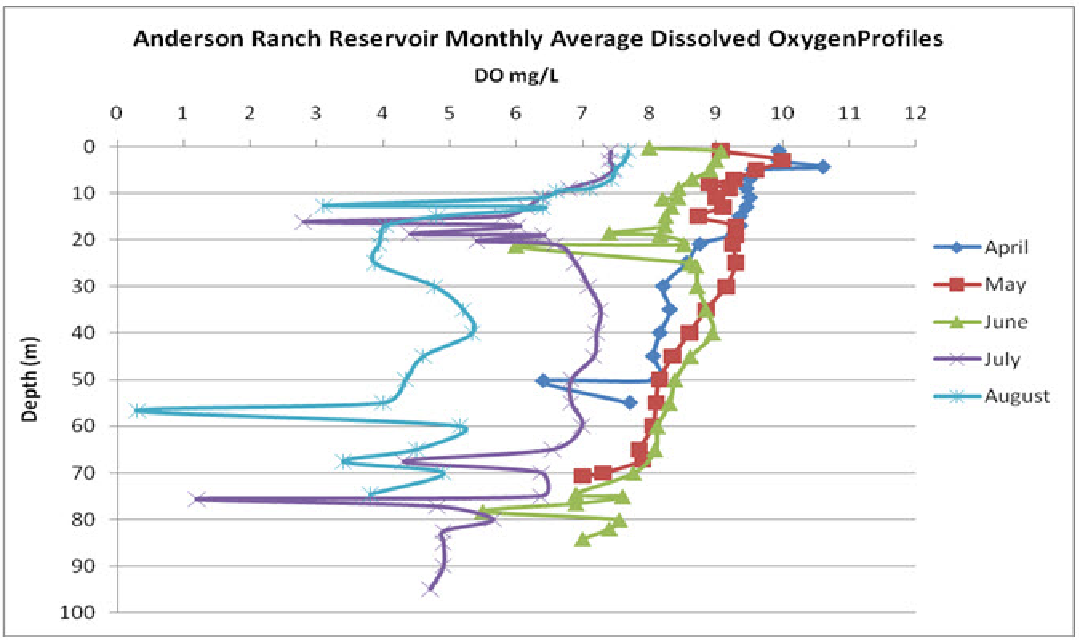

Figure 3. Monthly average of dissolved oxygen profiles in Anderson Ranch Reservoir, April through August.

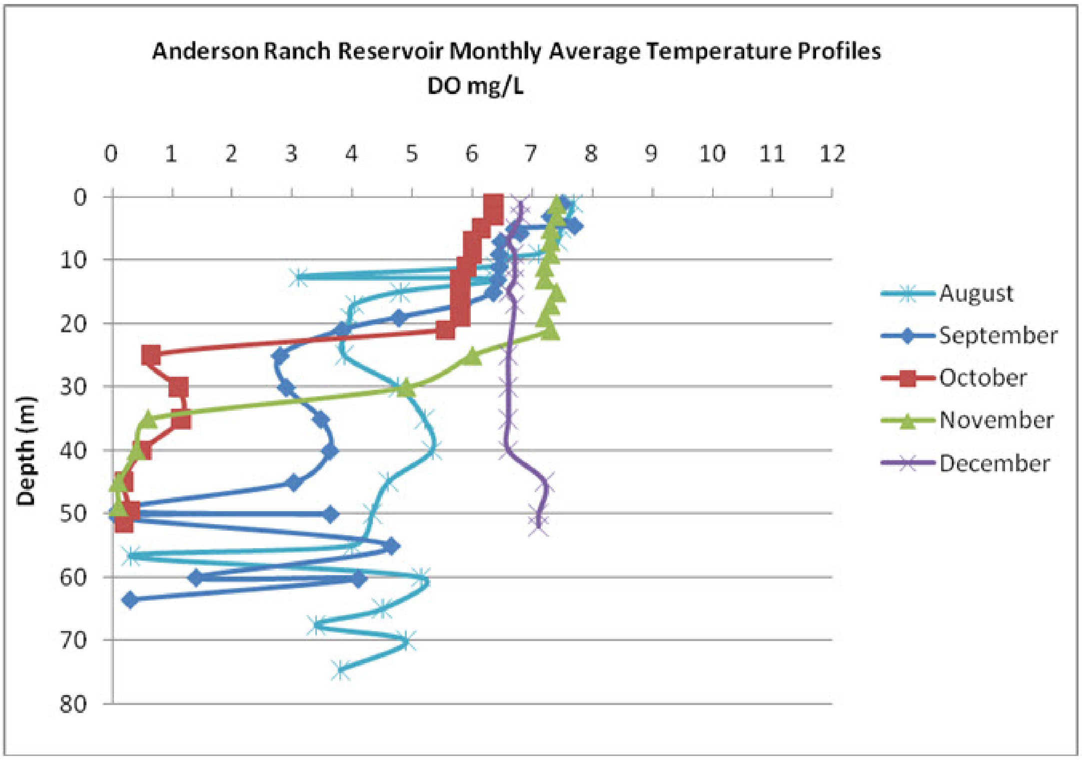

Figure 4. Monthly average of dissolved oxygen profiles in Anderson Ranch Reservoir, August through December.

Oxygen depletion was especially noticeable in August and September 2001 (Figure 5). Fish kills (kokanee) were observed in 2001, a drought year, when reservoir volumes were low and a combination of high water temperature, high air temperatures conditions and other factors caused an anoxic zone in the reservoir water (Reclamation 2004). While dissolved oxygen depletion was especially high in 2001, a deep zone of increased dissolved oxygen developed, near 40 meters, likely the result of metalimnetic chlorophyll maxima; however, this zone was apparently not sufficient to prevent a large fish kill.

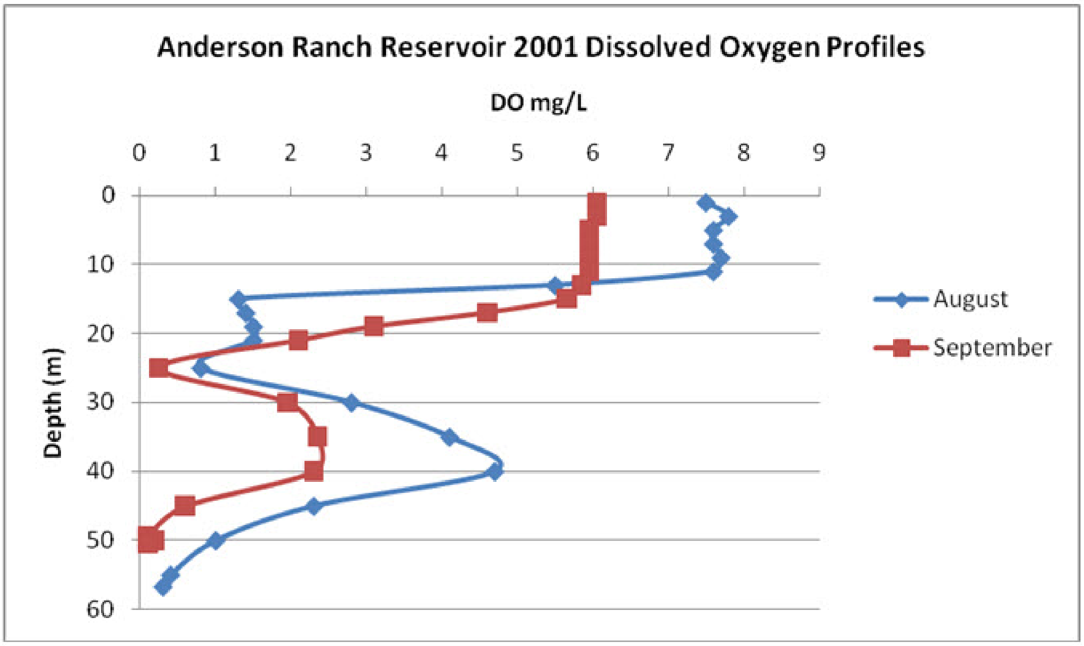

Figure 5. August and September 2001, monthly average of dissolved oxygen profiles in Anderson Ranch Reservoir.

September through October may be the hardest period of time for bull trout in the reservoir. At this time, the surface waters have cooled substantially, but remain above 18° C. The reservoir is building a well-developed epilimnion through cooling processes and is transitioning to an isothermal state. As a result, water temperature remains above 15 ºC to approximately 25 meters in depth. In September, the available area of the reservoir above 7 mg/L dissolved oxygen extends from 5 meters to the surface while temperature and oxygen values are close to tolerance levels. This situation may force bull trout to use vertical movements to thermoregulate and minimize oxygen stress if they remain in the reservoir during this period. Oxygen stress would continue through October, but by then the entire water column has cooled to below 14° C (Figure 4).

Sediment/Turbidity

Reclamation has collected sediment/turbidity samples from Anderson Ranch Reservoir periodically; 29 samples were collected in various years from the reservoir. Total suspended solids (TSS) levels were very low in this set of samples, with a mean concentration for the period of record of 3.125 mg/L and a range of less than 1 to 10 mg/L.

In addition, Reclamation measured turbidity and Secchi depths of the reservoir waters. Both measures are an indication of water clarity. While turbidity values were very low (mean reservoir turbidity was 2.02 nephelometric turbidity units [NTU]) indicating very clear water, Secchi depths were variable. Secchi depths ranged from very clear, near 7.3 meters deep, to relatively shallow of 1 meter deep (Figure 6). Coupled with the clarity measures, chlorophyll a and TSS samples give an indication that the clarity issues in Anderson Ranch Reservoir are biological in origin such as algae blooms rather than sediment-impaired clarity. Biological clarity issues can be episodic in nature with variable frequency as seen in the September increase in chlorophyll a and slight increase in turbidity. Sediment and turbidity issues should not impact sight foraging. Since TSS levels are very low, gill abrasions or other secondary or delayed mortality issues associated with high TSS or turbidity should be minimal.

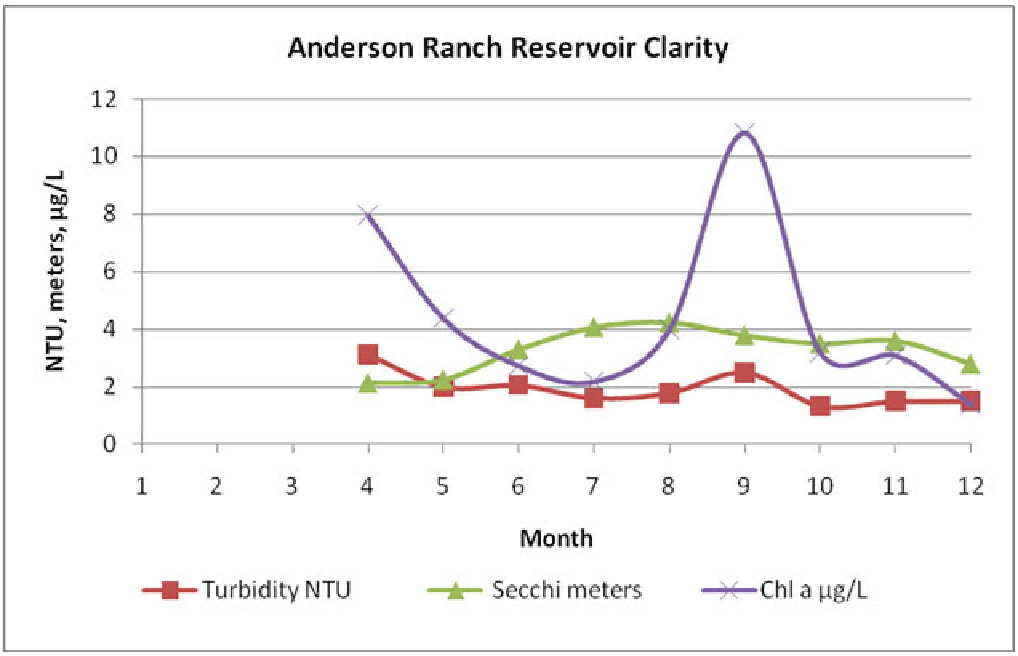

Figure 6. Water clarity of Anderson Ranch Reservoir.

Other Water Chemistry

The levels of the measured constituents in Anderson Ranch Reservoir are low to very low. These levels in most cases indicate a lower loading and pristine water quality compared to nearby reservoirs. The total phosphorus (TP) concentrations from the surface waters (less than 5 meters) were 0.016 mg/L, and at depth (less than 10 meters), TP concentrations averaged 0.022 mg/L (Figure 7). In the reservoir, the ratio of total nitrogen to total phosphorus (TN:TP) was well balanced with some seasonal variation. Average TN:TP ratio for all sample locations was 15.15; the ratio was greater than 11 in 28 of the samples. Biologically, this indicates that blue green algae and other unpalatable forms of nitrogen-fixing algae should not dominate the reservoir as nitrogen is common. Furthermore, the types of algae that are often associated with TN:TP ratios such as these should provide suitable forage for zooplankton and other aquatic invertebrates (Figure 8).

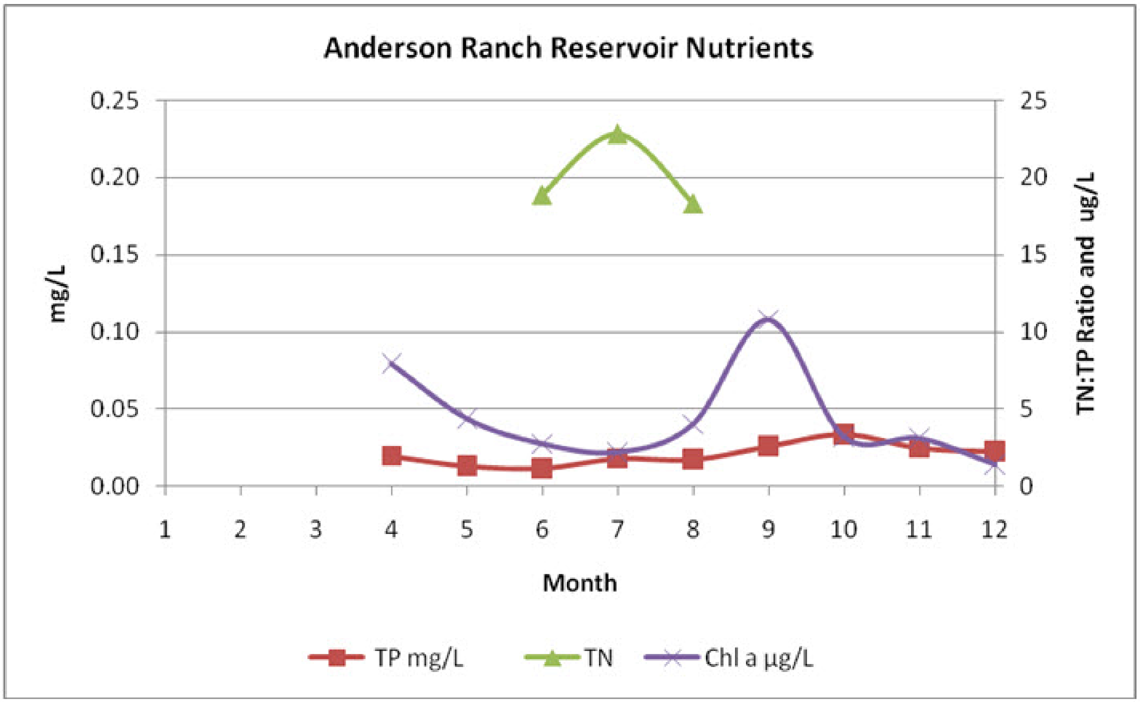

Figure 7. Nutrient and chlorophyll a levels at Anderson Ranch Reservoir.

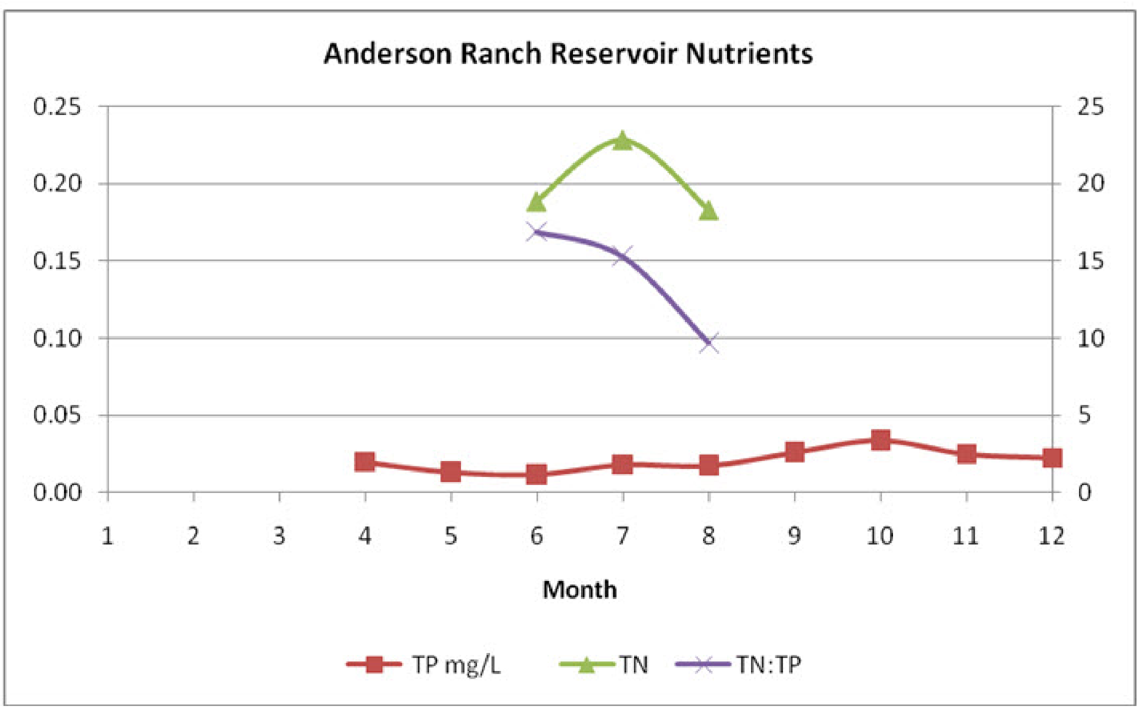

Figure 8. Nutrient levels at Anderson Ranch Reservoir.

For lakes, Carlson's Trophic State Index (TSI) can be used to determine if a lake is undergoing cultural eutrophication (Carlson 1977); however, a certain trade off exists between fish production and water quality. Since mesotrophic reservoirs are often seen as well balanced in terms of fish production and water quality, mesotrophic lakes are viewed by many as the ideal target. As a result, many states and water quality entities use a TSI target of 50 as their management goals. The Carlson's TSI can be broken into its individual components in order to determine mechanisms of impairment and used to determine if nutrients are in excess. A TSI of 50 corresponds with 0.024 mg/L of TP and 0.734 mg/L of total nitrogen (TN). In looking for the source of clarity issue, a TSI of 50 corresponds with a 2-meter Secchi depth and a concentration of 7.23 micrograms per liter (µg/L) for chlorophyll a.

The average TSI value calculated for Anderson Ranch Reservoir was 41.14 (Figure 9). This measure of eutrophication is below the mesotrophic break point of 50, indicating the reservoir is oligotrophic. In general, this indicates that a nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir.

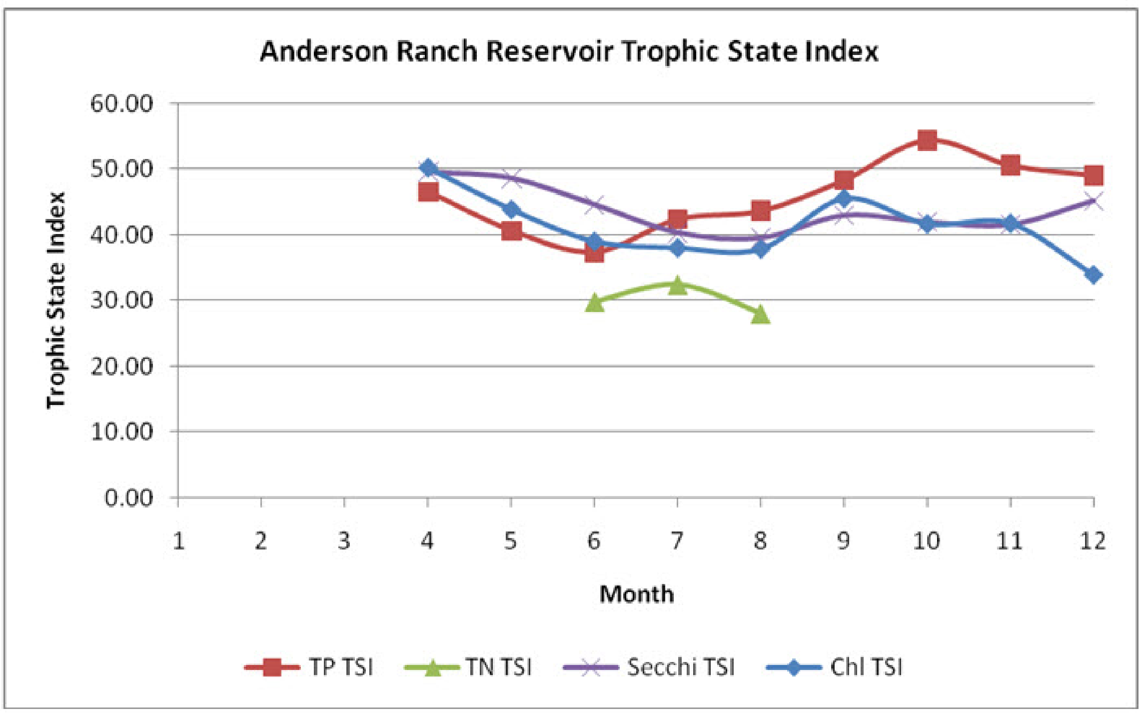

Figure 9. Trophic State Index for Anderson Ranch Reservoir.

In Anderson Ranch Reservoir, the average TSI for the individual components were 43.29 for TP, 30.25 for TN, 41.19 for chlorophyll a, and 43.53 for Secchi depth. Based on these numbers, Anderson Ranch Reservoir exhibits very low TN numbers, indicating a possibility of nitrogen fixing algae blooms. On average, the other TSI components were well balanced with one another and well within the oligotrophic index period.

The average TSI for TP concentrations of the reservoir were moderate and showed some seasonality. Summertime, epilimnetic TP averaged 0.012 mg/L, or TSI of 39.98. As the thermocline eroded and nutrients were mixed from the hypolimnion during fall turnover, concentrations increased, allowing increased primary production. In September through November, TP increased to a mean of 0.024 mg/L (TSI 49.98) (Figure 9). This may account for the increase in chlorophyll a concentrations and chlorophyll TSI values. As turnover continued, nutrients mixed from the hypolimnion fed the epilimnion's primary production. While these processes occur annually in Anderson Ranch Reservoir as a result of the impoundment, they are part of a dimictic stratification process natural to lakes.

Total Dissolved Gas

The data illustrated in Figure 10 show that total dissolved gas (TDG) levels below Anderson Ranch Reservoir at the Hydromet station ANDI are below 100 percent saturation. However, levels steadily increase in the downstream direction, reaching a peak of 106 percent at the Cow Creek boat ramp, where they remain stable at 106 percent to the Danskin boat ramp. This longitudinal increase in TDG in the downstream direction is most likely attributable to a corresponding increase in water temperature. The water released from the Anderson Ranch Dam is cool, at 5° C, but rapidly increases in temperature as it moves downstream.

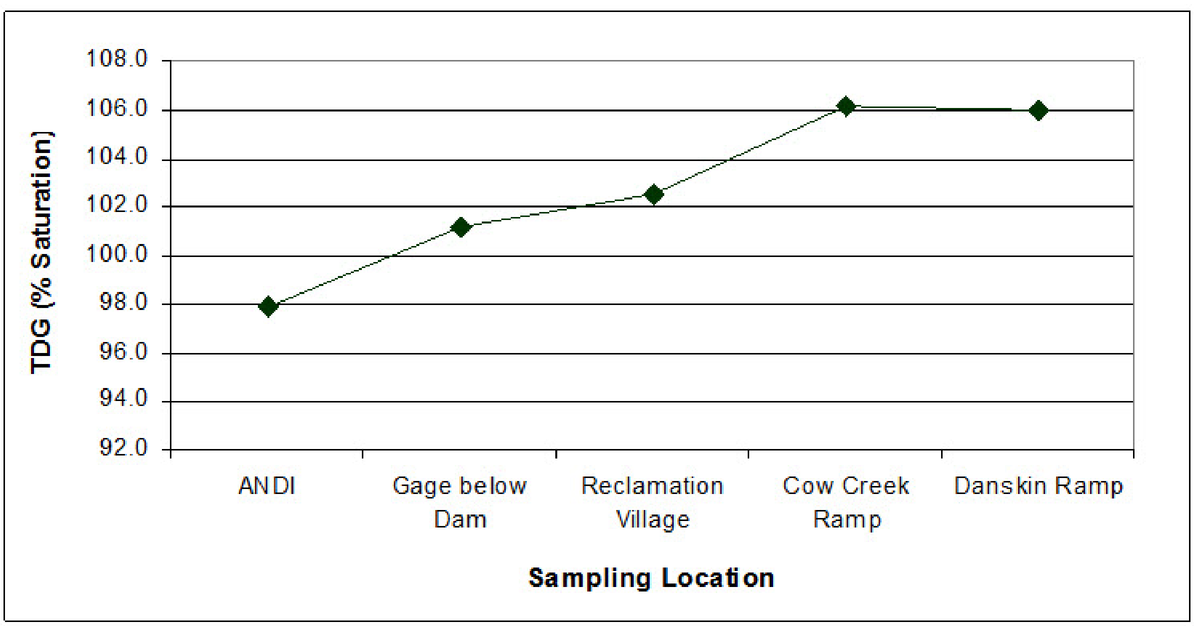

Figure 10. Total dissolved gas levels below Anderson Ranch Reservoir.

Results from the May 21, 2007, TDG monitoring efforts in the South Fork Boise River as part of the plant outage for balanced/unbalanced gate tests and inspections at Anderson Ranch Dam show that the water quality standard of less than 110 percent saturation was not exceeded. Measurements were collected in the stilling basin, where levels are expected to be highest, and at several locations below the dam.

Arrowrock Reservoir Water Quality Conditions

Temperatures

Reclamation has also collected temperature profiles in Arrowrock Reservoir periodically over the past 16 years. These profiles have been collected at various times throughout the years and at up to four different reservoir locations. Because of variability between depth at some of the locations, profile data exhibits some depth variability not normally seen in single station profiles. Some of this variability is associated with different oxygen depletions at depths in shallow locations as well as different heating regimes within a month. Some smoothing of the profiles was accomplished by rounding depth to the nearest meter integer or half value.

These monthly average temperature profiles indicate the annual progression of stratification and thermocline breakdown. Several profiles were collected during late winter; however, lakes and reservoirs are typically inversely stratified with colder water next to the ice and slightly warmer more dense water near the bottom of the reservoir. This was not the case in Arrowrock Reservoir which indicates a lack of ice cover during the profile collection.

January through April profiles indicate that the reservoir is isothermal with temperatures between 2 and 7° C (Figure 11). Warming of the epilimnion begins in May building a weak stratification; however, the epilimnion is not well defined, with a nearly linear temperature transition through the thermocline to the hypolimnion. This weak stratification remains in place through July, when a shallow, weakly developed epilimnion develops. This is probably the result of colder water from the watershed mixing with the epilimnion, delaying the development of a well-defined surface layer. The thermocline is also shallow, leading to a warmer hypolimnion than that seen in Anderson Ranch Reservoir. Average epilimnion depth in July and August is approximately 4 to 5 meters. The temperature difference between the surface waters and bottom waters increased to 12° C by July with maximum epilimnetic temperatures reaching 21+° C while the temperatures near the bottom of the reservoir remain relatively constant between 6 and 8° C. The average epilimnetic temperature during the summer was 21.18° C, which is above bull trout temperature tolerances. In August through September, the reservoir begins to cool and the thermocline begins to erode, transitioning to an isothermal state rather quickly (Figure 12). The isothermal reservoir quickly cools and is again near maximum density (4° C) by December. Ice formation would require significant cooling with calm cold nights. Due to the operation of the reservoir, it is highly likely that the reservoir would only weakly stratify in most years. It appears that during the critical summer months, the epilimnion and thermocline will warm above bull trout temperature tolerances, while temperatures below 40 to 50 meters remain below 10° C.

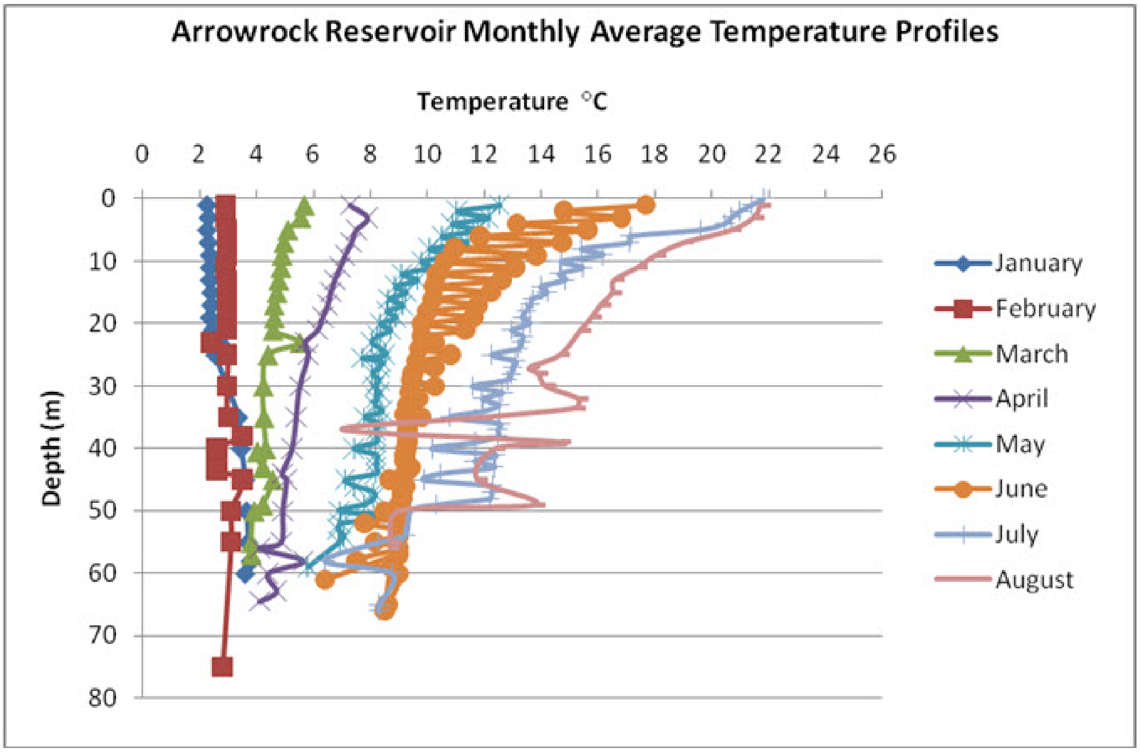

Figure 11. Monthly average temperature profiles of Arrowrock Reservoir, January through August.

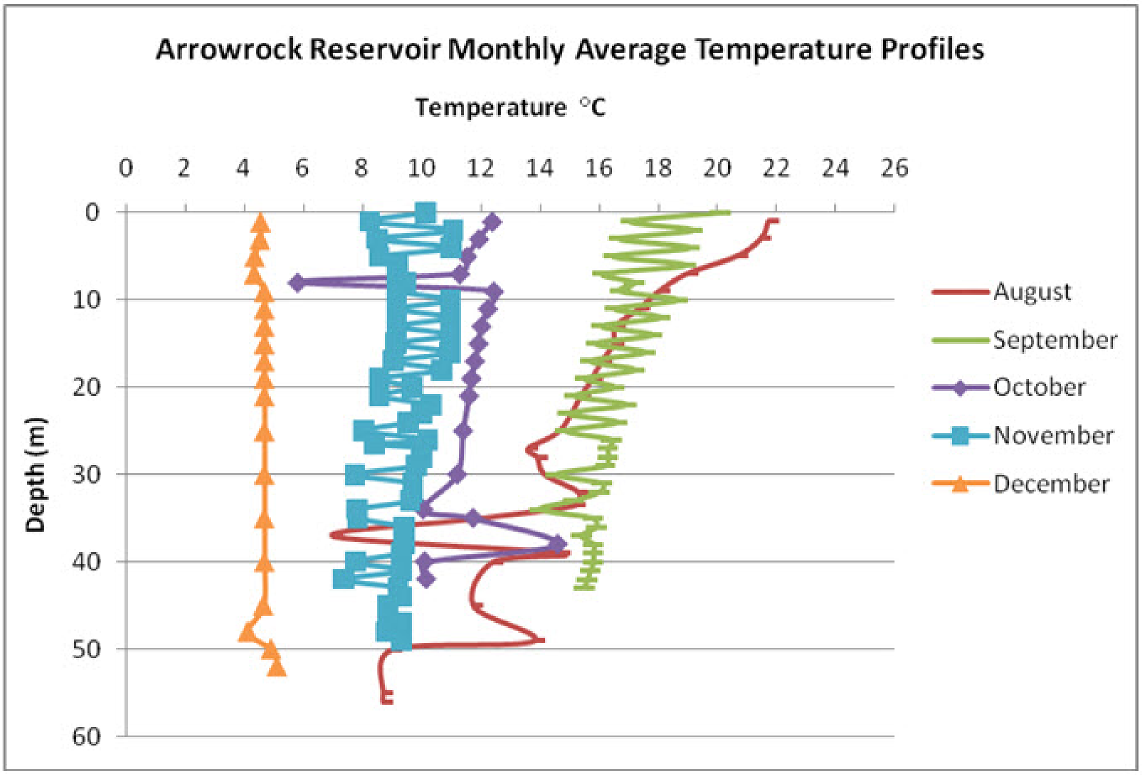

Figure 12. Monthly average temperature profiles of Arrowrock Reservoir, August through December.

Dissolved Oxygen

Dissolved oxygen profiles were also collected along with the temperature profiles and similar situations were observed. Throughout the year, dissolved oxygen levels were suitable for bull trout through the top portion of the water column (Figure 13). Oxygen depletion became evident only after the reservoir began to weakly stratify and cool following the summer months, supporting the idea that Arrowrock Reservoir only weakly stratifies as dissolved oxygen is well saturated throughout the water column. Due to the various locations monitored with variable depths, the average dissolved oxygen profiles were more erratic than expected, but were indicative of some sediment oxygen demand near the sediment water interface. Oxygen depletion was noted below the thermocline and oxygen was depleted below 7 mg/L beginning in August at 5 meters though September below 8 meters (Figure 14). This eliminates any thermal and oxygen refugia in the reservoir during August and September. Oxygen depletion reaches its maximum extent in September with the hypolimnion dissolved oxygen depleted to 3.4 mg/L near the bottom (Figure 14). Total phosphorus liberation due to anoxic conditions may be limited in most years, and as a result Arrowrock Reservoir likely acts as a nutrient sink for the remainder of the Boise River system.

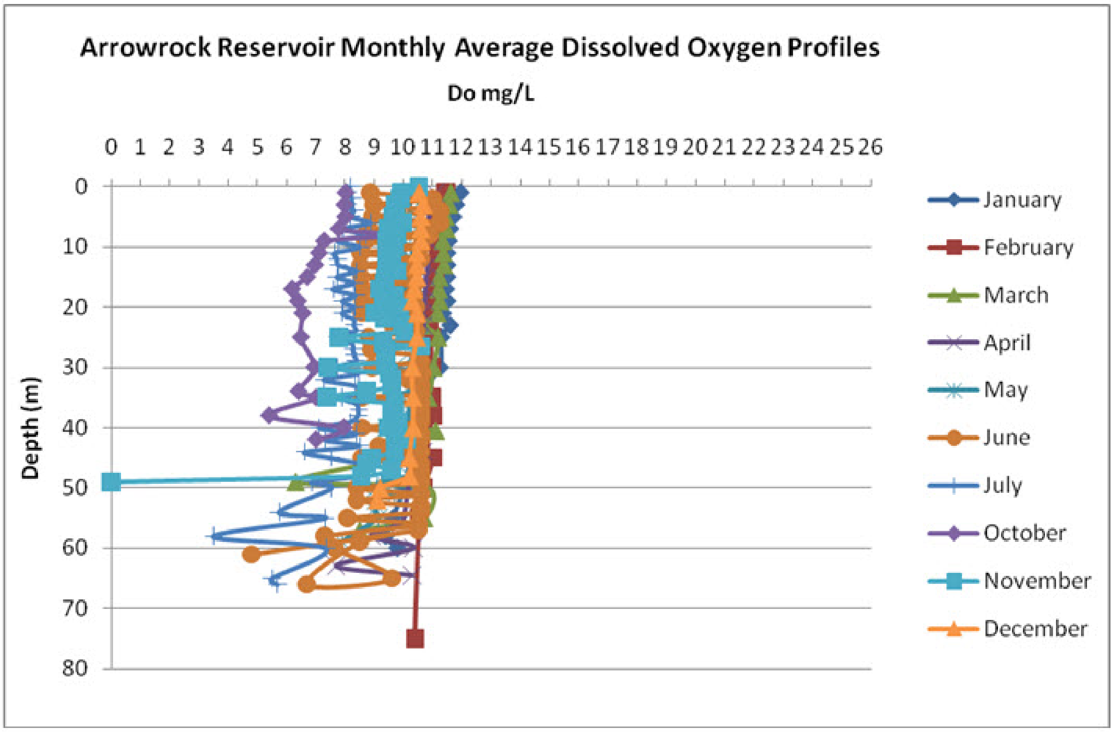

Figure 13. Monthly average dissolved oxygen profiles in Arrowrock Reservoir, year-round except for August and September.

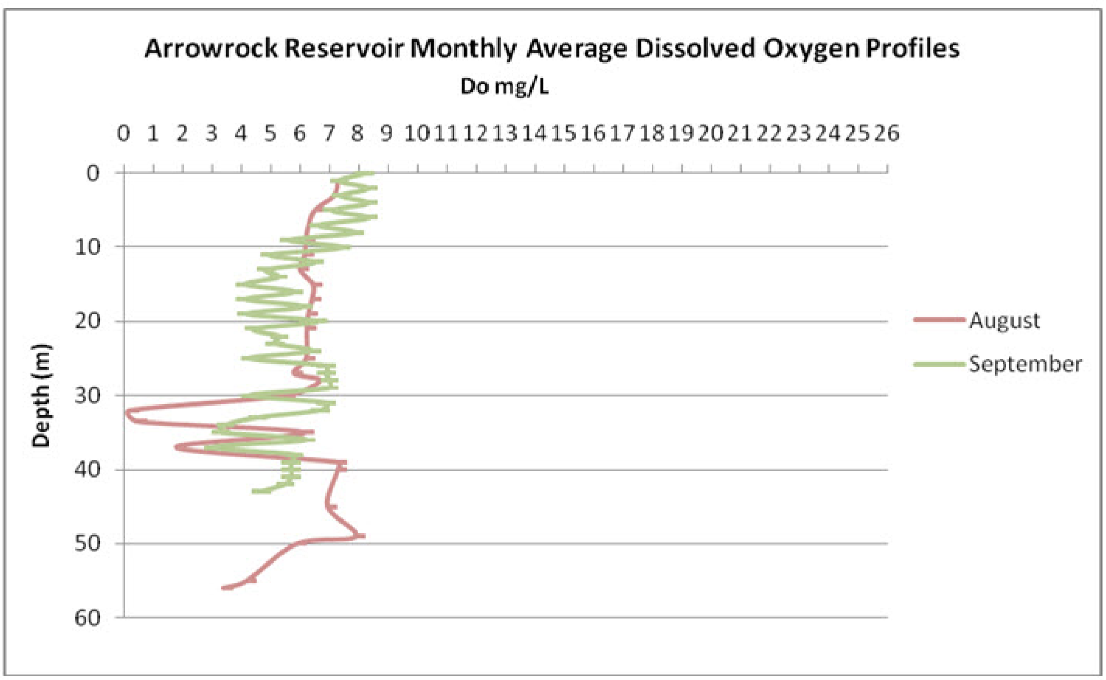

Figure 14. Monthly average dissolved oxygen profiles in Arrowrock Reservoir, August and September.

Sediment/Turbidity

Reclamation has periodically collected sediment/turbidity samples from Arrowrock Reservoir. The TSS levels showed a significant seasonal variation in the set of samples. Mean concentration for TSS during the period of record in the reservoir was 19.01 mg/L and the range was from less than 1 to 329 mg/L (Figure 15). Large amounts of suspended solids were mobilized in September, with mean TSS concentration near 80 mg/L. This may indicate a sediment turbidity plume associated with reservoir drawdown when reservoir volumes are typically near their lowest levels.

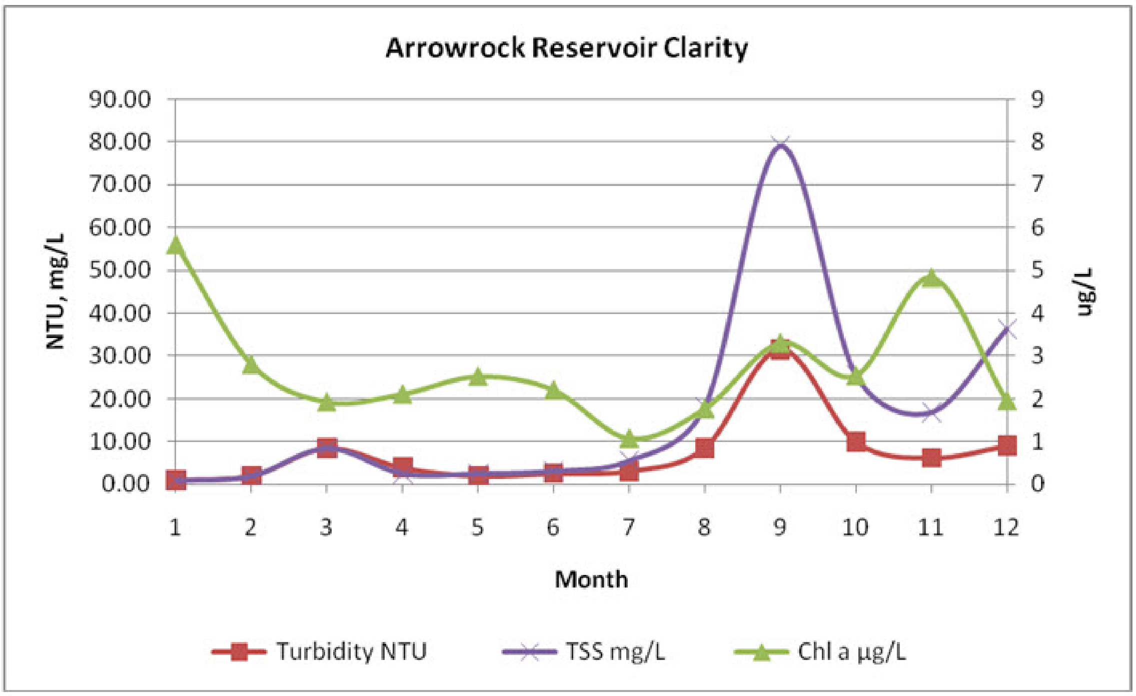

Figure 15. Water clarity values for Arrowrock Reservoir.

Reclamation also measured turbidity and Secchi depths of the reservoir waters to measure water clarity. Turbidity values were moderate, with a mean reservoir turbidity of 8.31 NTU, indicating clear water, but the values varied with season. Mean turbidity outside of September was 5.13 NTU. Coupled with the clarity measures, chlorophyll a and TSS samples give an indication that the clarity issues in Arrowrock Reservoir are sediment induced rather than biological in origin such as algae blooms. Sediment-induced clarity issues can be seasonal in nature, but are normally associated with the ascending limb of hydrographs rather than the reservoir drawdown seen in September. High sediment and turbidity issues may impact sight foraging and can indicate that gill abrasions or other secondary or delayed mortality issues associated with high TSS or turbidity could occur.

Other Water Chemistry

The levels of the measured constituents in Arrowrock Reservoir are low to moderate. These levels in most all cases indicate a balanced loading and good water quality. The average TP concentrations from the surface waters (less than 5 meters) were 0.013 mg/L; at depth (greater than 10 meters), TP concentrations averaged 0.024 mg/L (Figure 19). Only a few TKN samples were collected (n=12), so the interpretation of the TN:TP ratio is limited. The nutrient ratio was generally low, indicating nitrogen limitation (less than 10) with the exception of June 2011 where TN:TP skewed to excessive nitrogen (57). The average TN:TP ratio for all sample locations was 13.46; the ratio was greater than 15 in only 3 of 12 samples. Biologically this indicates that blue green algae and other unpalatable forms of nitrogen-fixing algae could begin to dominate the reservoir as nitrogen is limiting. This can be clearly seen with the small addition of TP in August causing a large change in TN:TP ratio. In addition, the types of algae that are often associated with TN:TP ratios such as these may not be suitable forage for zooplankton and other aquatic invertebrates (Figure 16).

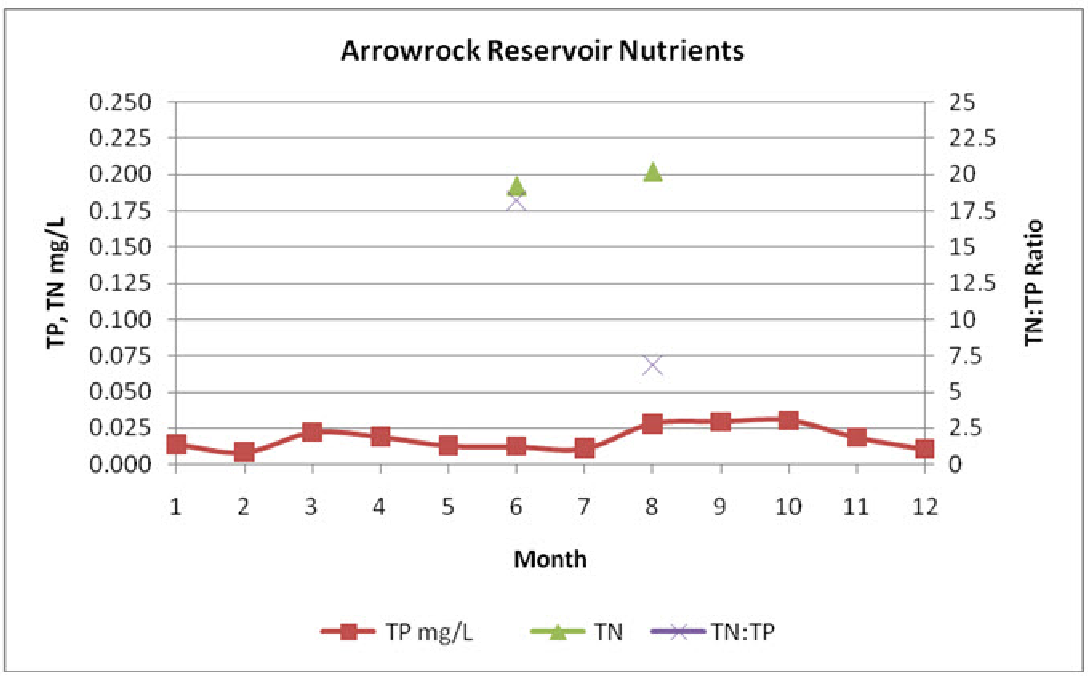

Figure 16. Nutrient levels in Arrowrock Reservoir.

The average TSI value calculated for Arrowrock Reservoir was 41.73. This measure of eutrophication is below the mesotrophic break point of 50, indicating the reservoir is oligotrophic. In general, this means that the nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir. In addition, the Carlson's TSI can be broken into its individual components in order to determine mechanisms of impairment.

The individual components of Carlson's TSI can be used to determine if nutrients are in excess and determine the source of clarity issues. In Arrowrock Reservoir, the average TSI for the individual components were 42.16 for TP, 30.48 for TN, 37.68 for chlorophyll a, and 47.22 for Secchi depth (Figure 17). Based on these numbers Arrowrock Reservoir exhibits very low TN numbers, indicating a possibility of nitrogen-fixing algae blooms, while Secchi TSI shows large decreases in clarity as the reservoir is drawn down coupled with slight increases in TP TSI. These indicate that sediment-derived nutrient and clarity issues occur that have not yet translated into primary production. Summertime, epilimnetic TP averaged 0.016 mg/L, or TSI of 44.13. As the thermocline eroded and nutrients were mixed from the hypolimnion during fall drawdown, the concentrations increased. In September through December, TP increased to a mean of 0.026 mg/L (TSI 51.13). These processes are expected to occur annually in Arrowrock Reservoir as a result of the water storage requirements of the impoundment.

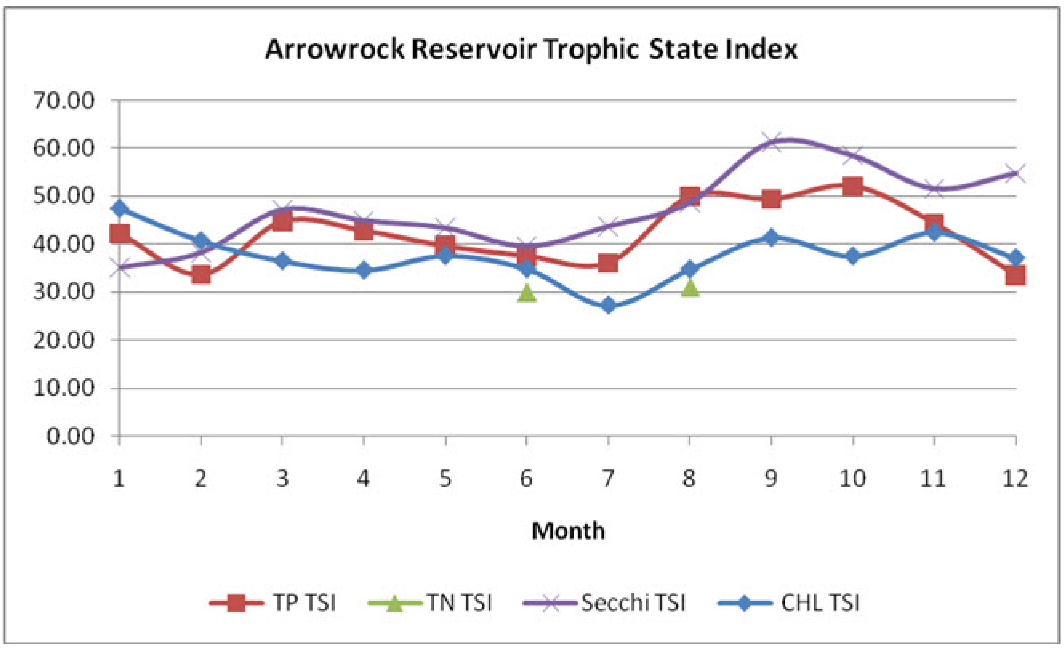

Figure 17. Trophic State Index of Arrowrock Reservoir.

Total Dissolved Gas - Arrowrock Reservoir

Reclamation has not collected TDG samples above Arrowrock Reservoir. It is unknown if TDG is elevated coming into the reservoir. Given the distance and the low TDG coming out of Anderson Ranch Reservoir, it is unlikely that TDG is elevated in the South Fork Boise River.

Boise River Water Quality Conditions

Temperature

Continuous temperature data has been collected periodically at several sites in the Boise River watershed since 1962, with the most recent efforts taking place at the Neal Bridge in 2011. Generally, the temperature data set runs through 1979 except at the Neal Bridge location. This historic temperature data illustrates the annual progression of the various rivers warming and cooling. Anderson Ranch Reservoir acts to modify the annual temperature regime of the South Fork Boise River (South Fork).

Following ice-off, the reservoir is isothermal until a weak stratification begins to develop, with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. These constant temperatures are delivered to the South Fork Boise River. Typically, stream temperatures in the river fluctuate between 4° C and 6° C from January through early June. By early June, the reservoir is usually stratified and additional heat is stored in the epilimnion.

As the stratification breaks down and the reservoir begins to mix, the temperature in the river slowly begins to increase until early September when it reaches its average maximum temperature of 13° C. The average river maximum temperature does not exceed bull trout temperature tolerances; however, near the middle to end of August through the middle of November, the river warms above the IDEQ bull trout temperature standard of 10° C (Figure 18).

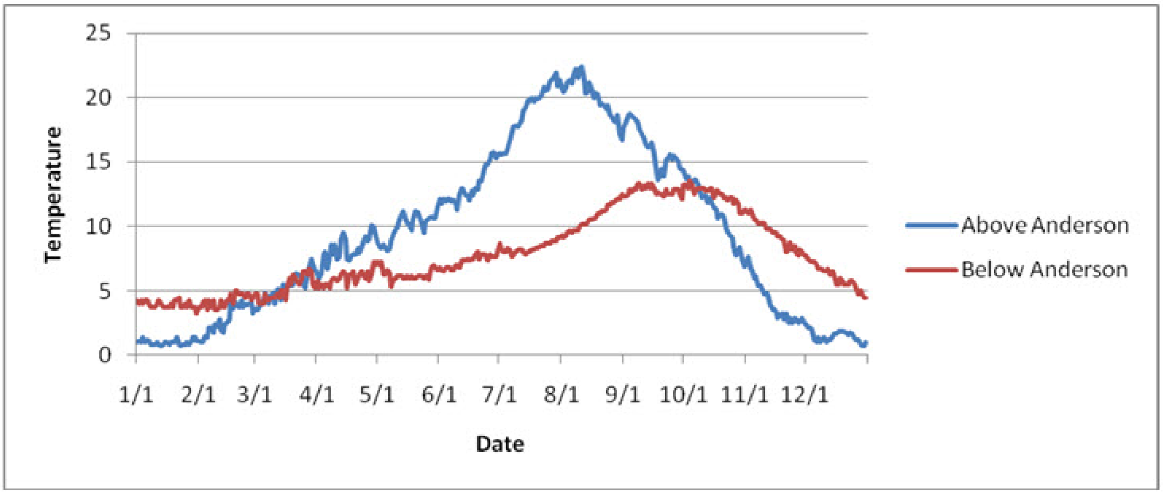

Figure 18. Daily maximum temperatures of the South Fork Boise River above and below Anderson Ranch Dam.

The river above Anderson Ranch Reservoir surpassed bull trout tolerances of 15° C near the end of June and remained above these levels through the end of September. The upstream river warms above water quality criteria from May through October.

The effect of the cool isolated hypolimnion in Anderson Ranch Reservoir are best illustrated by the daily temperature variation, the difference between daily maximum and daily minimum as measured upstream and downstream of the reservoir (Figure 19). Anderson Ranch Reservoir and the effects on the downstream temperature regime clearly modulate the daily temperature variations experienced by the aquatic biota of the South Fork in the vicinity of the dam. This effect appears to be translated downstream to Neal Bridge, but is dependent on shade and groundwater mediating the impacts from solar loading.

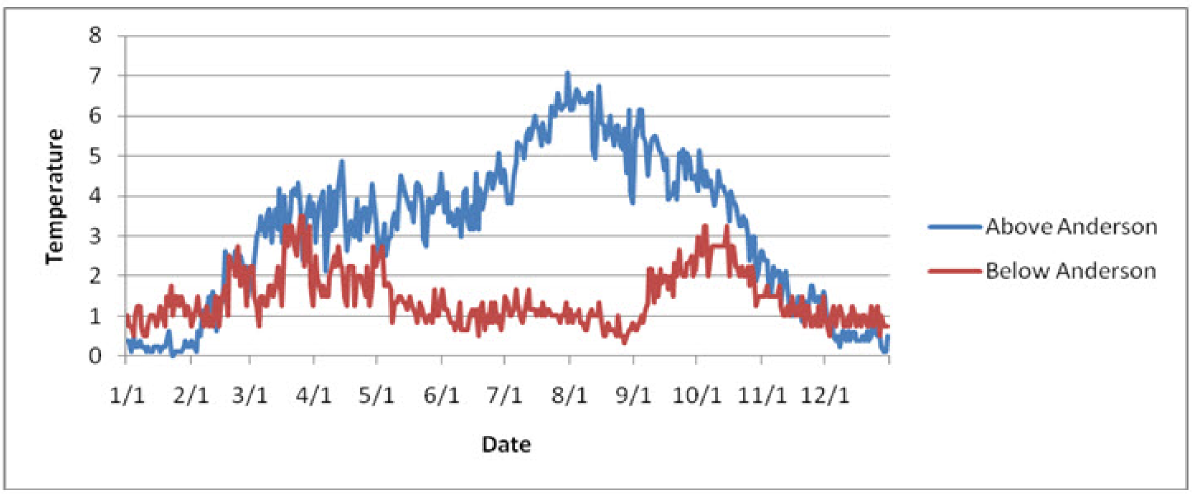

Figure 19. Daily variation of temperatures of the South Fork Boise River above and below Anderson Ranch Dam.

The period of record for continuous temperature data collected periodically near the backwaters of Arrowrock Reservoir in the South Fork Boise River at Neal Bridge begins in May 1977 and goes through September 1979. Temperature recording was resumed in May 2011 through October 2011. This temperature data illustrates the annual progression of river warming and cooling (Figure 19). The effects of Anderson Ranch Reservoir can be seen at this location and how the reservoir acts to modify the annual temperature regime of the South Fork. Cooler summertime water and warmer fall and wintertime water is delivered to the river from the reservoir. Typically, stream temperatures in the river fluctuate between 4 and 6° C from January through early March (Figure 20 and Figure 21). By early June, the reservoir discharge keeps the river cool, below 15° C until late August. The maximum temperatures are reached in early September and peak near 16° C. In comparison, the Middle Fork Boise River (Middle Fork), which has no upstream impoundment, exceeds 15° C by the end of June and reaches maximum temperatures of over 21° C near the end of July. Wintertime temperatures in the Middle Fork are usually between 1° C to 3° C through February.

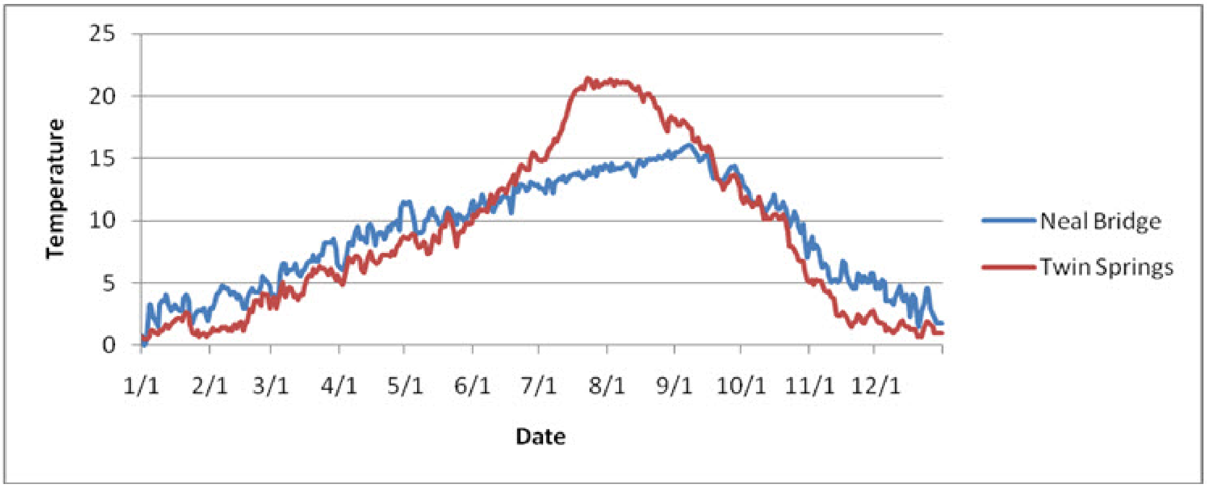

Figure 20. Daily maximum temperatures of the South Fork Boise River at Neal Bridge and the Middle Fork Boise River at Twin Springs.

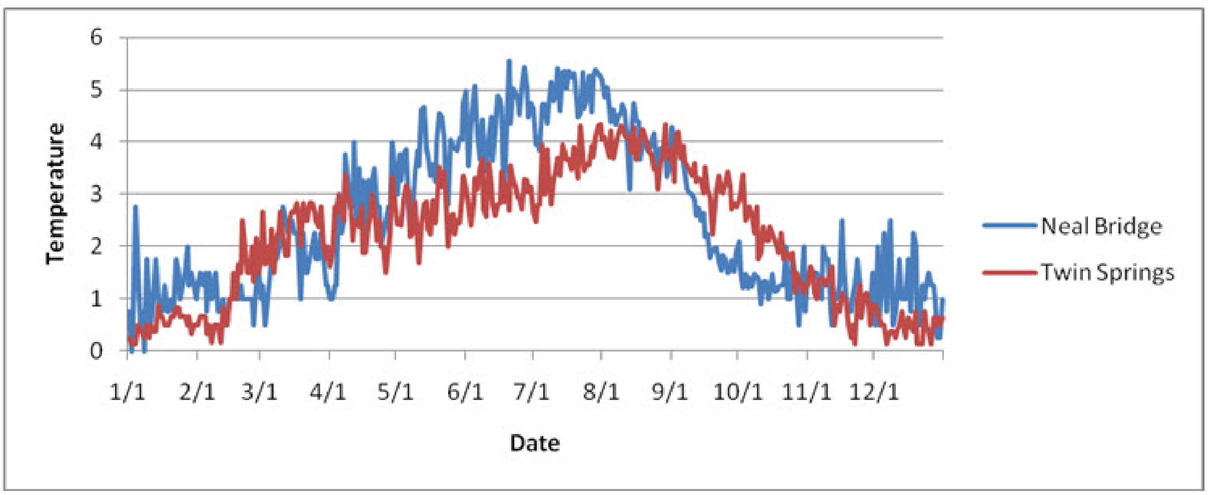

Figure 21. Daily variations in temperatures of the South Fork Boise River at Neal Bridge and the Middle Fork Boise River at Twin Springs.

Dissolved Oxygen

Dissolved oxygen data in the Boise River basin are sparse. Reclamation collected some dissolved oxygen measurements during the Regional Reservoir Monitoring Program. Dissolved oxygen levels were suitable for bull trout during all sampling events, even when oxygen depletion became evident in the upstream reservoir. Dissolved oxygen concentrations did not fall below 7 mg/L (Figure 22 and Figure 23). Riverine mixing processes should keep the dissolved oxygen levels in the South Fork and Middle Fork at or near saturation levels throughout the length of the river.

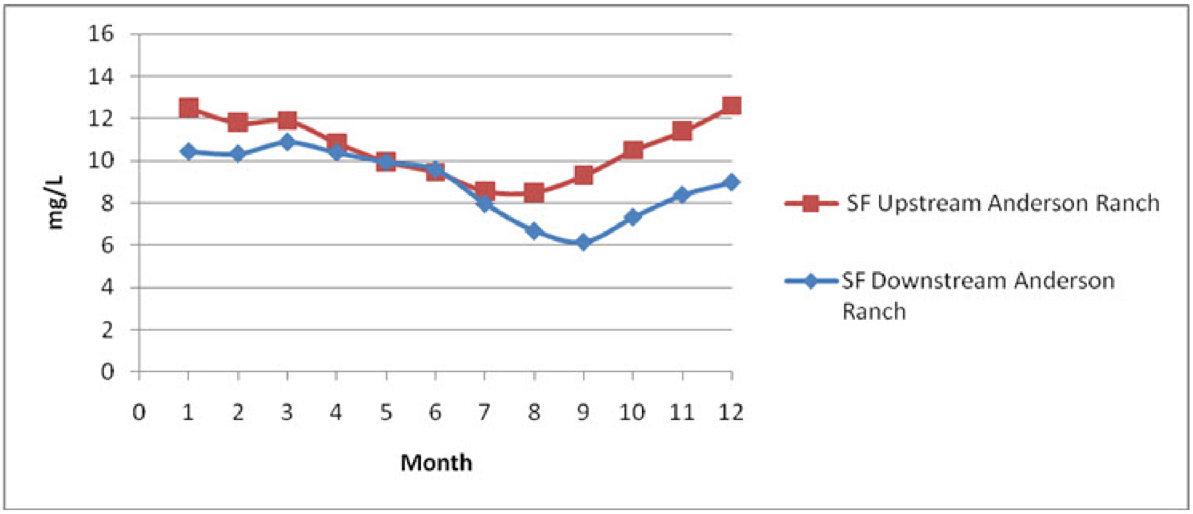

Figure 22. Dissolved oxygen levels in the South Fork Boise River upstream and downstream of Anderson Ranch Dam.

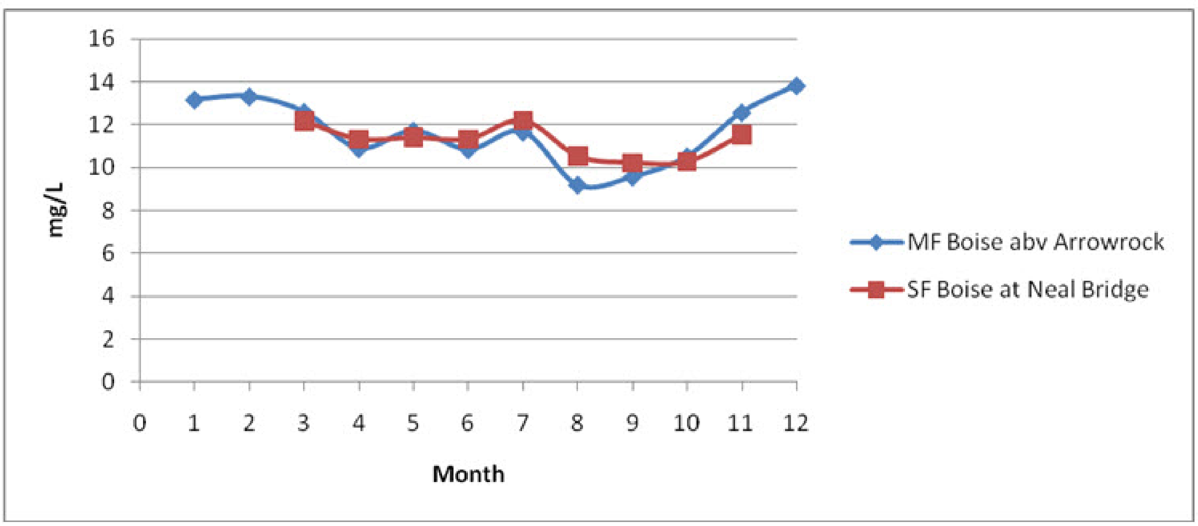

Figure 23. Dissolved oxygen levels in the Middle Fork Boise River upstream of Arrowrock Dam and the South Fork Boise River at Neal Bridge.

Sediment/Turbidity

Reclamation has collected sediment/turbidity samples in the Boise River system intermittently. Reclamation measured turbidity at several locations in the South Fork and occasionally in the Middle Fork. Both TSS and turbidity are an indication of water clarity and sediment load. Turbidity values in the South Fork were very low, 1 to 11 NTU, indicating very clear water (Figure 24 and Figure 25). The turbidity samples give an indication that the sediment load from Anderson Ranch Reservoir into the South Fork is very low. Sediment loading can be episodic in nature with variable frequency, but usually associated with high flows and the ascending limb of the annual hydrograph as seen in the turbidity samples collected from the Middle Fork. Sediment and turbidity appear limited in the South Fork, with the reservoir capturing and retaining a majority of the sediment from the upstream watershed.

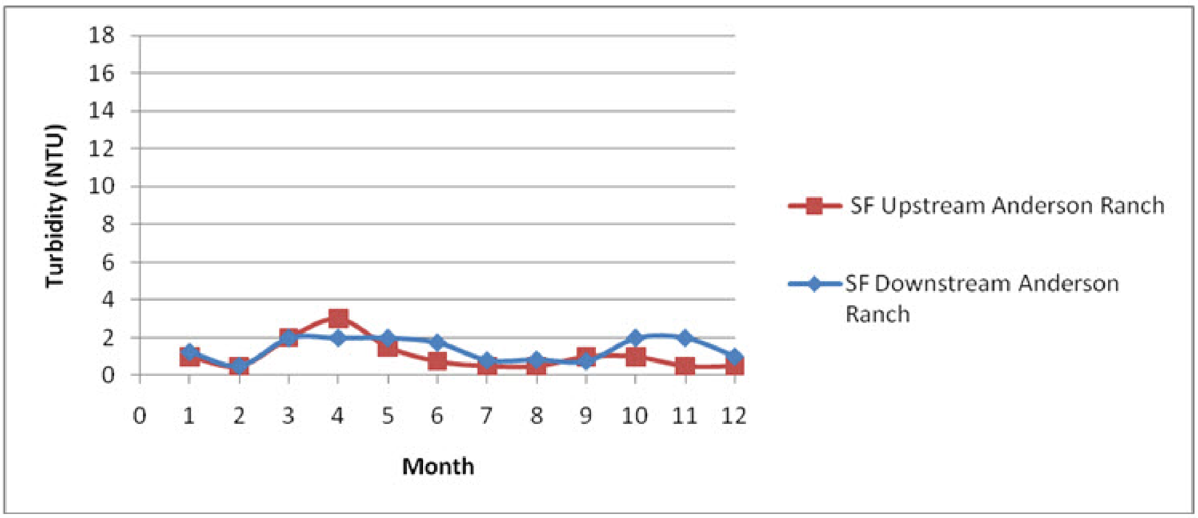

Figure 24. Turbidity levels in the South Fork Boise River upstream and downstream of Anderson Ranch Dam.

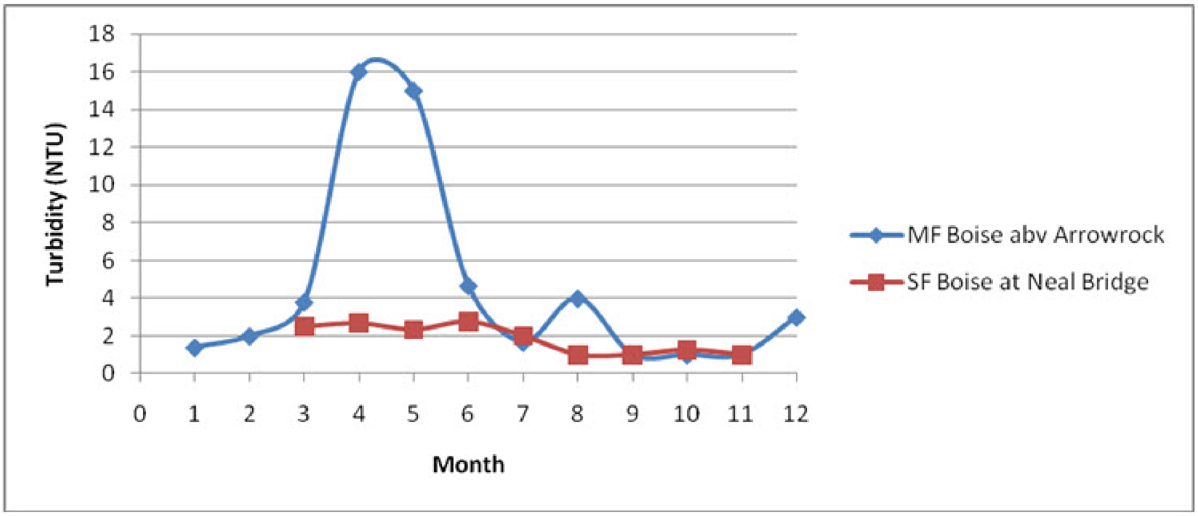

Figure 25. Turbidity levels in the Middle Fork Boise River upstream of Arrowrock Dam and the South Fork Boise River at Neal Bridge.

Other Water Chemistry

Nutrient retention in oligotrophic reservoirs is common. At depth, the nutrient cycling in a reservoir liberates nutrients generally only under anoxic conditions. Anoxic conditions occur in the fall in Anderson Ranch Reservoir (Figure 3 and Figure 4). Under well oxygenated situations, reservoirs can act like nutrient traps, retaining most of the nutrients which often leads to strong nutrient limitation in the rivers below lakes and reservoirs.

Levels of the measured constituents in South Fork upstream and downstream from Anderson Ranch Reservoir were very low and in most cases, indicated lower loading and less degradation of water quality compared to nearby rivers. The average TP concentrations discharged to the reservoir was 0.012 mg/L, as compared to the annual average concentration of 0.019 mg/L downstream from the reservoir. Both these values are very near background conditions (0.017 mg/l) for lakes and reservoirs and expected in the intermountain xeric west (EPA 2001).

Levels of the measured constituents in the South Fork near Neal Bridge and in the Middle Fork indicate increased nutrient loading, with some very strong seasonality associated with runoff and high water events. The average TP concentrations in the South Fork at this lower location remained consistent with concentrations delivered from Anderson Ranch Reservoir (0.019 mg/L) (Figure 26 and Figure 27). In comparison, the Middle Fork annual average concentration was 0.027 mg/L, with concentrations averaging 0.063 mg/L in April and May. Consequently, it appears that the Anderson Ranch Reservoir and the South Fork may be at or near background levels, acting as a nutrient sink, while the Middle Fork may act as the nutrient source for Arrowrock Reservoir.

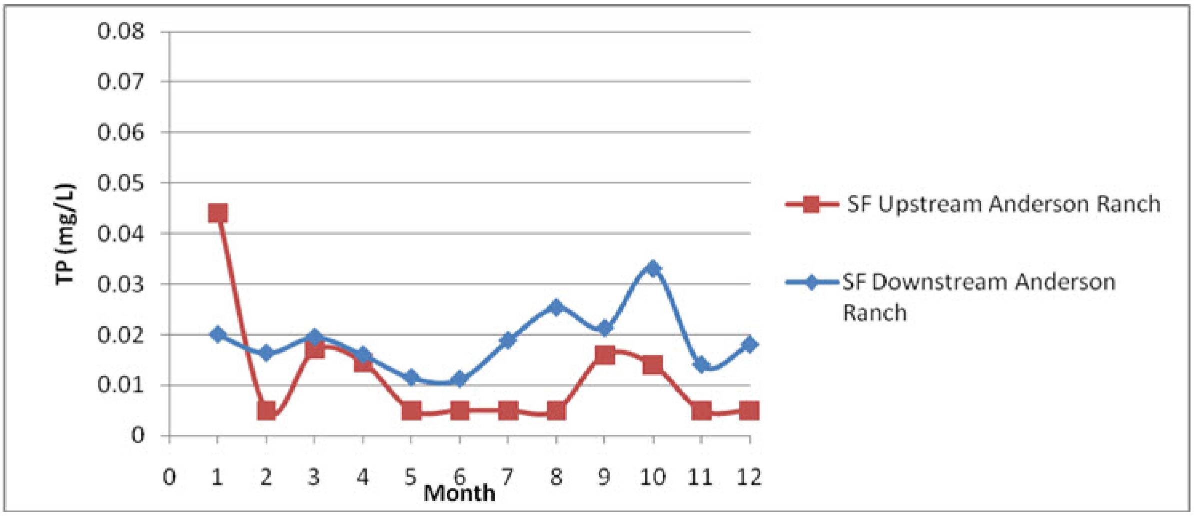

Figure 26. Total phosphorus levels in the South Fork Boise River upstream and downstream of Anderson Ranch Dam.

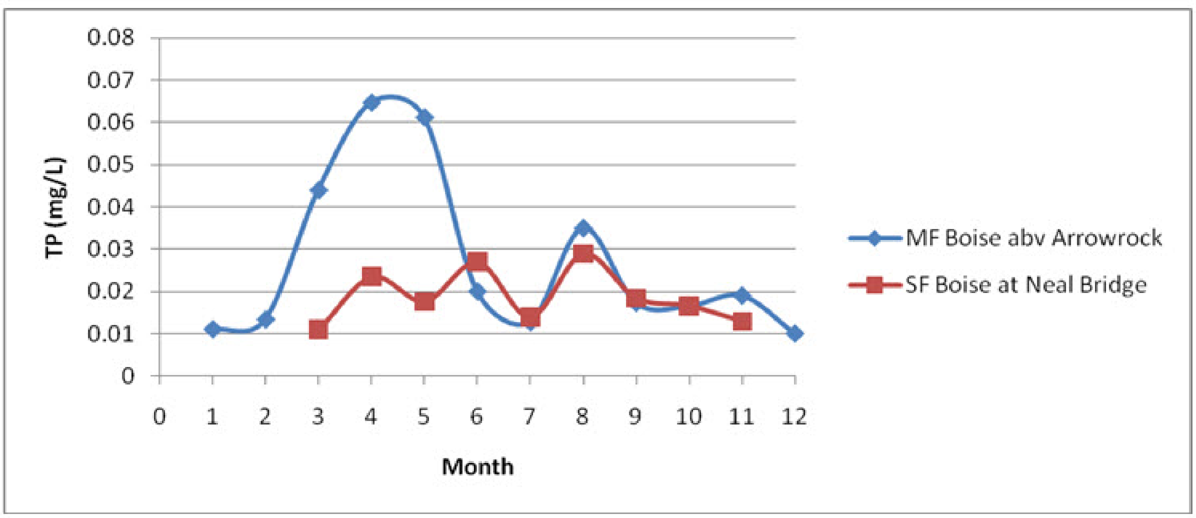

Figure 27. Total phosphorus levels in the Middle Fork Boise River upstream of Arrowrock Dam and the South Fork Boise River at Neal Bridge.

DEADWOOD RIVER SYSTEM

Deadwood Reservoir Water Quality Conditions

Temperature

Reclamation collected temperature profiles periodically over the past 15 years at various times throughout the years and at up to 13 reservoir locations. In addition, intensive temperature and dissolved oxygen profiles were collected for Reclamation's Deadwood Reservoir bull trout investigations. These temperature profiles indicate the annual progression of stratification and thermocline breakdown (Figure 33 and Figure 34).

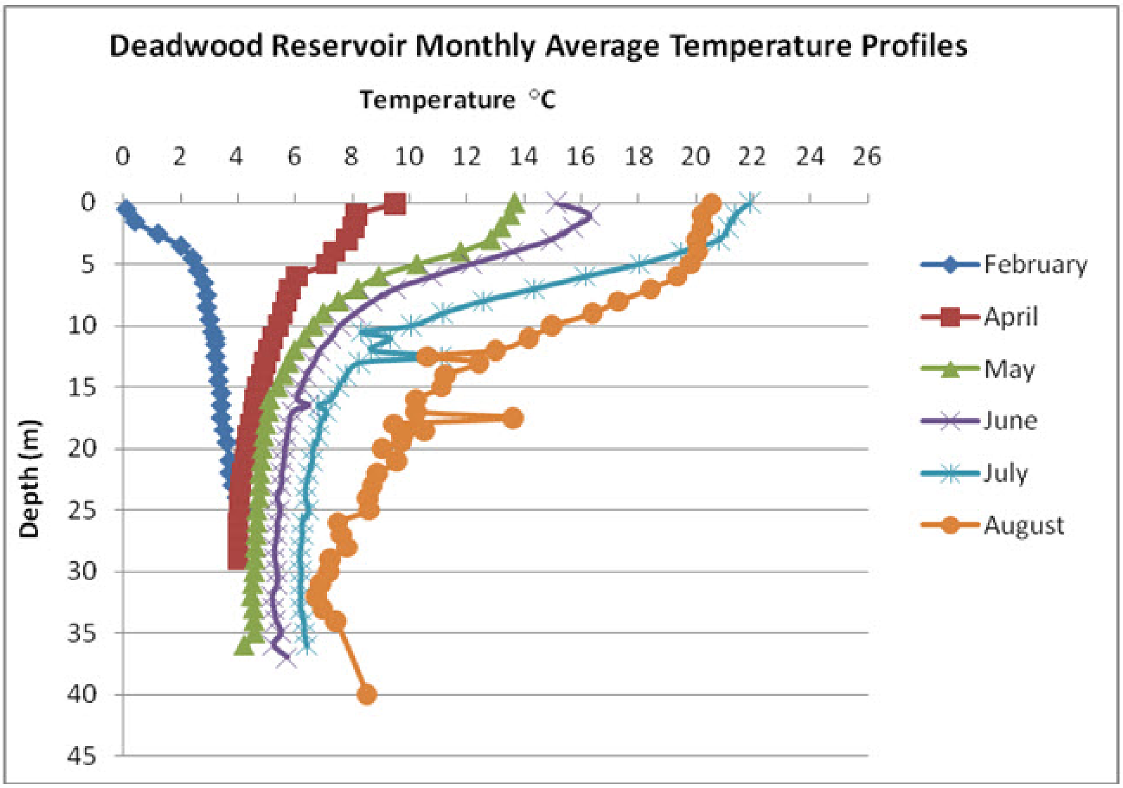

Figure 28. Monthly average temperature profiles for Deadwood Reservoir, February through August.

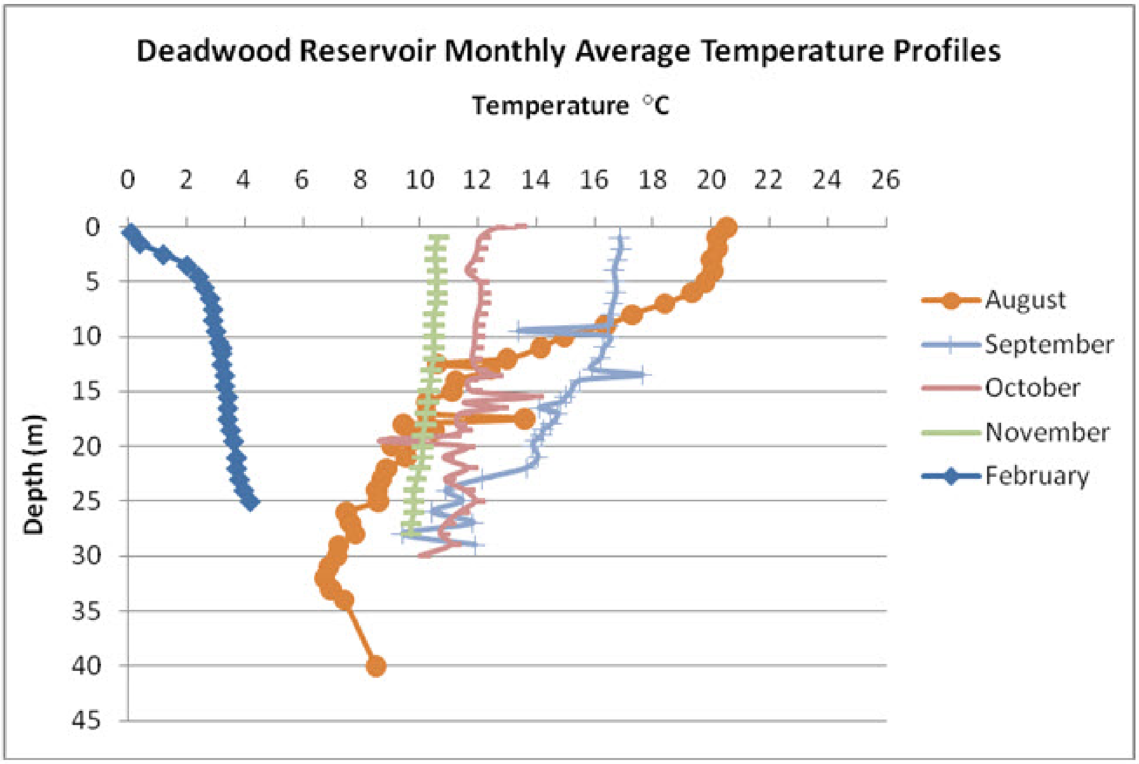

Figure 29. Monthly average temperature profile in Deadwood Reservoir, August through February.

During the ice-covered period, the reservoir is inversely stratified with colder water next to the ice and slightly warmer, more dense water near the bottom of the reservoir. Following ice-off, the reservoir is isothermal until a weak stratification begins to develop in April, with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. By May, the reservoir is usually stratified. Average epilimnion depth at this time is 5 meters. The temperature difference between the surface waters and bottom waters increased to 15° C by July with maximum epilimnetic temperatures reaching 21+° C while the temperatures near the bottom of the reservoir remain relatively constant between 6 and 7° C. The average epilimnetic temperature during the summer was 19.74° C which is above bull trout temperature tolerances. During this time, the epilimnion remained between 5 and 6 meters deep. In August through October, the reservoir begins to cool and the thermocline begins to erode until the reservoir is again isothermal. Due to the morphology of the reservoir, it is highly likely that the reservoir would stratify in most years. It appears that during the critical summer months, the epilimnion warms above bull trout temperature tolerances, while average temperatures below 6 meters remain below 10° C.

Dissolved Oxygen

Dissolved oxygen profiles were also collected along with the temperature profiles and similar situations were observed (Figure 35). Throughout the year, dissolved oxygen levels were suitable for bull trout through the top portion of the water column. Some oxygen depletion became evident as the year progressed and under ice covered conditions, likely due to the hypolimnion of reservoir becoming isolated from the atmosphere by stratification or ice cover. This coupled with bacterial respiration and sediment, oxygen demand in the hypolimnion removed dissolved oxygen. Oxygen depletion was noted below the thermocline and oxygen was depleted below 7 mg/L at 15 to 16 meters in February, July, and August. This leaves a thermal and oxygen refugia in the reservoir during the summer critical period between 6 and 16 meters. Oxygen depletion reached its maximum extent in September and October with the hypolimnion dissolved oxygen depleted to near anoxic conditions near the bottom.

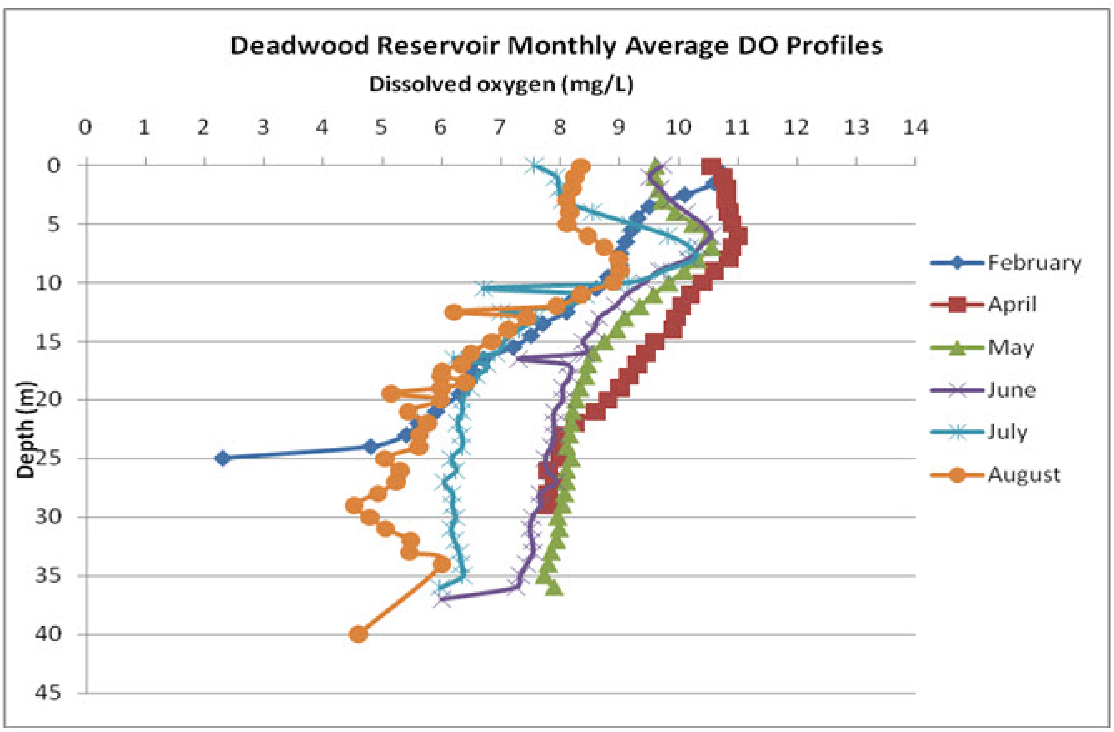

Figure 30. Monthly average dissolved oxygen profiles for Deadwood Reservoir, February through August.

September may be the hardest period of time for bull trout in the reservoir when the surface waters have cooled substantially, but remain above 16° C (Figure 36 and Figure 37). The reservoir transitions to an isothermal state at this time as well. As a result, water temperature remains above 15 ºC to approximately 16 meters in depth. In September, the available area of the reservoir above 7 mg/L dissolved oxygen extends from 12 meters to the surface while temperature and oxygen values are close to tolerance levels. This situation may force bull trout to use vertical movements to thermoregulate and minimize oxygen stress if they remain in the reservoir during this period.

Based upon the chlorophyll a concentrations and the limited oxygen depletion, it is likely that nutrients may limit primary and secondary production in the reservoir.

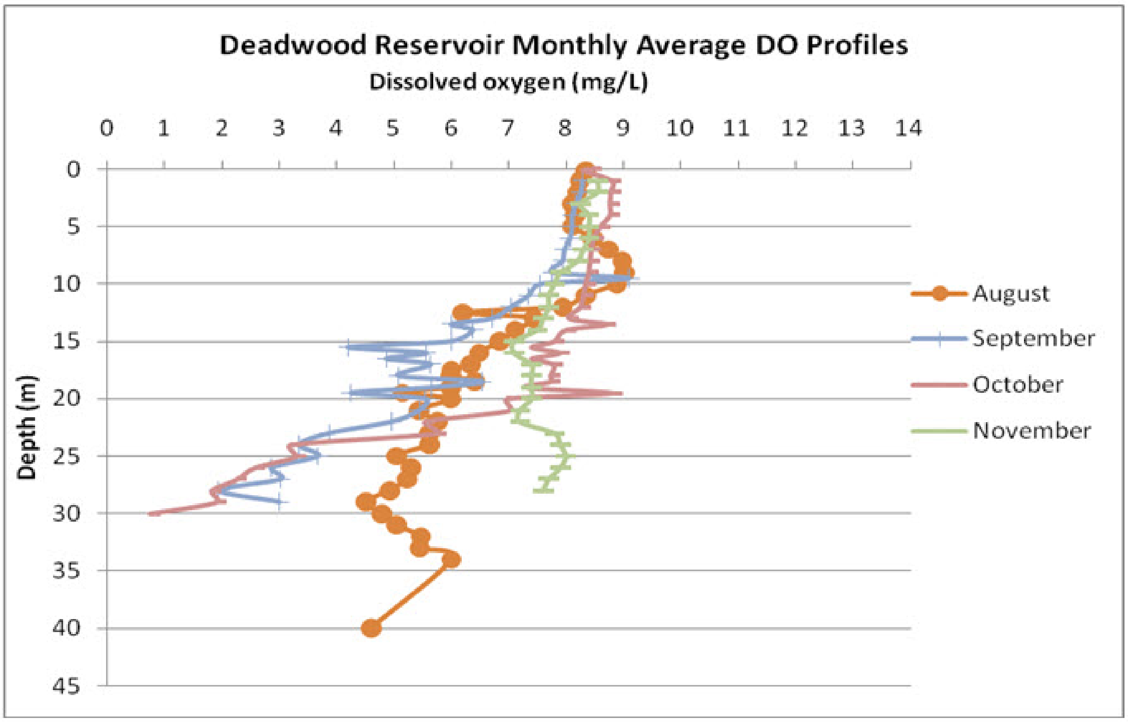

Figure 31. Monthly average dissolved oxygen profiles for Deadwood Reservoir, August through November.

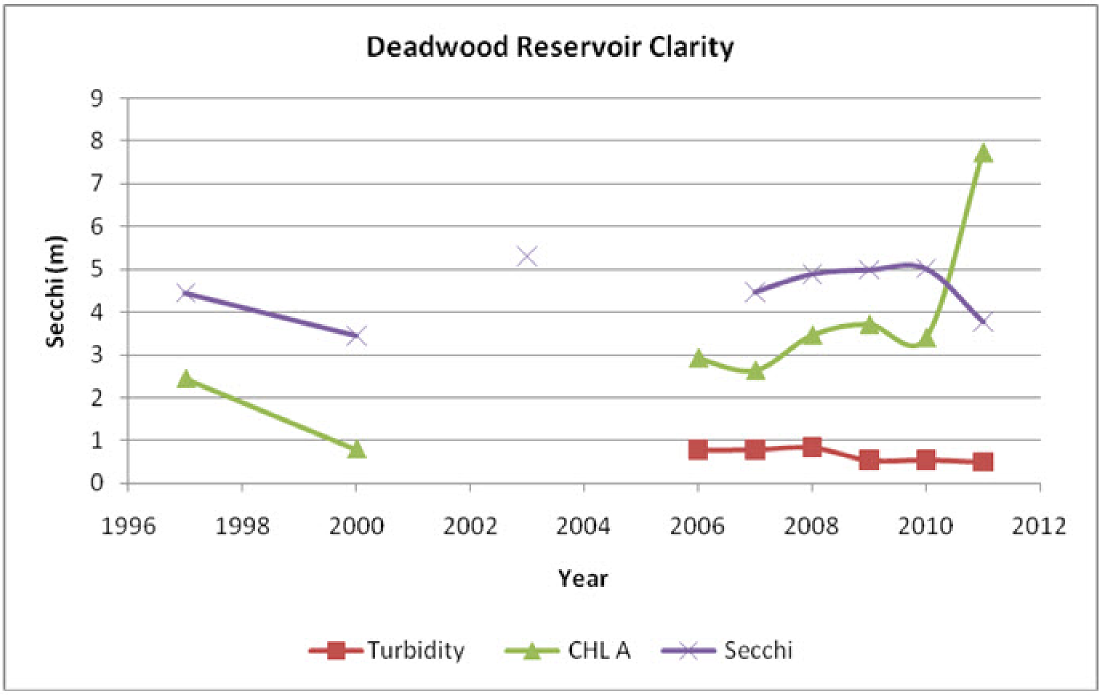

Figure 32. Yearly water clarity for Deadwood Reservoir.

Total Dissolved Gas

Reclamation collected total dissolved gas samples downstream from Deadwood Reservoir once in each year in 1997, 2003, and 2009 as part of the Regional Reservoir Monitoring Program. The samples ranged from 102 to 105 percent total dissolved gas which may indicate that the discharge from Deadwood Dam does not generate total dissolved gas at or above state water quality standards during summer operations. Since the number of samples is very low, little can be said about total dissolved gas generation below Deadwood Dam.

Sediment/Turbidity

Reclamation has periodically collected sediment/turbidity samples from Deadwood Reservoir and 7 samples from below the reservoir in the Deadwood River. TSS levels were very low in the set of samples from the reservoir, with a mean concentration of 1.16 mg/L for the period of record. From below the reservoir, the mean concentration was 0.71 mg/L and the range was less than 1 to 3 mg/L.

Reclamation measured turbidity and Secchi depths to measure the water clarity. While turbidity values were very low (mean reservoir turbidity was less than 1 to 35 NTU, indicating very clear water), Secchi depths were variable (Figure 38 and Figure 39). Secchi depths ranged from very clear, near 9 meters deep, to relatively shallow of 1 meter deep, with monthly average Secchi depth from 3.5 to 5.9 meters. Coupled with the clarity measures, chlorophyll a and TSS samples give an indication that the clarity issues in Deadwood Reservoir are biological in origin such as algae blooms rather than sediment-impaired clarity. Biological clarity issues can be episodic in nature with variable frequency. Sediment and turbidity issues should not impact sight foraging and are very low indicating that gill abrasions or other secondary or delayed mortality issues associated with high TSS or turbidity should be minimal.

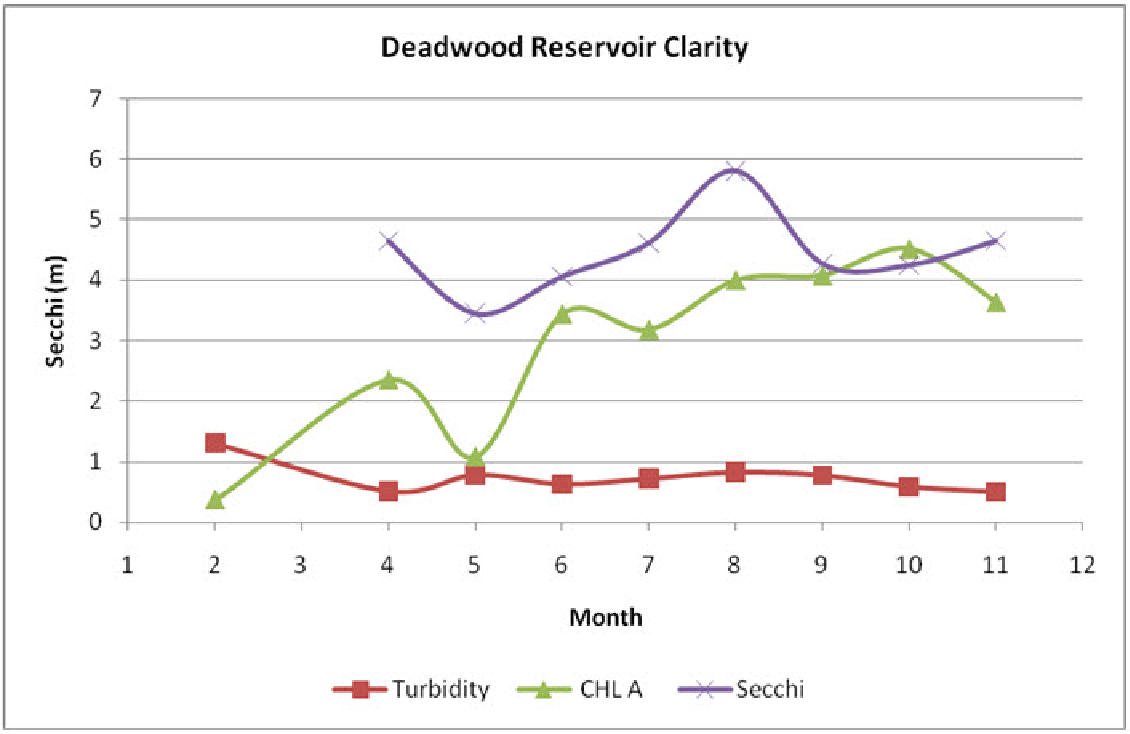

Figure 33. Monthly water clarity for Deadwood Reservoir.

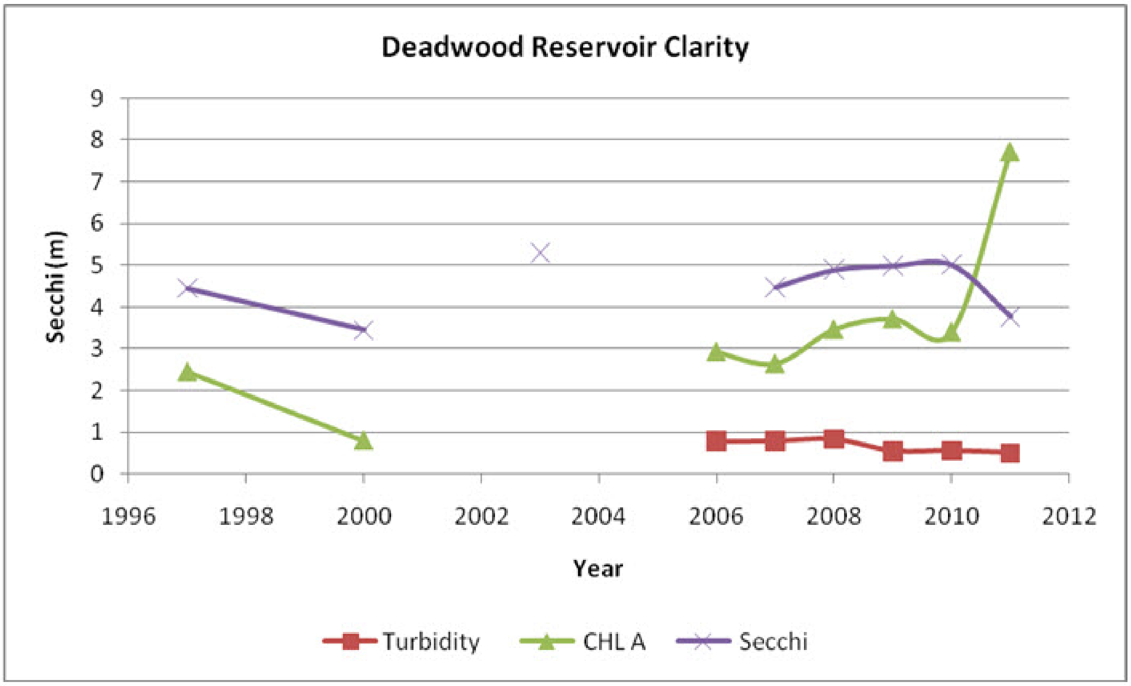

Figure 34. Yearly water clarity for Deadwood Reservoir.

Other Water Chemistry

Nutrient retention in a well-oxygenated oligotrophic reservoir is common. At depth, the nutrient cycling in a reservoir liberates nutrients generally only under anoxic or near anoxic conditions. Anoxic conditions are rare in Deadwood Reservoir (see the dissolved oxygen profiles), but hypoxia (dissolved oxygen less than 3 mg/L) occurs in September and October and in some cases can release nutrients from the sediments.

The levels of the measured constituents in Deadwood Reservoir were low to very low (Figure 40 and Figure 41). These levels in most all cases indicate a lower loading and pristine water quality compared to nearby reservoirs. The average TP concentrations from the surface waters (less than 5 meters) were 0.011 mg/L. At depths greater than 10 meters, TP concentrations during the summer stratification period averaged 0.015 mg/L.

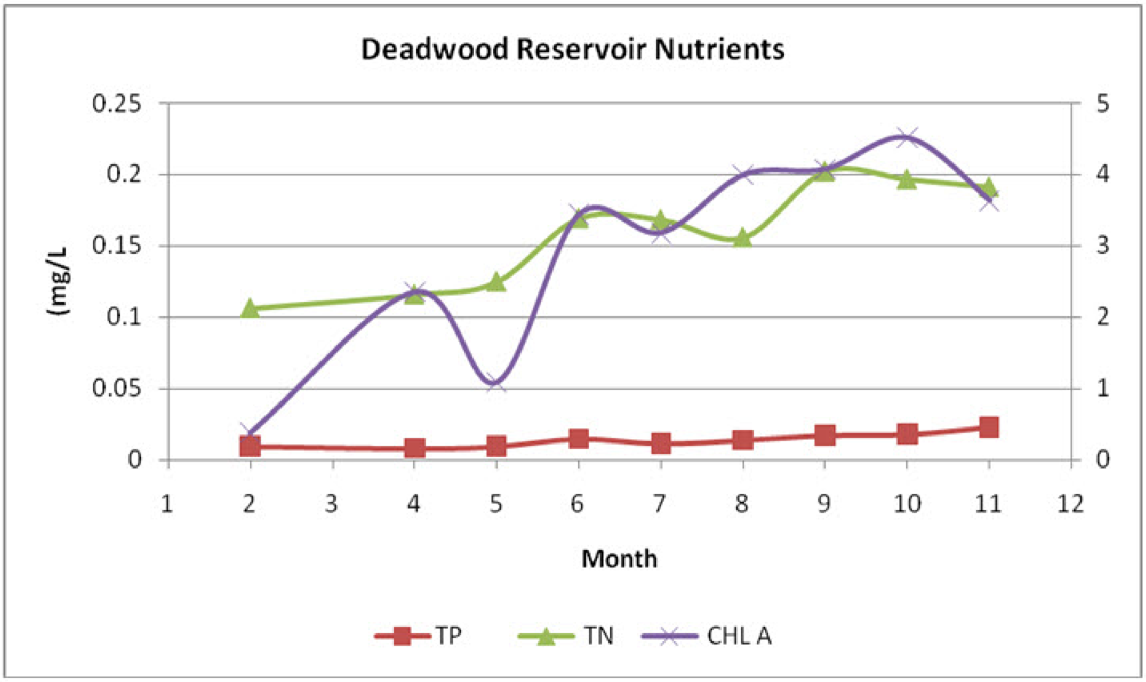

Figure 35. Monthly nutrient levels in Deadwood Reservoir.

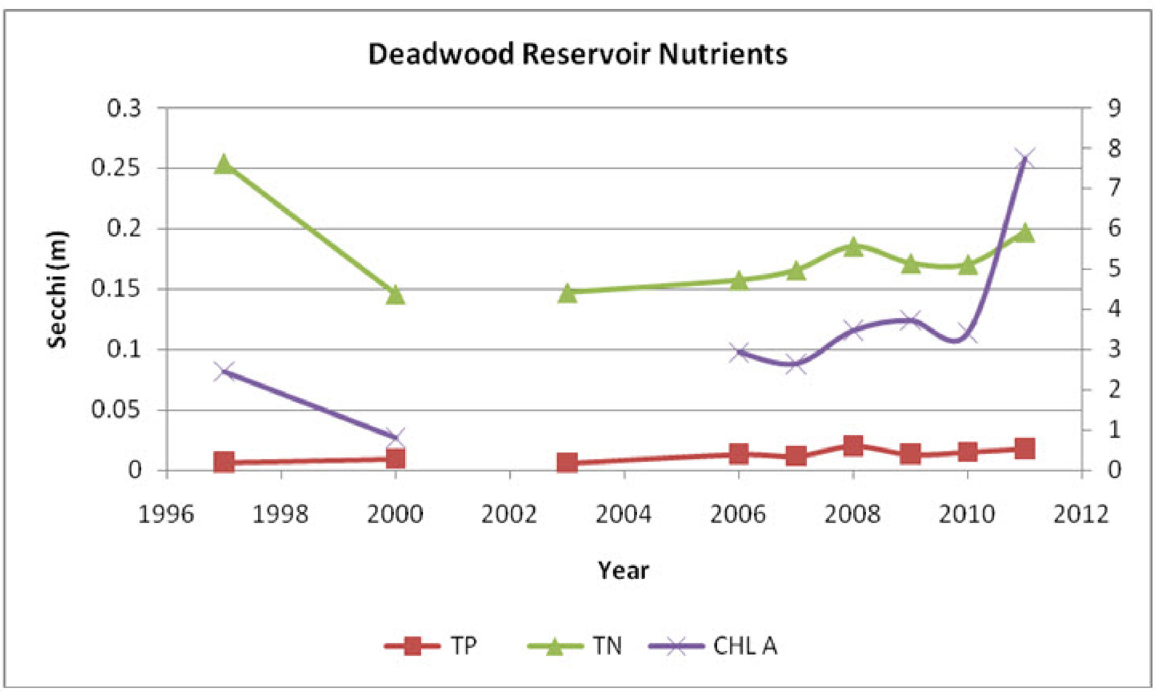

Figure 36. Yearly nutrient and chlorophyll a levels in Deadwood Reservoir.

In the reservoir, the TN:TP ratio was well balanced with some seasonal variation. Average TN:TP ratio for all sample locations was 16.85, which would indicate a slight TP limitation. As TP is depleted from the reservoir's epilimnion as seen in July in Figure 45, the TN:TP ratio moves towards excess nitrogen or TP limitation. Biologically this indicates that blue green algae and other unpalatable forms of nitrogen fixing algae should not dominate the reservoir as nitrogen is common; however, recent studies indicate that a fall dominance of blue green algae can develop which may indicate a seasonal depletion of nitrogen. Furthermore, the types of algae that are often associated with TN:TP ratios such as these should provide suitable forage for zooplankton and other aquatic invertebrates (Figure 42 and Figure 43). In Deadwood Reservoir, it appears that TP is limiting; however, on a monthly basis and yearly basis, chlorophyll a is more associated with variations in TN concentration (Figure 44).

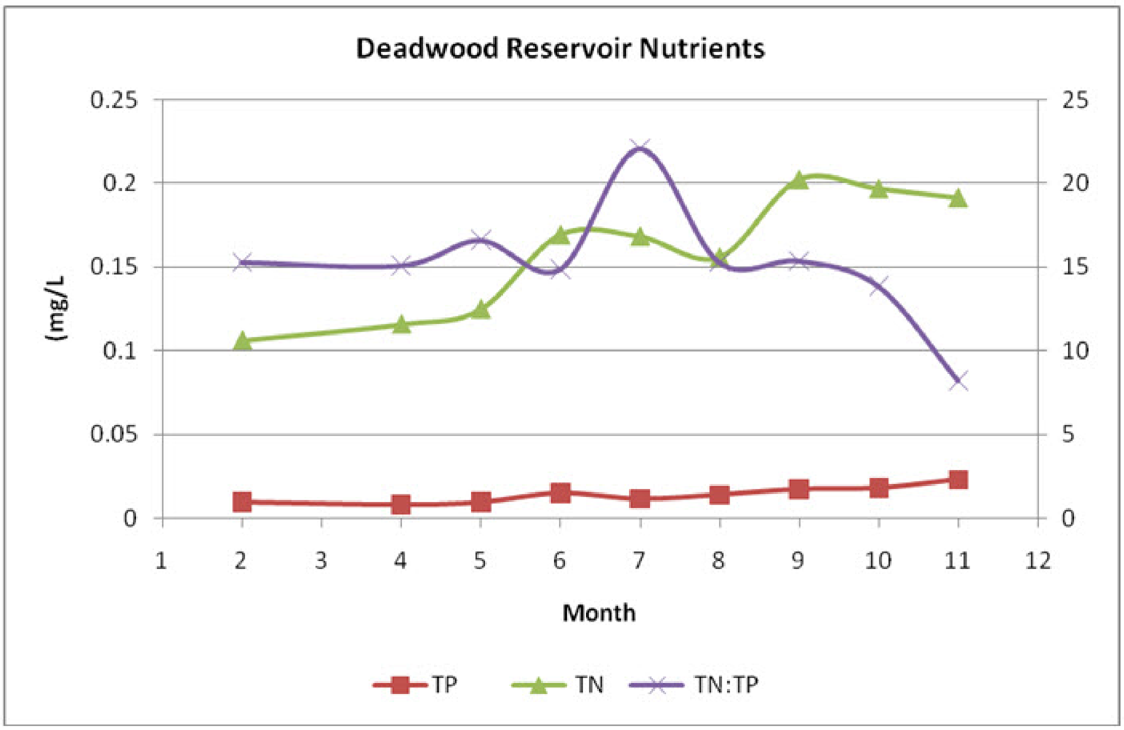

Figure 37. Monthly total-nitrogen-to-total-phosphorus ratio in Deadwood Reservoir.

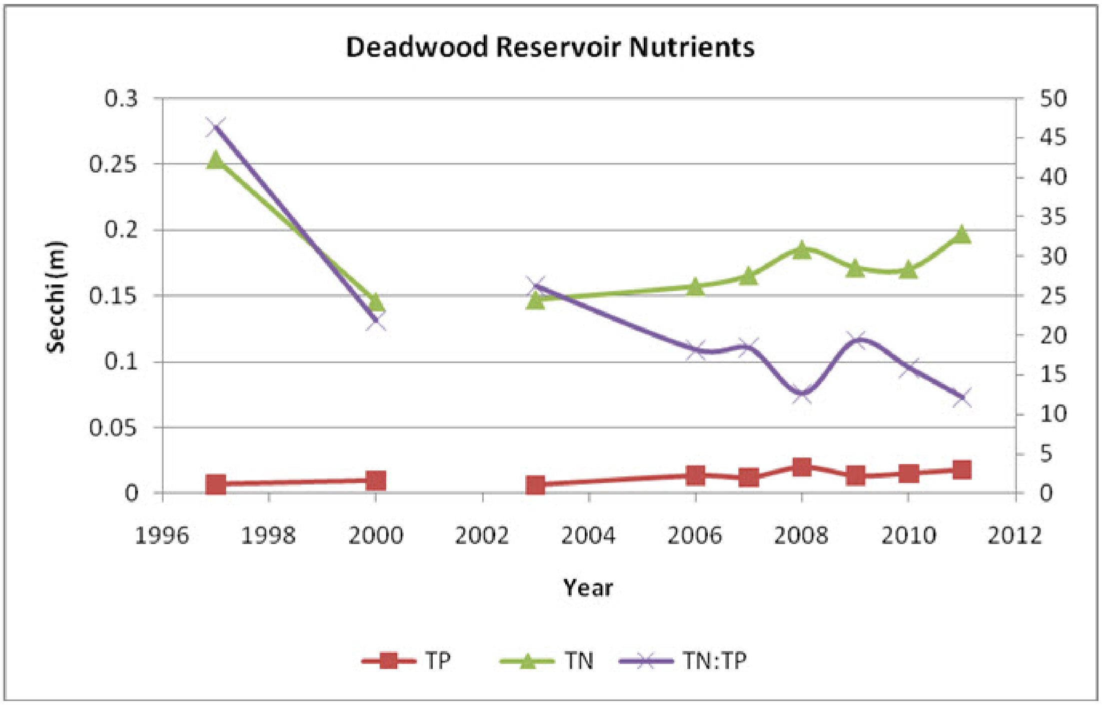

Figure 38. Yearly total-nitrogen-to-total-phosphorus ratio in Deadwood Reservoir.

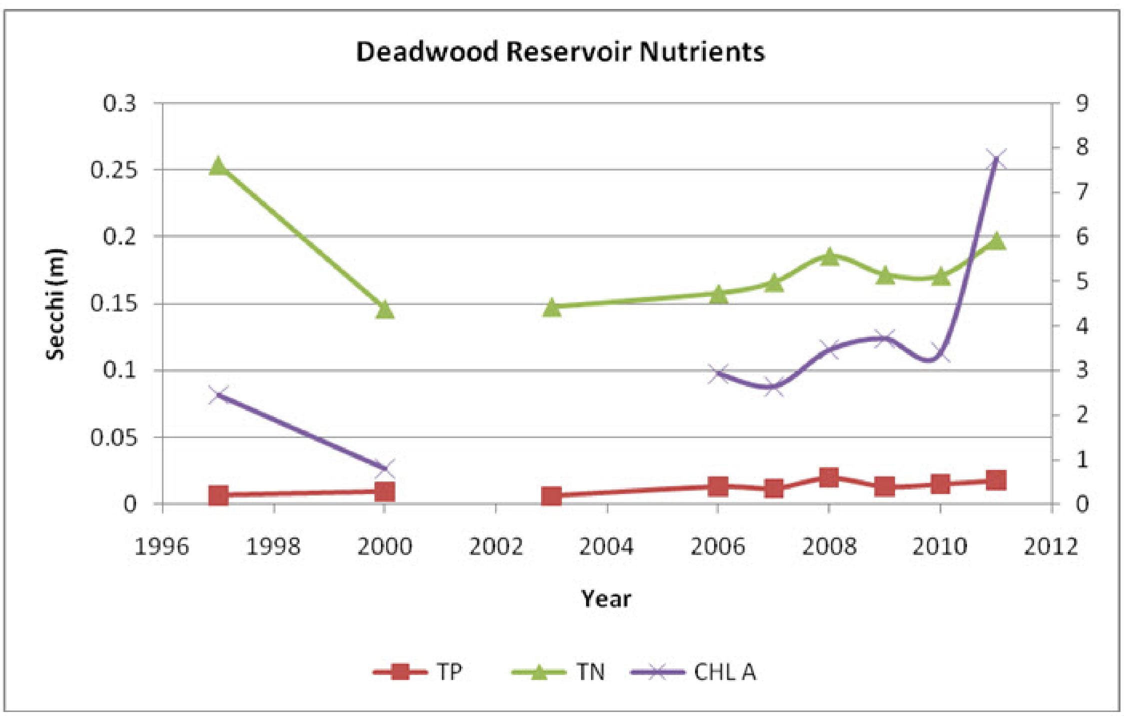

Figure 39. Yearly nutrient and chlorophyll a levels in Deadwood Reservoir.

For lakes, Carlson's TSI can be used to determine if a lake is undergoing cultural eutrophication (Carlson 1977); however, a certain trade off exists between fish production and water quality. Mesotrophic reservoirs are often seen as well balanced in terms of fish production and water quality. Therefore, mesotrophic lakes are viewed by many as the ideal target; as a result, many states and water quality entities use a TSI target of 50 as their management goals. In more oligotrophic lakes, such as Deadwood Reservoir, fish production is lower while water clarity is higher. The same trade off exists for eutrophic waters with higher fish production and lower water clarity. However, often the fish production seen in eutrophic waters in the west is towards less desirable species of fishes, as the water quality is such that the higher temperatures or lower DO levels seen in eutrophic waters stress salmonids, which are the more desirable species.

The average TSI (average of TP, TN CHL and Secchi TSI) value calculated for Deadwood Reservoir was 42 (Figure 45). This measure of eutrophication is below the mesotrophic break point of 50, indicating the reservoir is oligotrophic. In general, this indicates that nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir. In addition, the Carlson's TSI can be broken into its individual components in order to determine mechanisms of impairment.

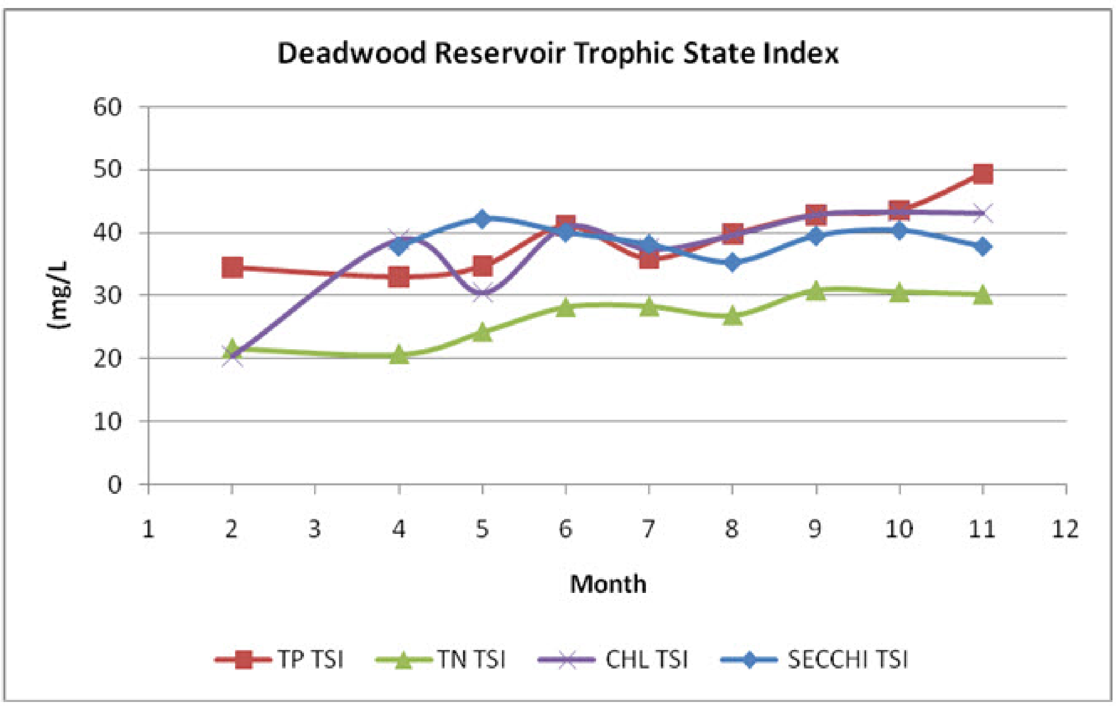

Figure 40. Monthly average Trophic State Index for Deadwood Reservoir.

One such mechanism the individual components of Carlson's TSI can be used to determine is if nutrients are in excess. A TSI for TP above 50 has been used in other states as a threshold for excess nutrients. A TSI of 50 corresponds with 0.024 mg/L of TP and 0.734 mg/L of TN and with a 2-meter Secchi depth and a concentration of 7.23 µg/L for chlorophyll a. The source of clarity issues can also be extracted from a review of the individual TSI components.

In Deadwood Reservoir, the average TSI for the individual components were 39.4 for TP, 26.8 for TN, 37.5 for chlorophyll a, and 38.9 for Secchi depth (Figure 46). Based upon these numbers, Deadwood Reservoir exhibits low TN numbers, indicating a possibility of nitrogen fixing algae blooms. On average, the other TSI components were well balanced with one another and well within the oligotrophic index period.

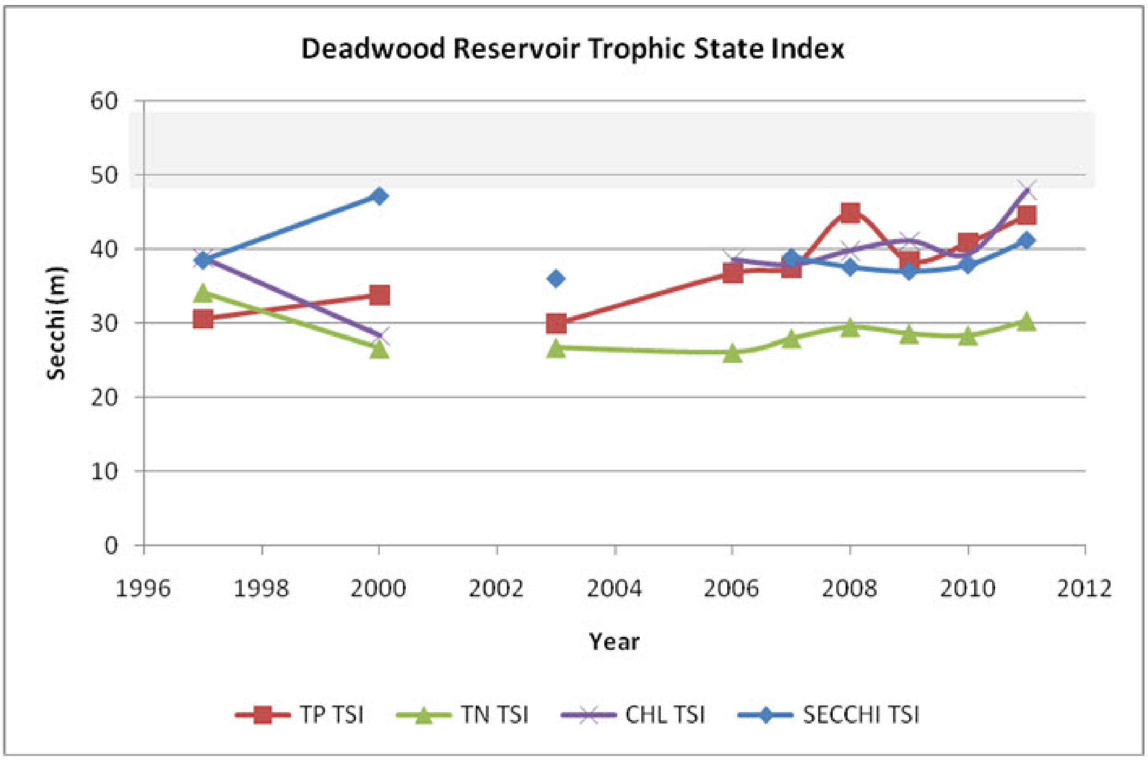

Figure 41. Yearly average Trophic State Index for Deadwood Reservoir.

The average TSI for chlorophyll a concentrations in the reservoir were very low and showed some seasonality. Winter-time, epilimnetic, chlorophyll a averaged 0.375 µg/L, or TSI of 20.40. As ice cover broke and nutrients were mixed from the hypolimnion during spring turn-over, concentrations increased and allowed increased primary production. In May, the decrease in chlorophyll a concentrations and TSI values were likely the result of increased discharge from the nutrient poor headwater streams, or depletion of nutrients by primary production after stratification impeded mixing within the water column. As turn-over continued, nutrients mixed from the hypolimnion fed the epilimnion's primary production. A zooplankton clearing phase common in lakes and reservoirs can be seen in August, this is coupled with a nutrient reduction as the lake stratifies and nutrients from the reservoirs sediments are cut off from the epilimnion. Fall turn-over begins in September, refreshing the nutrients in the epilimnion and spurring a late season spate of primary production seen in increased chlorophyll a concentrations. While these processes occur annually in Deadwood Reservoir as a result of the impoundment, they are part of a dimictic stratification process natural to lakes.

It appears from annual TSI values for chlorophyll a and Secchi that the reservoir contains adequate phosphorus, with TSI scores that were typically in the mid-30s to 40s and nitrogen concentrations and scores were near 20 to 30; thus, it is highly likely that nutrients are currently limiting primary production.

Deadwood River Water Quality Conditions

Temperature

Reclamation has collected continuous temperature data from the outflow of Deadwood Dam since October 1997. Figure 47 illustrates the annual progression of river warming and cooling. The reservoir acts to modify the annual temperature regime of the Deadwood River. Following ice-off, the reservoir is isothermal until a weak stratification begins to develop in May, with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. These constant temperatures are delivered to the Deadwood River. Typically stream temperatures in the Deadwood River fluctuate between 4 and 6° C from January through to early June. By early June, the reservoir is usually stratified and additional heat is stored in the epilimnion. The temperature difference between the surface waters and bottom waters increases to 15° C by July with maximum epilimnetic temperatures reaching 21+° C while the temperatures near the bottom of the reservoir remain relatively constant near 6° C.

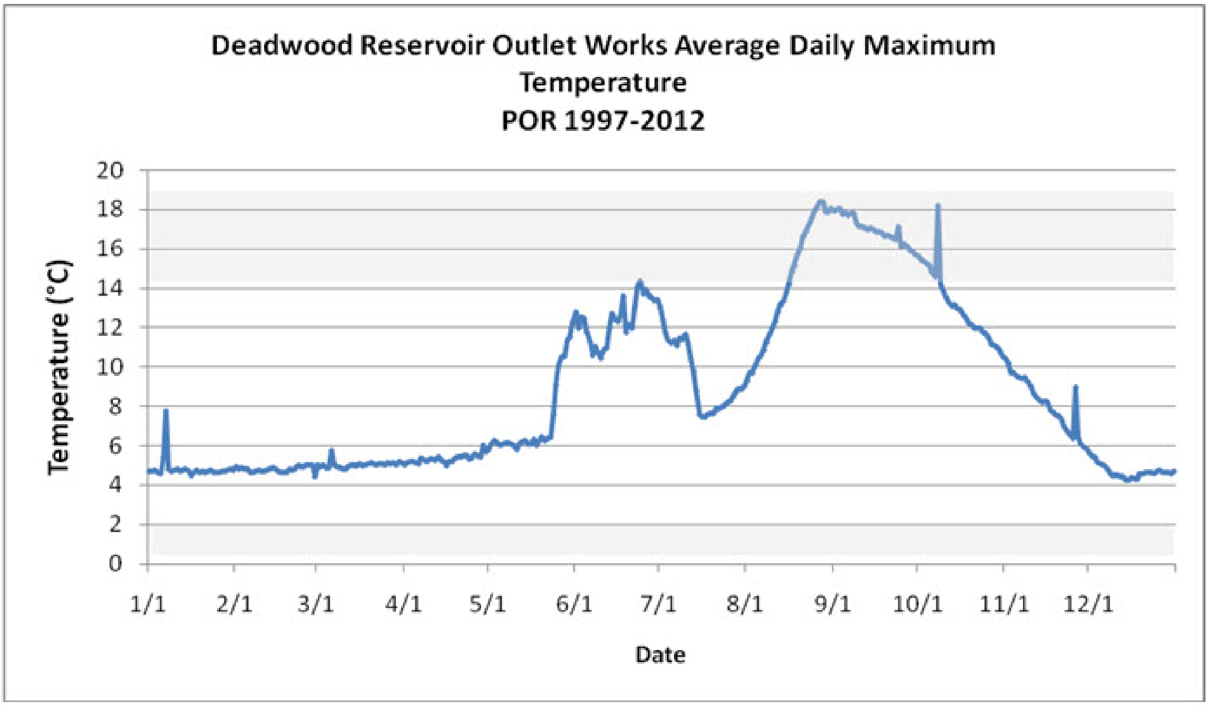

Figure 42. Deadwood Reservoir outlet works average daily maximum temperatures for period of record (POR) 1997 to 2012.

Spill is sometimes required at Deadwood Reservoir which results in outflow temperatures that are often a mixture of outlet works and surface waters over the spillway. This change in temperature regime can be seen as river temperatures change from 6° C to between 10° C to 14° C during the spill season. Following the end of the spill season, temperatures return to those seen in the hypolimnion.

As the stratification breaks down and the reservoir begins to mix, the temperature in the river slowly begins to increase until early September when it reaches its average maximum temperature of 18° C. The average river maximum temperature reaches above bull trout temperature tolerances near the middle to end of August. However, annual weather variation changes the timing of temperature peaks. For example, the river above Deadwood Reservoir surpassed this temperature in 2006 near the first of August, but fell to less than 15° C by the middle to end of August. Through September, the reservoir begins to cool and the thermocline begins to erode until the reservoir is again isothermal.

The effect of the cool isolated hypolimnion are best illustrated by the daily temperature variation, the difference between daily maximum and daily minimum as measured below Deadwood Reservoir (Figure 48). Deadwood Reservoir and the effects on the downstream temperature regime modulate the daily temperature variation experienced by the aquatic biota of the Deadwood River in the vicinity of the dam (Figure 49). How far downstream this effect is translated is unknown, and is dependent on shade and groundwater mediating the impacts from solar loading.

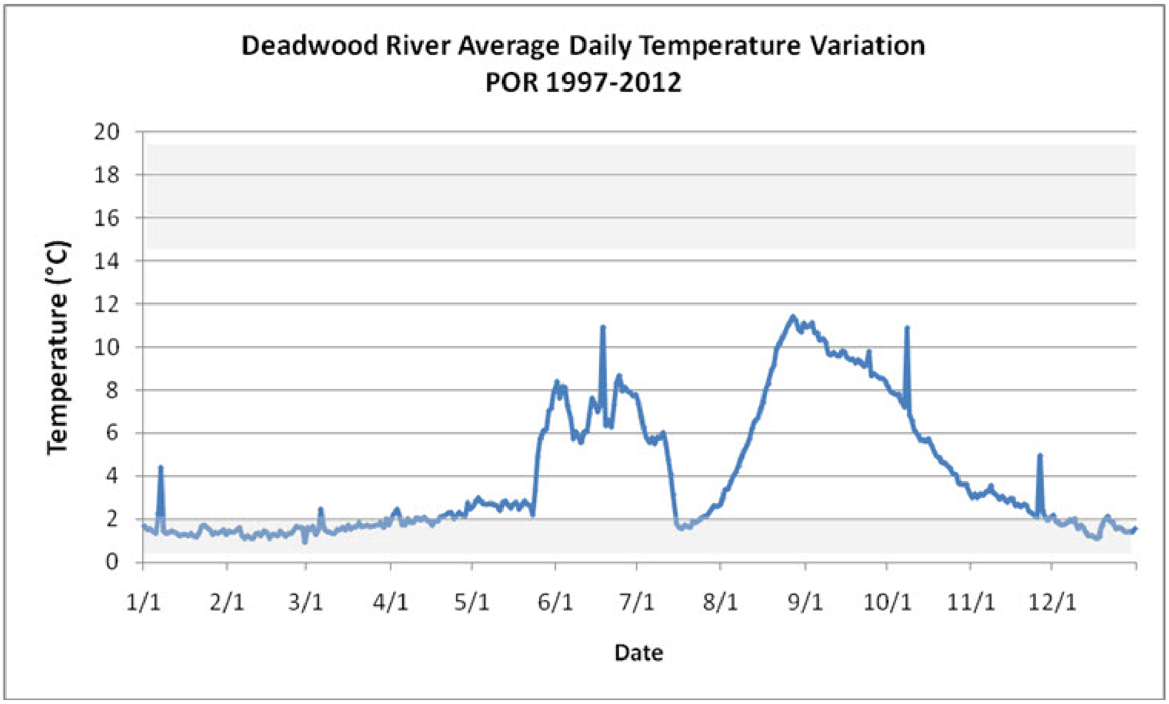

Figure 43. Deadwood River average daily temperature variation (maximum – minimum).

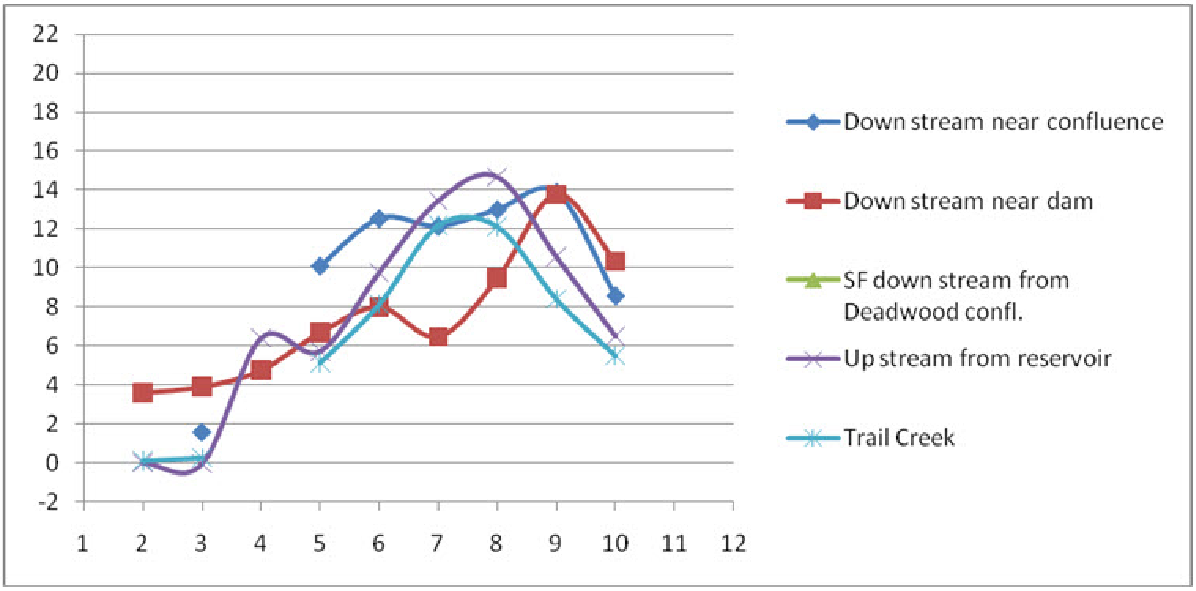

Figure 44. Instantaneous temperature measurements in the Deadwood River.

Dissolved Oxygen

Dissolved oxygen data in the Deadwood River are sparse. Reclamation collected some outlet dissolved oxygen measurements during the Regional Reservoir Monitoring Program (Figure 50) and dissolved oxygen levels were suitable for bull trout during all sampling events. Even when oxygen depletion became evident in the upstream reservoir, dissolved oxygen concentrations in the river did not fall below 7 mg/L. Riverine mixing processes should keep the dissolved oxygen levels in the Deadwood River at or near saturation levels throughout the length of the river.

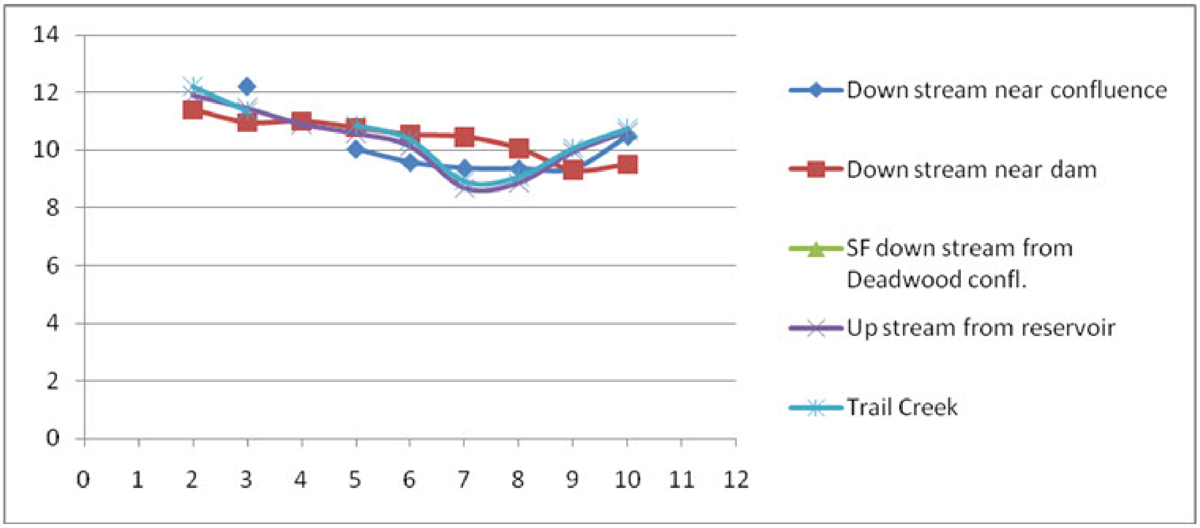

Figure 45. Instantaneous dissolved oxygen measurements in the Deadwood River.

Sediment/Turbidity

Both TSS and turbidity are an indication of water clarity and sediment load. Sediment loading can be episodic in nature with variable frequency, but is usually associated with high flows and the ascending limb of the annual hydrograph.

Reclamation has intermittently collected sediment/turbidity samples below the reservoir in the Deadwood River. In 2006, two samples had very low TSS levels, less than 1 and 2 mg/L. Reclamation also measured turbidity at the same location and the turbidity values were very low, 1 to 11 NTU, indicating very clear water. Coupled with the suspended sediment measures, the turbidity samples indicate that the sediment load from Deadwood Reservoir into the Deadwood River is very low. Sediment and turbidity should be limited in the Deadwood River near the dam by the reservoir capturing and retaining a majority of the sediment from the upstream watershed.

Other Water Chemistry

As previously discussed, well oxygenated reservoirs can act like nutrient traps, and often times lead to strong nutrient limitation in the rivers below lakes and reservoirs. In addition, during mixing events or turn-over nutrient recycling from the hypolimnion also occurs, as indicated in TP concentrations downstream from the reservoir (Figure 51).

Levels of the measured constituents in the Deadwood River below Deadwood Reservoir are very low, indicating in most all cases, a lower loading and less degradation of water quality as compared to nearby rivers. The average TP concentrations discharged from the reservoir was 0.029 mg/L (Figure 51). In comparison, nuisance aquatic vegetation is often seen when TP in rivers is greater than 0.100 mg/L (EPA 1986, page 240). The Snake River Hells Canyon TMDL set nutrient targets for many of the tributaries to the Snake River in Oregon and Idaho at 0.07 mg/L (IDEQ and ODEQ 2003).

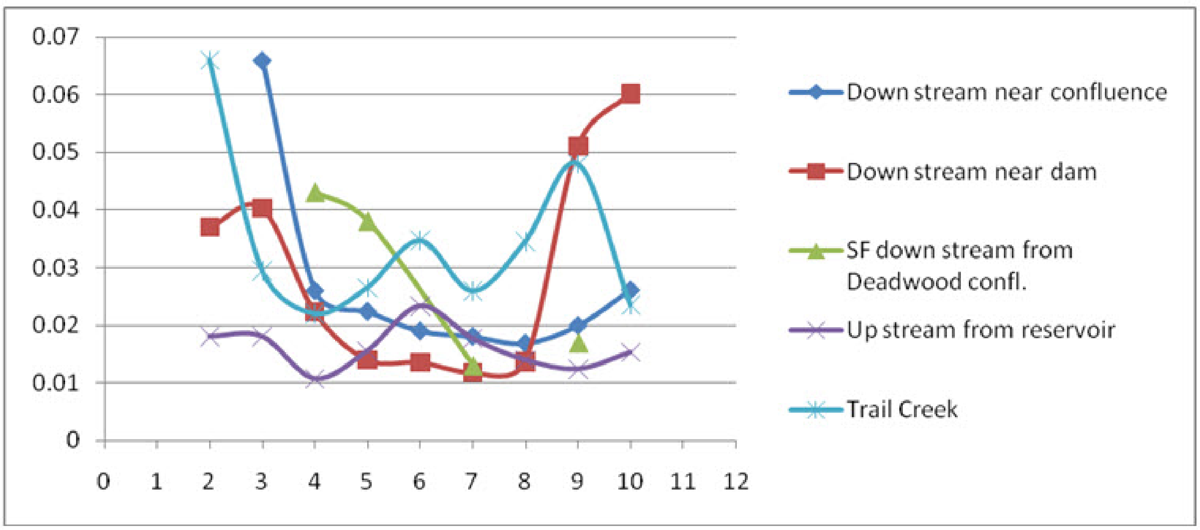

Figure 46. Total phosphorus levels in the Deadwood River.

Riverine surface water typically has very low total nitrogen concentrations which is also the case with the Deadwood River. Bioavailable nitrogen is very low with most TN composed of organic nitrogen (i.e., total Kjeldahl nitrogen [TKN]), which would have to undergo several steps in the nitrogen cycle before it could be used for primary productivity. Average TN concentrations in the Deadwood River were 0.20 mg/L (Figure 52). Ratios of TN:TP are also indicative of the reservoir acting as a nutrient (TP) trap. In the outfall from the reservoir, the average TN:TP ratio was 10.03, and ranged upwards to 17.07, indicating very low TP (Figure 53). Biologically, this indicates that primary production will be limited by the low levels of phosphorus.

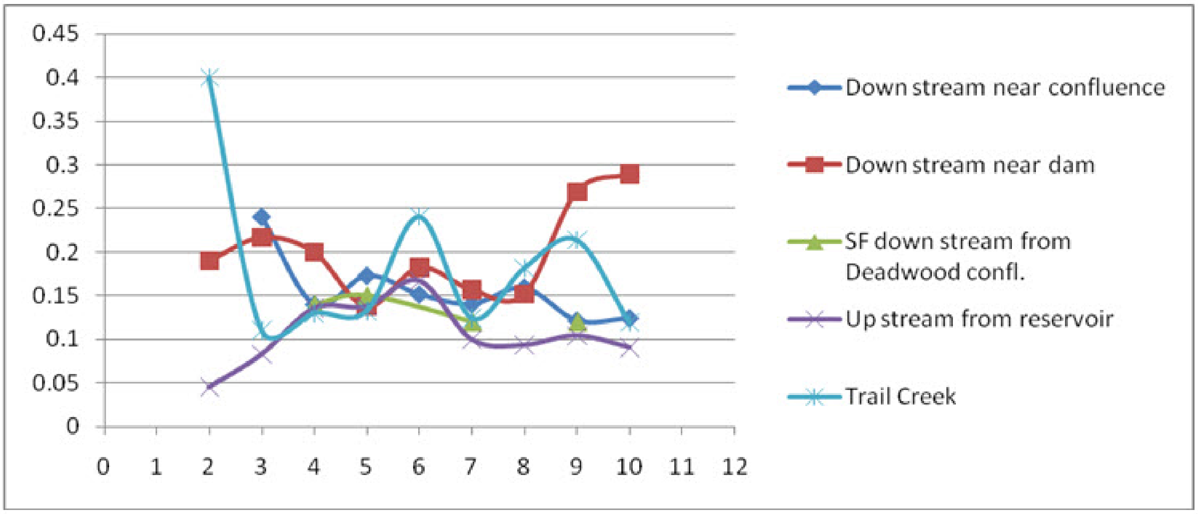

Figure 47. Total nitrogen in the Deadwood River.

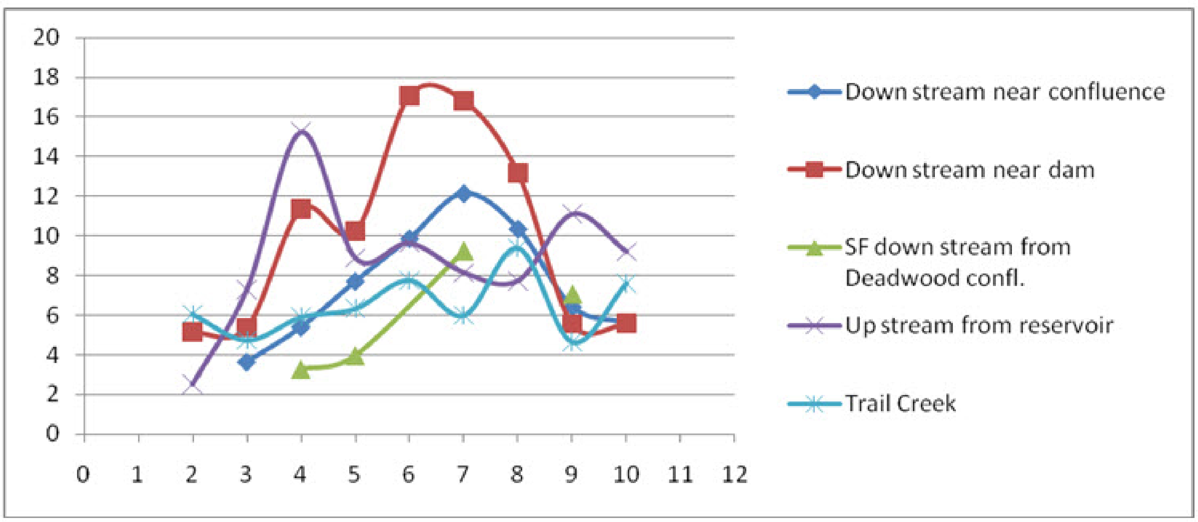

Figure 48. TN:TP ratio for the Deadwood River.

Bacteria

Bacteria, in riverine systems can be used as an indicator of nonpoint source pollutant sources; however, the use in lentic systems is problematic as sedimentation of bacteria sources is enhanced in the quiescent waters of a lake or reservoir. At best, they can be used as an indicator or near-shore impacts. Reclamation has collected a single bacteria sample in the Deadwood watershed, the results of that test was 1 unit of *E. coli* per 100 milliliter. It is unknown if other water quality entities have collected pathogen data.

MALHEUR RIVER SYSTEM

Beulah Reservoir Water Quality Conditions

Temperature

Reclamation has collected temperature profiles from Beulah Reservoir since 1996 as part of the Regional Reservoir Monitoring Program in which individual reservoirs were sampled on a 3-year cycle. In addition, Reclamation conducted several years of intensive data collections to support water quality investigations concerning bull trout occurrence in the reservoir. Most of the regional reservoir profiles were collected at a deep station located approximately 100 meters from the dam. These temperature profiles indicate the annual progression of isothermal temperatures to a very weak stratification and back to isothermal conditions as the thermocline breaks down (Figure 28).

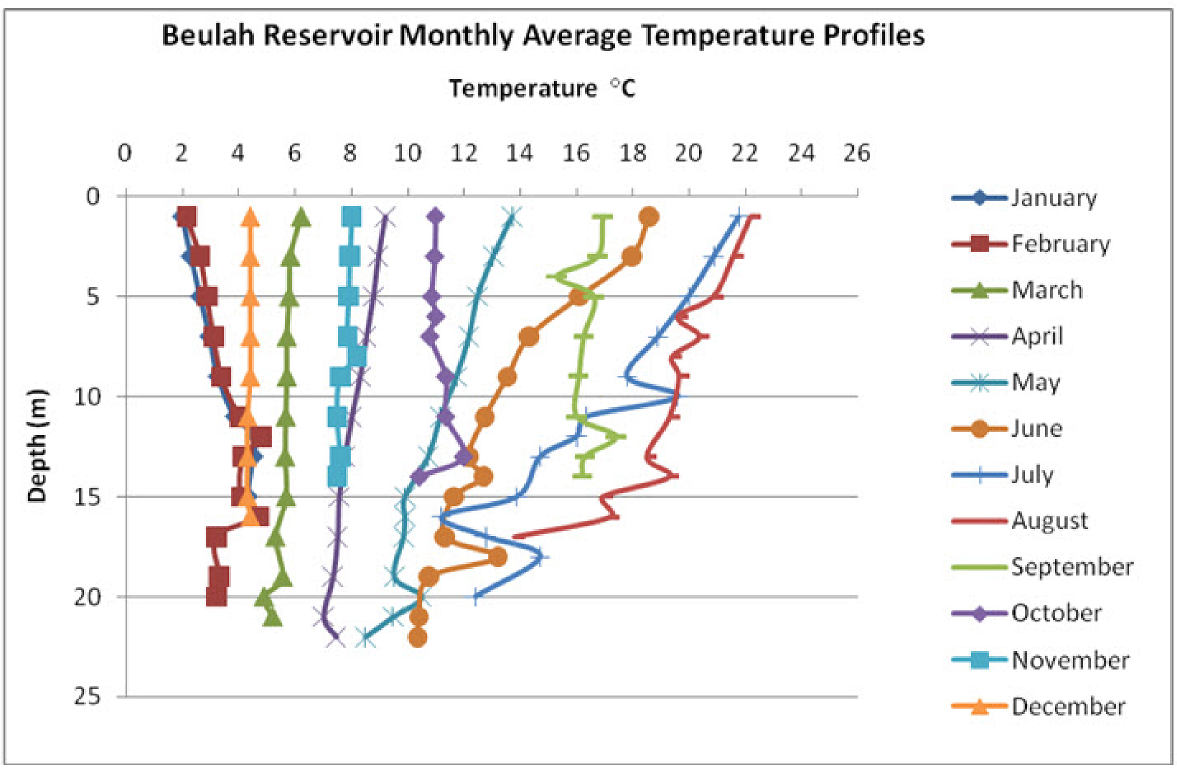

Figure 49. Monthly average temperature profiles in Beulah Reservoir.

Following ice-off, the reservoir is isothermal until a weak stratification begins to develop in June, with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. The epilimnion increases in temperature from March through June by approximately 4° C per month and the temperature difference between the surface waters and bottom waters increases to approximately 8 °C to 9° C. By July, the reservoir will show some stratification, but it is usually weakly stratified and may depend on water year. The epilimnion depth is approximately 7 to 9 meters. The temperature difference between the surface waters and bottom waters tend to increase slightly to over 10° C, with maximum epilimnetic temperatures reaching 21° to 22° C while the temperatures near the bottom of the reservoir remain relatively constant between 11 to 12° C. The monthly temperature gained in the epilimnion, (3° C in July and 0.41° C in August) slows as maximum temperatures are reached in July or August. The average epilimnetic temperature during the summer was 20.82° C, well above bull trout temperature tolerances; during this time, the epilimnion remained between 8 and 10 meters deep. In September and October, the reservoir begins to rapidly cool, with the epilinion losing between 5° and 6° C per month. Any thermocline remaining after August is quickly eroded until the reservoir is again isothermal. Due to the operation of the reservoir, it is highly unlikely that the reservoir would stratify in most years. It appears that during the summer months, the epilimnion will warm above bull trout temperature tolerances, and average temperatures below 10 meters will remain below 15° C.

Dissolved Oxygen

Dissolved oxygen profiles were also collected along with the temperature profiles and similar situations were observed (Figure 29). During the summer, dissolved oxygen levels were only suitable for bull trout through the top 7 meters in June. By July, this area was limited to the top 3 meters, with some of the surface waters (less than 1 meter) above 7 mg/L in August. The oxygen depletion in the hypolimnion became more evident as the year progressed, likely due to the reservoir warming and increased bacterial respiration in the hypolimnion removing dissolved oxygen. In some years, an anoxic zone developed and extended from the bottom to 14 meters in August. Based upon the chlorophyll a concentrations and the early season oxygen depletion, it is likely that excess aquatic growths are a regular occurrence in Beulah Reservoir.

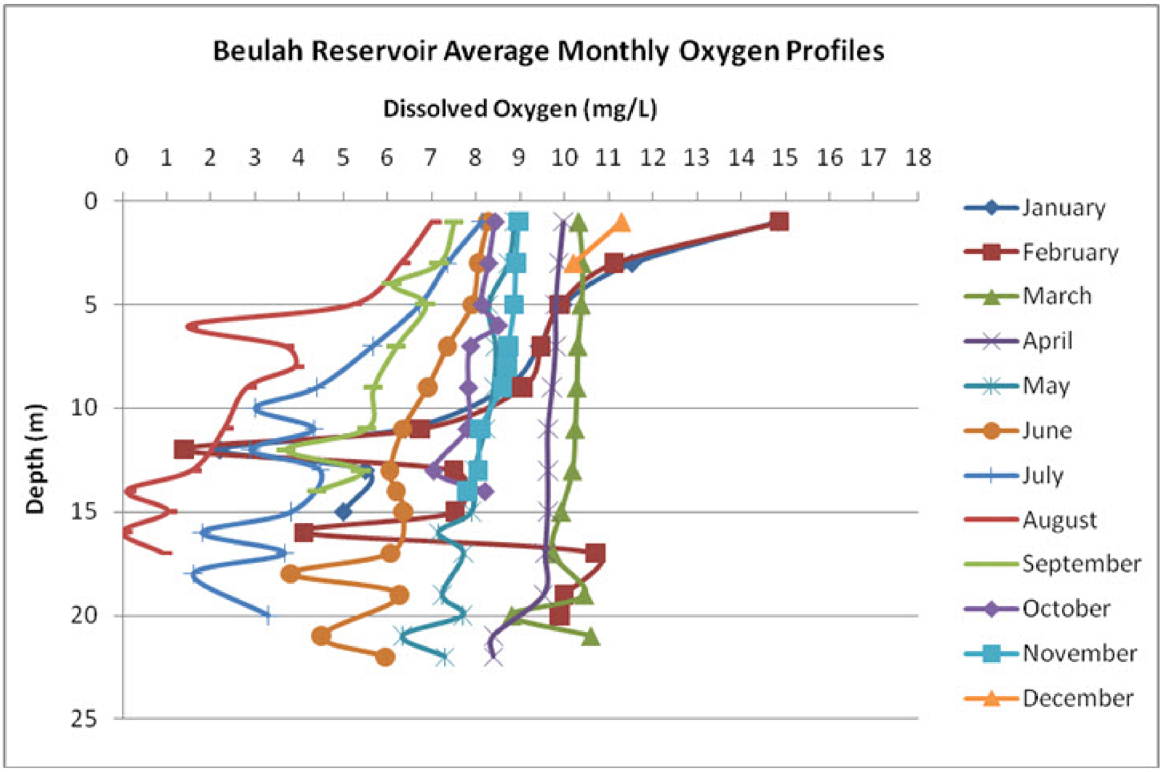

Figure 50. Average monthly oxygen profiles in Beulah Reservoir.

Total Dissolved Gas

Reclamation has collected very few TDG samples downstream from Beulah Reservoir. The outlet works of Beulah Reservoir consisted of two 36-inch needle valves until 1990 when these valves were replaced with jet valves which tend to increase the likelihood of TDG generation below the reservoir. The high-velocity jets entrain air and could lead to a deep plunge that increases the TDG in the river when the valves are in use. TDG levels may also be generated with discharges during high flow operations.

Four separate measurements were collected below the reservoir approximately 0.3 miles downstream from the outlet works spill. The average TDG for these four measurements was 103.1 percent, with a high of 108.1 percent that occurred when the discharge was approximately 485 cfs. While not clearly supported due to the sparse data, there is some indication that TDG above 110 percent may occur when discharge is in excess of 560 cfs. Critical to the development of gas bubble trauma (GBT) is the availability of deep water to compensate for elevated TDG or the proximity to riffles and rapids which may quickly degas the river. It is unknown at this time if GBT has been reported below Agency Valley Dam. If sufficient depth is available for fish below the depth compensation point, TDGs in this range may not be harmful or cause GBT.

Sediment/Turbidity

Reclamation has collected numerous sediment/turbidity samples from Beulah Reservoir. The majority of these samples were collected for water quality studies conducted in 1999 through 2001 (Figure 30). TSS samples were collected very rarely in this set of samples; however, when collected, the mean TSS concentration for the period of record was 3.95 mg/L (n = 11) and the range of TSS samples was 9 to less than 1 mg/L.

Reclamation measured turbidity and Secchi depths of the reservoir waters to measure water clarity. Mean turbidity values were low, 12.44 (n = 144) turbidity units, indicating clear water, while Secchi depths were variable. Secchi depths ranged from relatively clear near 3.0 meters deep to very shallow of 0.2 meters deep. Coupled with the other clarity measures (chlorophyll a and turbidity), the samples indicated that the clarity issues in Beulah Reservoir are seasonal in nature and may relate to the operation of the reservoir and the natural hydrograph. Early season turbidity naturally increases with the ascending limb of the hydrograph; however, this season also corresponds with the refill or maximum pool elevations in the reservoir. Some turbidity issues of biological origin such as algae blooms occur rather than sediment-impaired clarity.

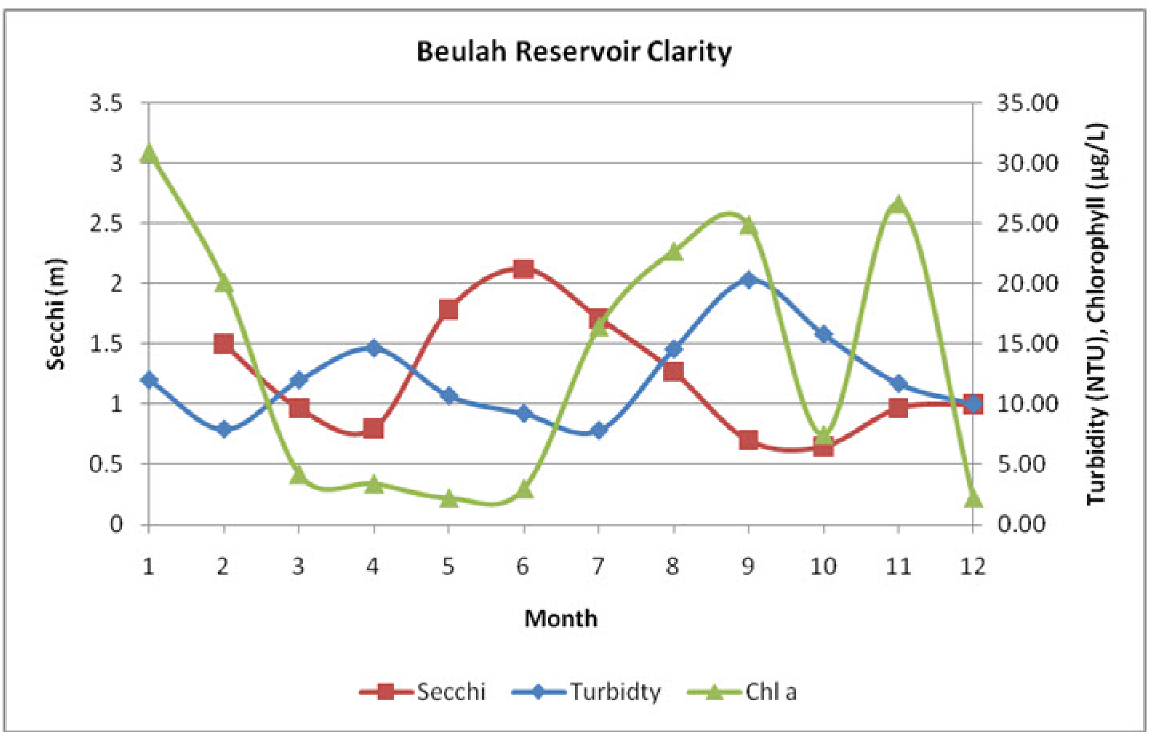

Figure 51. Clarity values for Beulah Reservoir.

A naturally occurring clear water phase often exists in many reservoirs as the zooplankton community rebounds from winter lows and reduces chlorophyll through grazing pressure. This period can be seen in the May through June Secchi depths coupled with the low chlorophyll a concentrations. As the summer season progresses, Secchi depths begin to fall while turbidity and chlorophyll y values increase. This is likely when blue-green algae begin to dominate the system and are unpalatable to the zooplankton community. Biological clarity issues can be episodic in nature with variable frequency. Seasonal biological turbidity issues should not impact other secondary or delayed mortality issues associated with high TSS such as gill abrasions.

Clarity issues in Beulah Reservoir are seasonal in nature and may relate to the operation of the reservoir and the natural hydrograph. Early season turbidity naturally increases with the ascending limb of the hydrograph; however, this season also corresponds with the refill or maximum pool elevations in the reservoir. Some turbidity issues of biological origin such as algae blooms occur rather than sediment-impaired clarity.

Other Water Chemistry

Nutrient cycling within a reservoir, especially one with dissolved oxygen depletions in the hypolimnion, are often strongly associated with stratification. As the upper surface waters are isolated from the sediments, nutrients are depleted through biological uptake and sedimentation. It is not uncommon for primary production in the epilimnion to become limited by nutrients. Furthermore, this nutrient limitation can lead to the expression of nuisance levels of some algae taxa, such as blue green algae, as they can fix nitrogen from the atmosphere. At depth, the nutrient cycling is expressed by the liberation of nutrients under anoxic conditions. These liberated nutrients are isolated from primary production until the reservoir's stratification breaks down and mixing processes bring these nutrients to the surface.

The levels of the measured constituents in Beulah Reservoir are very high (Figure 31). These levels in most all cases indicate a higher loading and degradation of water quality compared to nearby reservoirs. The average TP concentrations from the surface waters (less than 5 meters) near the dam were 0.130 mg/L. At depth (less than 10 meters) TP concentrations during the summer stratification period averaged 0.138 mg/L. In comparison, some eutrophic reservoirs, averaged greater than 0.100 mg/L while mesotrophic reservoirs TP concentrations are typically between 0.025 and 0.035 mg/L at their deepest locations.

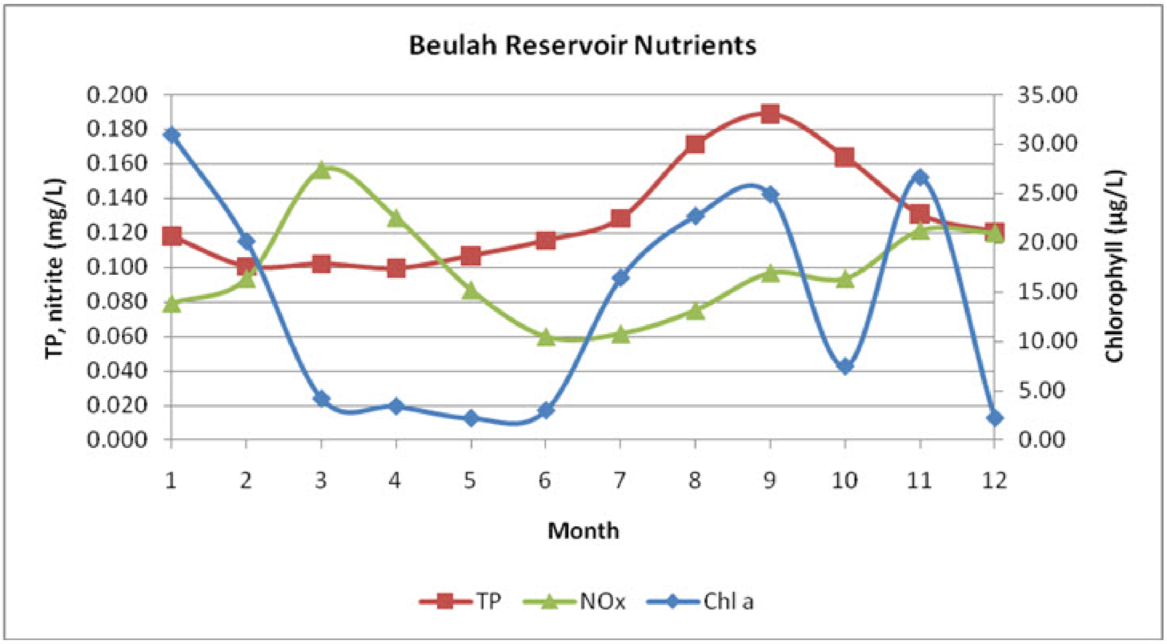

Figure 52. Nutrients levels found in Beulah Reservoir.

Nitrogen-to-phosphorus ratios (N:P) are also telling in Beulah Reservoir. In the North Fork of the Malheur River above the reservoir, the N:P ratio was less than 5, indicating excess TP for 100 percent of the time. In the Beulah Reservoir area, the ratio was also less than 5 for nearly 82 percent of the time. Biologically this indicates that blue green algae and other unpalatable forms of nitrogen-fixing algae will dominate in the backwaters through the main pool to the dam. Furthermore, these types of algae are often associated with algae blooms that the general public views as a nuisance. In all cases, the N:P ratio was less than approximately 10, indicating that even under the best conditions, TP was still in excess.

Total phosphorous **-** Extreme summer drawdowns will continue to mobilize total phosphorous, resulting in eutrophic conditions which may be excessive enough to limit productivity in the reservoir. Additionally, an anoxic zone of water can form in summer which can adversely affect prey fish species. Multiple year drought and dry conditions can result in increased drawdown levels that will exacerbate water quality issues. These conditions will most likely occur during July and August when bull trout have migrated into the North Fork Malheur River to spawn or over-summer.

For lakes, TSI can be used to determine if a lake is undergoing cultural eutrophication (Carlson 1977). Average TSI values for Beulah Reservoir were 57.83 near the dam at the deepest location which exceeds the mesotrophic break point of 50, indicating the reservoir is eutrophic. Additionally the phosphorus component of the index indicates the reservoir is highly eutrophic or hypereutrophic. In general, this indicates that a nutrient reduction is needed throughout the reservoir; however, in order to determine the mechanism of impairment, the Carlson's TSI should be broken into its individual components.

To determine if nutrients are in excess, the individual components of TSI of 50 should corresponds with 0.024 mg/L of TP, 2 m Secchi, 7.23 µg/L chlorophyll a, and 0.734 mg/L of TN. Based upon these numbers, Beulah Reservoir exceeded the threshold value for TP at every sample date while never exceeding the TN threshold value. Secchi depth or clarity appears to be improving over time, but may be confounded by Secchi depths collected during the spring clear-water phase driven by zooplankton grazing.

The TSI scores in a reservoir can be further complicated under severe drawdown events as well as during spring filling events as indicated by the seasonality of Secchi depth (Figure 32). The complications from drawdown events, which occur annually at Beulah Reservoir, can arise when phosphorus is mobilized from the sediments in the deeper portions of the lake due to natural processes under anaerobic conditions.

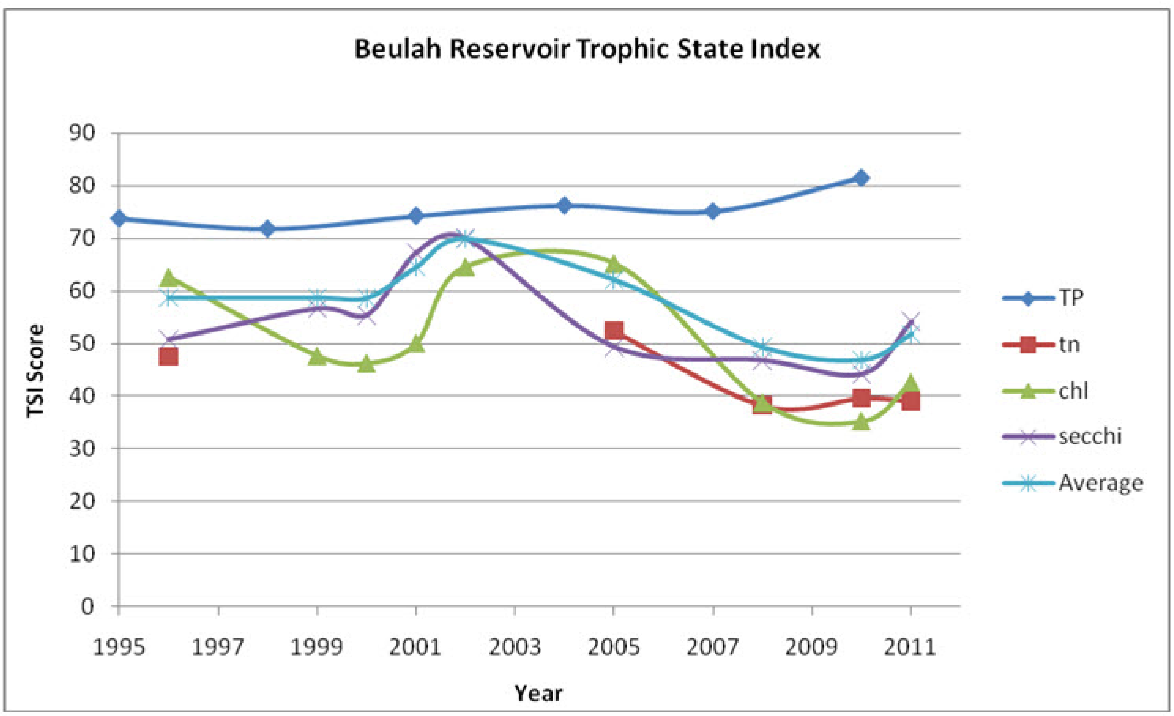

Figure 53. Beulah Reservoir trophic state index.

Further investigations are required to determine if there is a significant trend in TSI scores; however it appears from TSI values for TP that the reservoir contains excess nutrients as the TSI scores were typically in the mid-70s, while Secchi scores were near 50. Thus, it is highly likely that nutrients are impairing the aquatic life of the reservoir.

Water quantity is suitable except during dry and drought year conditions when severe reservoir drawdowns can occur, reducing reservoir levels to run-of-river. No minimum pool has been established, but a 4-year study is underway to provide minimum pool recommendation.

Degraded water quality and quantity will likely continue under the proposed action as Reclamation attempts to meet water delivery needs in the face of limited water supply and high temperatures. Multiyear droughts will likely increase the number of extreme drawdown events, resulting in increased degradation of water quality as well as reduced water supply. The establishment of a biologically-based minimum pool recommendation will reduce the adverse impacts to the prey base in Beulah Reservoir from periodic drawdowns below 2,000 acre-feet.

Bacteria

Bacteria, in riverine systems can be used as an indicator of nonpoint source pollutant sources; however, the use in lentic systems is problematic as sedimentation of bacteria sources is enhanced in the quiescent waters of a lake or reservoir. At best, they can be used as an indicator of near-shore impacts. Bacteria samples were rarely collected from Beulah Reservoir, but several samples were collected from the reservoir at a deep water location near the dam during the early summer of 2005, 2008, 2010, and 2011. Organisms of E. coli were seldom present in the samples and when they were, it was in very low numbers (less than 4 col/100 ml max).

POWDER RIVER SYSTEM

Phillips Lake and Powder River Water Quality Conditions

Temperature

Reclamation has collected continuous temperature data from the outfall of Mason Dam since July 2005 and this temperature data illustrates the annual progression of river warming and cooling. The reservoir acts to modify the annual temperature regime of the Powder River. Typically during the winter, a western river is very cold, often near 1 to 2° C, unless there are significant groundwater additions or the water body is located below a lake or reservoir as is the case with the Powder River.

For the Powder River below Mason Dam, Phillips Lake dictates the outflow temperature regime. Solar loading heats the water body along its length while shade provides an insulation to offset or minimize this solar loading from atmospheric heat sources. Following ice-off, the reservoir is isothermal until a weak stratification begins to develop in May, with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. These constant temperatures are delivered to the Powder River. Typically stream temperatures in the Powder River fluctuate between 4° and 5° C from January through mid-April. By early June, the reservoir is usually stratified and additional heat is stored in the epilimnion. The temperature difference between the surface waters and bottom waters increased to 10° C by July with maximum epilimnetic temperatures reaching over 20° C while the temperatures near the bottom of the reservoir remain relatively constant between 10.4 and 11.2° C. The isolation of the hypolimnion keeps the outflow temperatures between 6° and 12° C until the end of July. The average hypolimnetic temperature finally reaches above bull trout temperature tolerances near the end of August, well past the time frame when the Powder River above Phillips Lake has surpassed this temperature (June). In late September, the outlet temperatures peak (approximately 16° C to 17° C), but only slightly above bull trout tolerances as the reservoir begins to cool and the thermocline begins to erode until the reservoir is again isothermal (Figure 54).

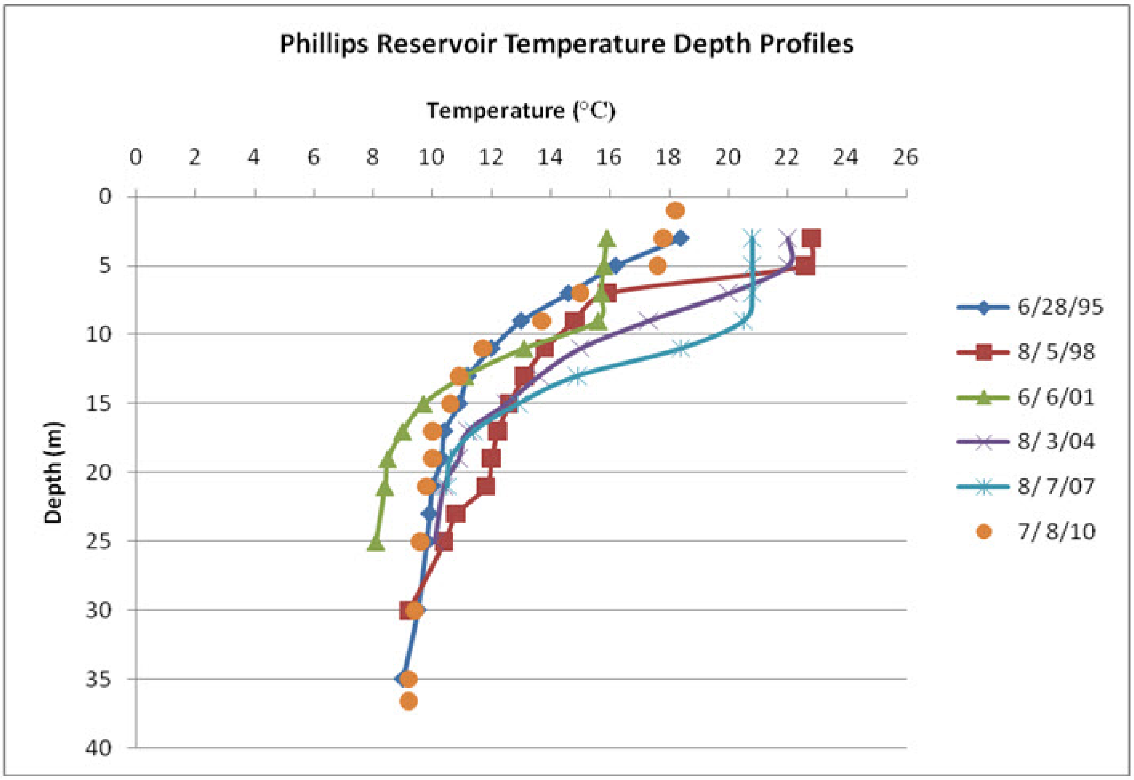

Figure 54. Phillips Lake temperature depth profiles.

These periods of isothermal reservoir temperatures and the effect of the cool isolated hypolimnion are best illustrated by the daily temperature variation, the difference between daily maximum and daily minimum, at two locations along the Powder River. The first is the Powder River above Phillips Lake (Figure 55) and the second from the outlet works at Mason Dam (Figure 56). Phillips Lake and the effects on the downstream temperature regime clearly modulate the daily temperature variation experienced by the aquatic biota of the Powder River in the vicinity of the dam (Figure 57). How far downstream this effect is translated is unknown, and is dependent on shade and groundwater mediating the impacts from solar loading.

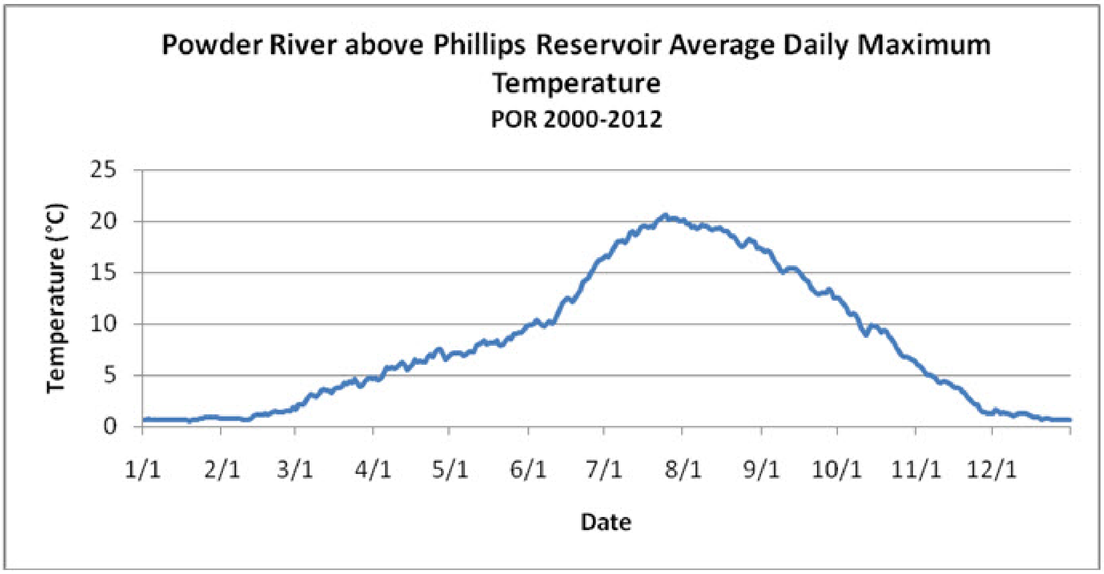

Figure 55. Powder River above Phillips Lake average daily maximum temperatures.

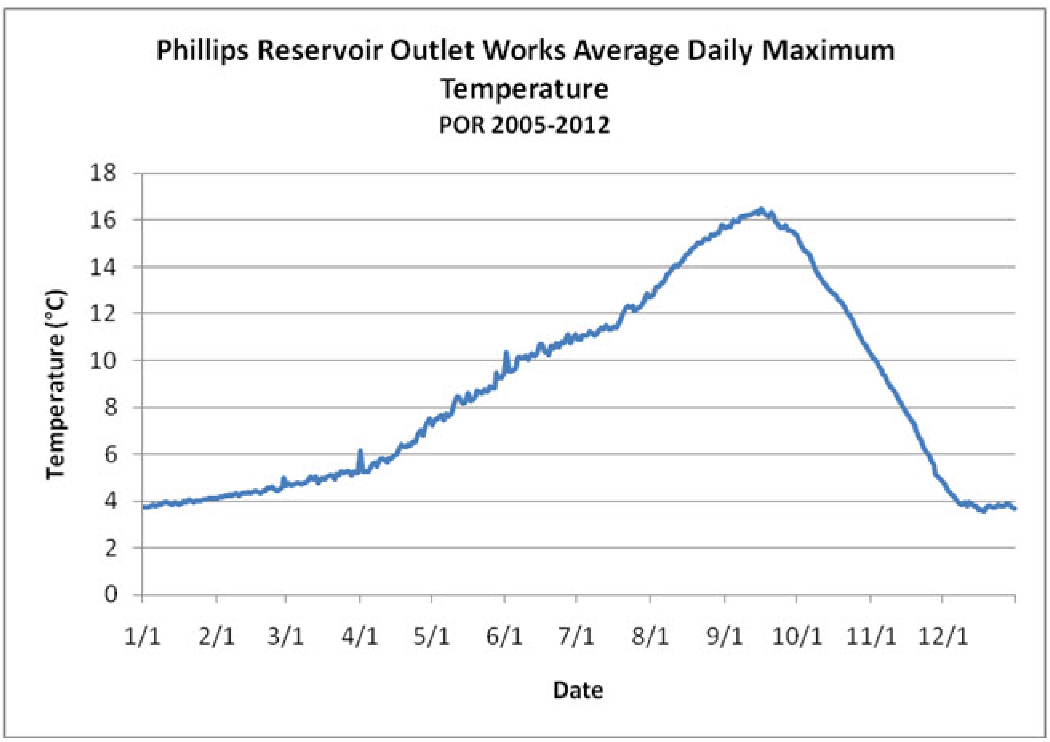

Figure 56. Phillips Lake outlet works average daily maximum temperatures.

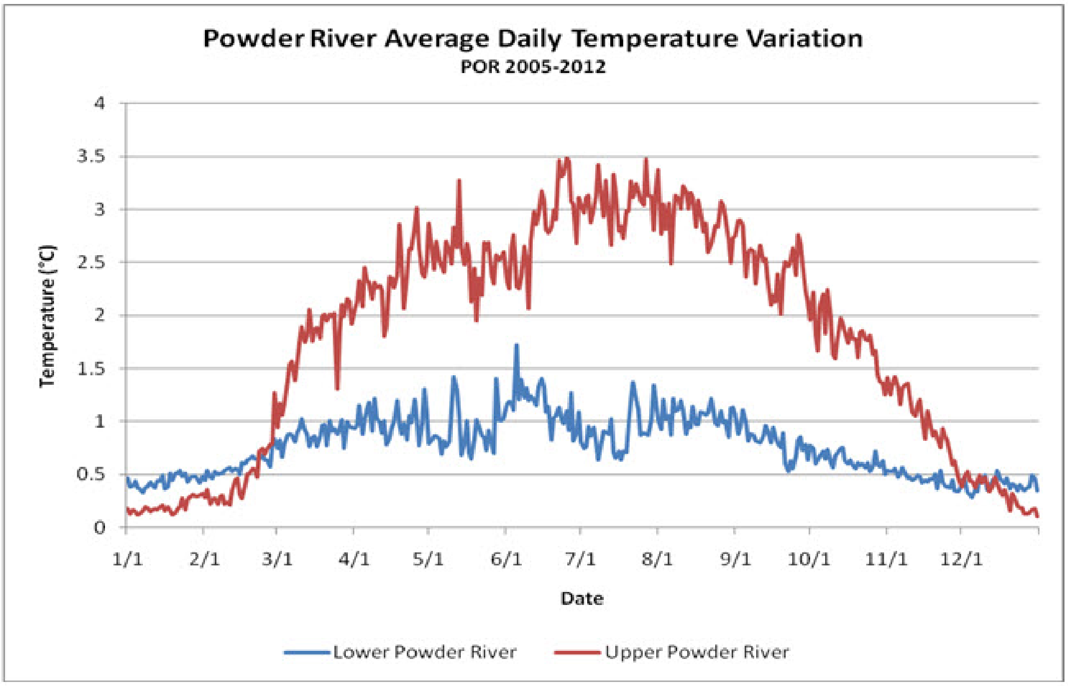

Figure 57. Powder River Average Daily Temperature Variation (maximum – minimum).

Beginning in May, Phillips Lake starts to stratify with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. These differences increase to 10° C by July, as the surface layer warms to more than 20° C (above bull trout tolerances), while the temperatures near the bottom of the reservoir remain relatively constant between 10.4° C to 11.2° C (preferred bull trout temperatures).

Lake Creek is a tributary to Deer Creek. Deer Creek enters Phillips Lake approximately 5 miles downstream of the confluence between Lake and Deer Creeks. Bull trout are known to occur in Lake Creek approximately 1½ miles upstream from the confluence with Deer Creek (or about 6½ miles upstream of Phillips Lake) (USFWS 2009, p. 253). According to the U.S. Forest Service, 7-day maximum temperatures exceeding 18° C have been recorded at the Deer Creek temperature gage (FERC 2009, p. 20).

Dissolved Oxygen

Dissolved oxygen profiles were also collected along with the temperature profiles and similar situations were observed as with temperatures. During the early summer stratification period, dissolved oxygen levels were suitable for bull trout through July in the top portion of the water column (Figure 58). The oxygen depletion became more evident as the year progressed, likely due to the reservoir becoming strongly stratified and increased bacterial respiration in the hypolimnion removed dissolved oxygen. Oxygen depletion was noted throughout the water column and oxygen was depleted below 7 mg/L at 10 to 15 meters beginning in June. Although the temperatures in the hypolimnion remain suitable for bull trout, the dissolved oxygen levels quickly drop below bull trout tolerances as the season progressed. In some years, an anoxic zone developed and extended from the bottom to 10 meters (i.e., August 2007). Based on the chlorophyll a concentrations and the early season oxygen depletion, it is likely that excess aquatic growths are a regular occurrence in Phillips Lake.

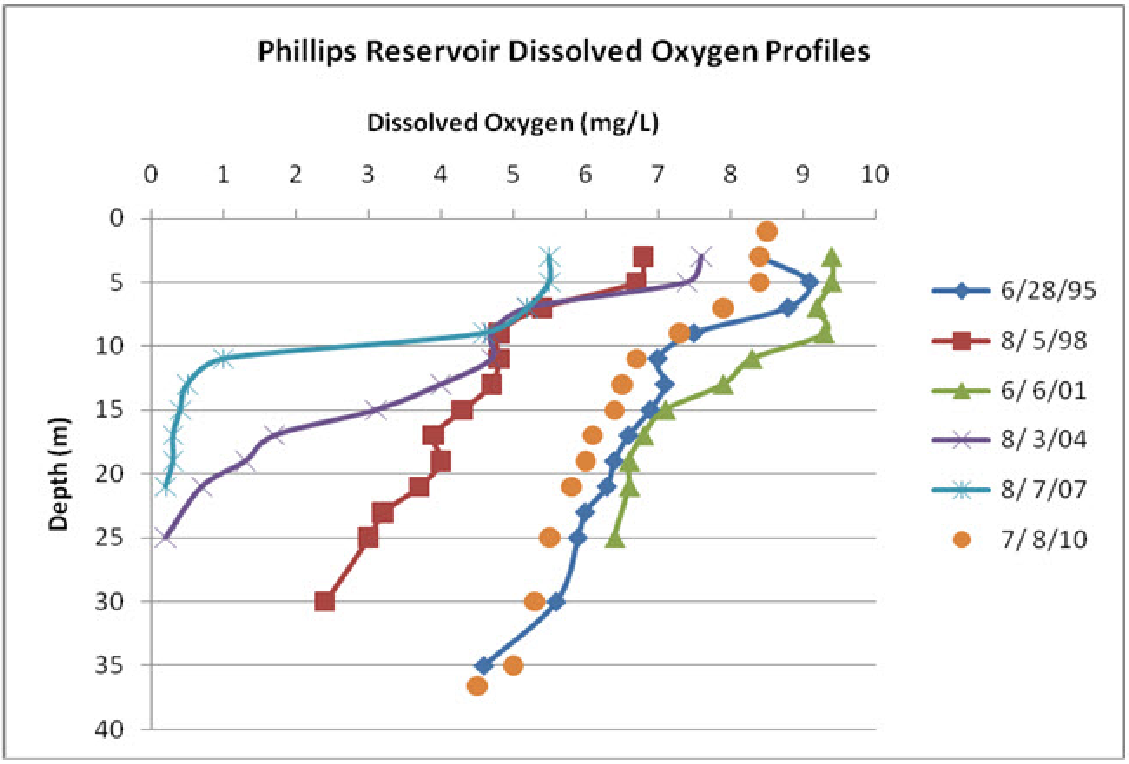

Figure 58. Phillips Lake dissolved oxygen profiles.

Total Dissolved Gas

Reclamation has collected few total dissolved gas samples downstream from Phillips Lake. Six samples were collected, once in each year during 1995, 1998, 2001, 2004, 2007, and 2010 as part of the Regional Reservoir Monitoring Program. However, because the number of samples is very low, little can be said about TDG generation below Mason Dam.

The yearly samples ranged from 109 to 114 percent TDG which may indicate that the discharge from Mason Dam generates TDG at or above state water quality standards during summer operations. Critical to the development of GBT is the availability of deep water to compensate for elevated TDG or the proximity to riffles and rapids which may quickly degas the river. It is unknown at this time if GBT has been reported below Mason Dam. If sufficient depth is available for fishes below the depth compensation point, TDGs in this range may not be harmful or cause GBT.

Sediment/Turbidity

Reclamation has collected sediment/turbidity samples from Phillips Lake or from below the reservoir in the Powder River intermittently. Three samples were collected in 2001, 2007, and 2010 and four samples were collected in 2004. TSS levels were very low in this set of samples, with a mean concentration for the period of record of 3.54 mg/L and a range of 7 to 1 mg/L. In addition, Reclamation measured turbidity and Secchi depths of the reservoir waters to measure water clarity. While turbidity values were very low, 2 to 3 NTU, indicating very clear water, Secchi depths were variable. Secchi depths ranged from relatively clear, near 3.1 meters deep, to relatively shallow of 1.6 meters deep. Coupled with the clarity measures, chlorophyll a and TSS samples give an indication that the clarity issues in Phillips Lake are likely biological in origin such as algae blooms rather than sediment-impaired clarity. Biological clarity issues can be episodic in nature with variable frequency. Sediment and turbidity issues should not impact sight foraging and are very low indicating that gill abrasions or other secondary or delayed mortality issues associated with high TSS or turbidity should be minimal.

Other Water Chemistry

Nutrient cycling within a reservoir, especially one with dissolved oxygen depletions in the hypolimnion, are often strongly associated with stratification. As the upper surface waters are isolated from the sediments, nutrients are depleted through biological uptake and sedimentation. It is not uncommon for primary production in the epilimnion to become limited by nutrients. Furthermore, this nutrient limitation can lead to the expression of nuisance levels of some algae taxa, such as blue green algae as they can fix nitrogen from the atmosphere. At depth, the nutrient cycling is expressed by the liberation of nutrients under anoxic conditions. These liberated nutrients are isolated from primary production until the reservoir's stratification breaks down and mixing processes bring these nutrients to the surface.

However, the levels of the measured constituents in Phillips Lake were moderate to low. These levels in most all cases indicated a lower loading and degradation of water quality compared to near-by reservoirs. The average TP concentrations from the surface waters near the dam were 0.019 mg/L respectively and at depth, TP concentrations during the summer stratification period averaged 0.02 mg/L. In comparison, some eutrophic reservoirs averaged greater than 0.100 mg/L while mesotrophic reservoirs TP concentrations are typically between 0.01 and 0.025 mg/L (Carlson 1977). TN:TP ratios were also telling in Phillips

Lake; in dam area, the TN:TP ratio was never less than 5, which indicates excess TP. The ratio was almost always greater than 10 and, in some cases, was greater than 50. Biologically this indicates that blue green algae and other unpalatable forms of nitrogen-fixing algae should not dominate the reservoir as nitrogen is common. Furthermore, the types of algae that are often associated with these TN:TP ratios should provide suitable forage for zooplankton and other aquatic invertebrates. The average TN:TP ratio was approximately 23, indicating that under normal best conditions TN would not be limiting.

For lakes, Carlson's TSI can be used to determine if a lake is undergoing cultural eutrophication (Carlson 1977). As previously discussed, some Western environmental quality agencies use a TSI score of 50 as a threshold value to indicate impaired water quality in many of the TMDLs completed for excess nutrients in lakes (UDEQ 2000). Many States and water quality entities also use a TSI target of 50 as their management goals. However, a certain trade off exists between fish production and water quality. Mesotrophic reservoirs are often seen as well balanced in terms of fish production and water quality; therefore, mesotrophic lakes are viewed by many as the ideal target. In more oligotrophic lakes, fish production is lower while water clarity is higher. The same trade off exists for eutrophic waters with higher fish production and lower water clarity. However, often the fish production seen in eutrophic waters in the west is towards less desirable species of fishes, as the water quality is such that the higher temperatures or lower dissolved oxygen levels seen in eutrophic waters stress salmonids, which are the more desirable species.

The average TSI value calculated for Phillips Lake was 42.01, below the mesotrophic break point of 50, indicating the reservoir is mesotrophic to slightly oligotrophic. In general, this indicates that a nutrient loading from the watershed is balanced with the nutrient cycling within the reservoir.

The individual components of Carlson's TSI can be broken into its individual components to determine if nutrients are in excess. A TSI of 50 corresponds with 0.024 mg/L of TP and 0.734 mg/L of TN. A TSI of 50 corresponds with a 2 m Secchi depth and a concentration of 7.23 µg/L for chlorophyll a. Near the dam in Phillips Lake, the average TSI for the individual components were 43 for TP, 36 for TN, 45 for chlorophyll a, and 49 for Secchi depth. Based upon these numbers, Phillips Lake exhibited slightly elevated TP with lower TN numbers, indicating a possible trend towards nitrogen fixing algae.

The average Secchi depth for the reservoir was very near the mesotrophic threshold of 50 with some individual recordings slightly above (range 44 to 53). A similar pattern was seen in chlorophyll a concentrations collected in the epilimnetic waters during the summer time. Summer-time epilimnetic chlorophyll a averaged 6.86 mg/L, or TSI of 49.49, near the dam. The apparent correlation between the chlorophyll a and Secchi data at the dam location was likely due to a decrease in water clarity due to increased algal biomass.

The TSI scores in a reservoir can be further complicated under severe drawdown events as well as during spring filling events. The complications from drawdown events, which occur annually at Phillips Lake, can arise when phosphorus is mobilized from the sediments in the deeper portions of the lake due to natural processes under anaerobic conditions.

When a lake is drawn down, the hypolimnetic layer of water, with the elevated TP concentrations can become mixed with the epilimnetic (and low TP) waters, enriching the system later in the year when it is typically poor in nutrients (Wetzel 1983). In addition, sediments rich in adsorbed TP can be remobilized as the waters recede (Wetzel 1983). Both of these situations likely occur in Phillips Lake annually.

Further investigations are required to determine if there is a significant trend in TSI scores; however, it appears from TSI values for chlorophyll a and Secchi that the reservoir contains adequate nutrients as the TSI scores were typically in the mid-40s to 50s, while nutrient scores were near 30 to 40. Thus, it is highly likely that nutrients are currently in balance with primary production.

MAINSTEM SNAKE/COLUMBIA RIVER SYSTEMS

Reclamation's 2004 Upper Snake Biological Assessment (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 (Reclamation 2004, pp. 248-252). Plans for achieving State water quality standards in water quality-limited stream reaches in the action area have been formulated through the TMDL process specified under Section 303(d) of the Clean Water Act. Table 9-3 in Reclamation's 2004 Upper Snake BA provides the Section 303(d) listings and TMDL schedule at that time for achieving State water quality standards in the upper Snake River basin reaches and major tributaries in areas affected by Reclamation project operations. The following text provides recent information on water quality monitoring in the upper Snake River basin since publication of the 2004 Upper Snake BA.

Snake River Water Quality Conditions

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 (Reclamation 2004, pp. 248-252). Plans for achieving State water quality standards in water quality-limited stream reaches within the action area have been formulated through the TMDL process specified under Section 303(d) of the 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. The following text provides recent information on water quality monitoring in the upper Snake River basin since publication of the 2004 Upper Snake BA.

Temperature

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 in-river locations among irrigated lands in the upper Snake River. This study is anticipated to continue through 2015.

Reclamation currently has 52 water temperature monitoring sites throughout the upper Snake River basin. To supplement this, 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 (Reclamation 2007, p. 59).

Water temperature data from Reclamation’s 2007 Upper Snake River BA are displayed from upstream to downstream in Figure 59 through Figure 61. 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. 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 in the following discussions illustrate water temperature differences in the Snake River (Reclamation 2007, p. 59).

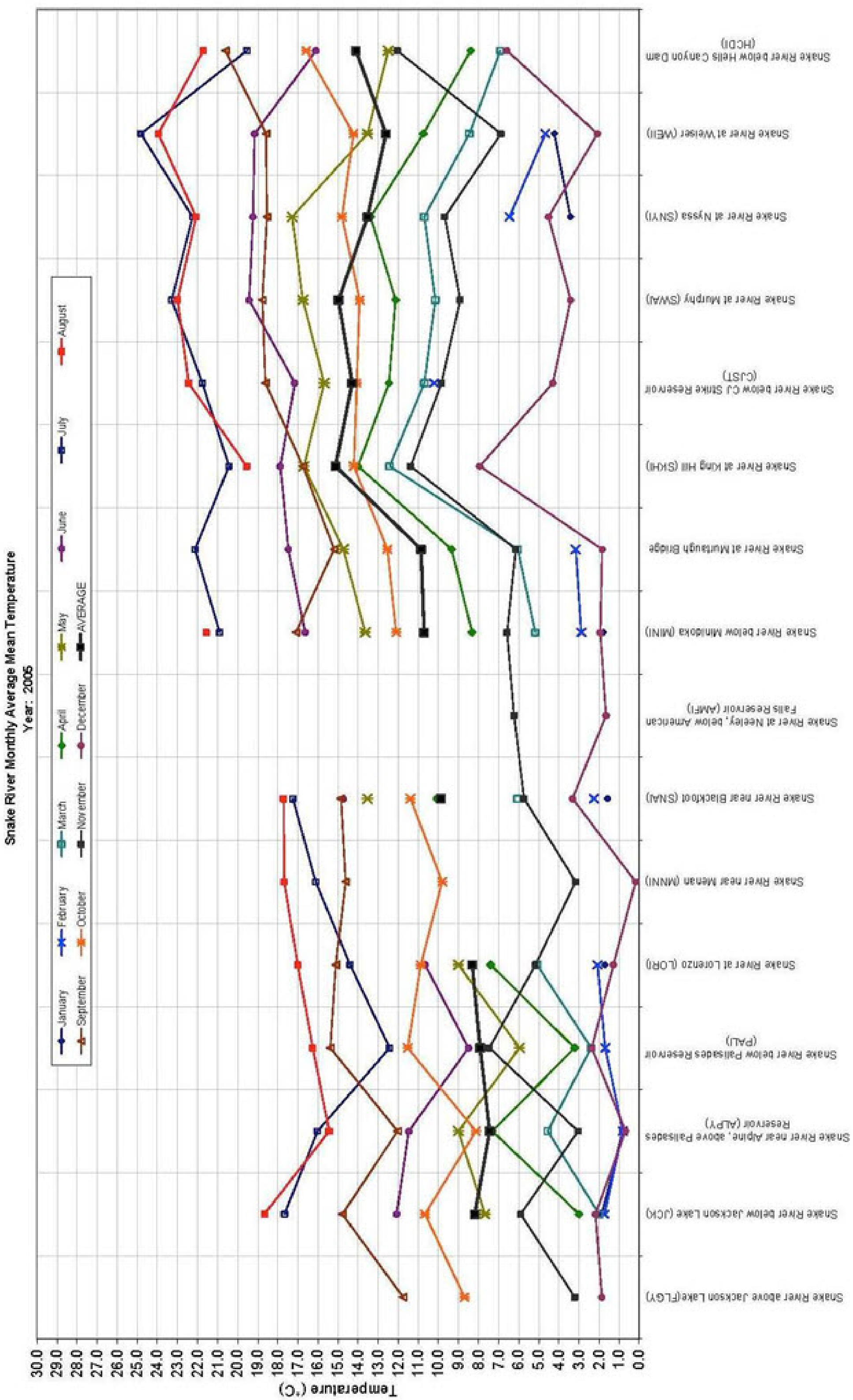

Figure 59. Average monthly water temperature at locations along the Snake River – 2005 (from Reclamation 2007, p. 60).

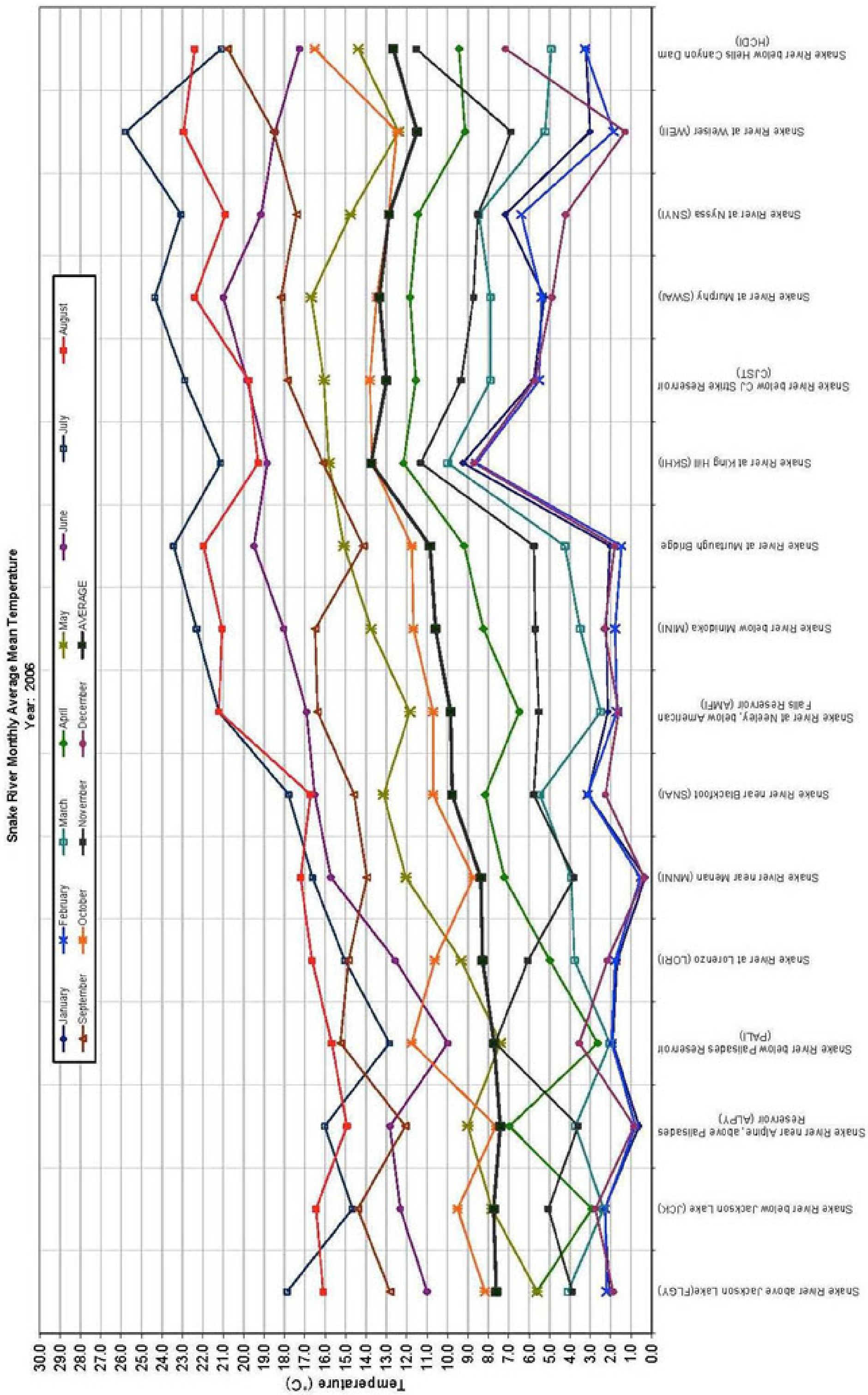

Figure 60. Average monthly water temperature at locations along the Snake River – 2006 (from Reclamation 2007, p. 61).

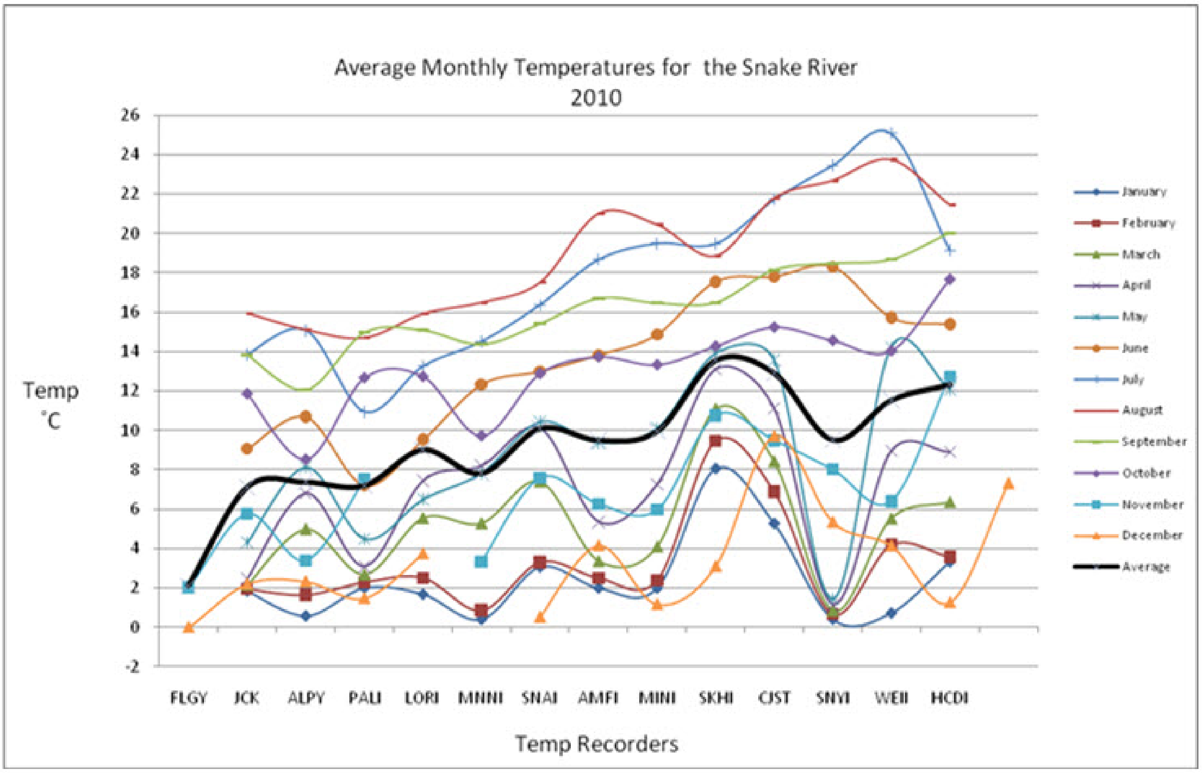

Figure 61. Average monthly water temperature at locations along the Snake River – 2010.

Many factors interact to influence water temperature and contribute to temperature dynamics in the Snake River and its tributaries, including 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. Figure 59 and Figure 60 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 (Figure 59 and Figure 60). 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 River basin will be identified; however, a future predictive modeling effort is not anticipated at this time (Reclamation 2007, p. 59).

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 (Figure 59 and Figure 60).

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 the ratio of discharges from Hells Canyon Dam on the Snake River and Dworshak Dam on the Clearwater River. 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 drafted for flood control purposes. Under high water year conditions, cold water residing in the reservoir over the 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 from 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. 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 River 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 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 NOAA Fisheries Service, 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). The 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 BA proposed actions in place, in most years resulting temperatures did not exceed 20°C at Lower Granite Reservoir (NOAA Fisheries Service 2005a; see 2005 Upper Snake BiOp, Tables 6-10 and 6-11).

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 substantially reduce 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 study (2000) 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.

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 are expected.

Sediment/Turbidity

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. 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.

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 runoff 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.

Columbia River Water Quality Conditions

Temperature

Reclamation, the U.S. Army Corps of Engineers, and the Public Utility Districts have collected temperature data at various water quality monitoring locations throughout the Columbia River. Typically these locations are in the forebay or tailraces of the various projects. This temperature data has been summarized to daily average temperature for a 10-year period beginning in 2002, and monthly average temperature, which illustrates the annual progression of river warming and cooling (Figure 62).

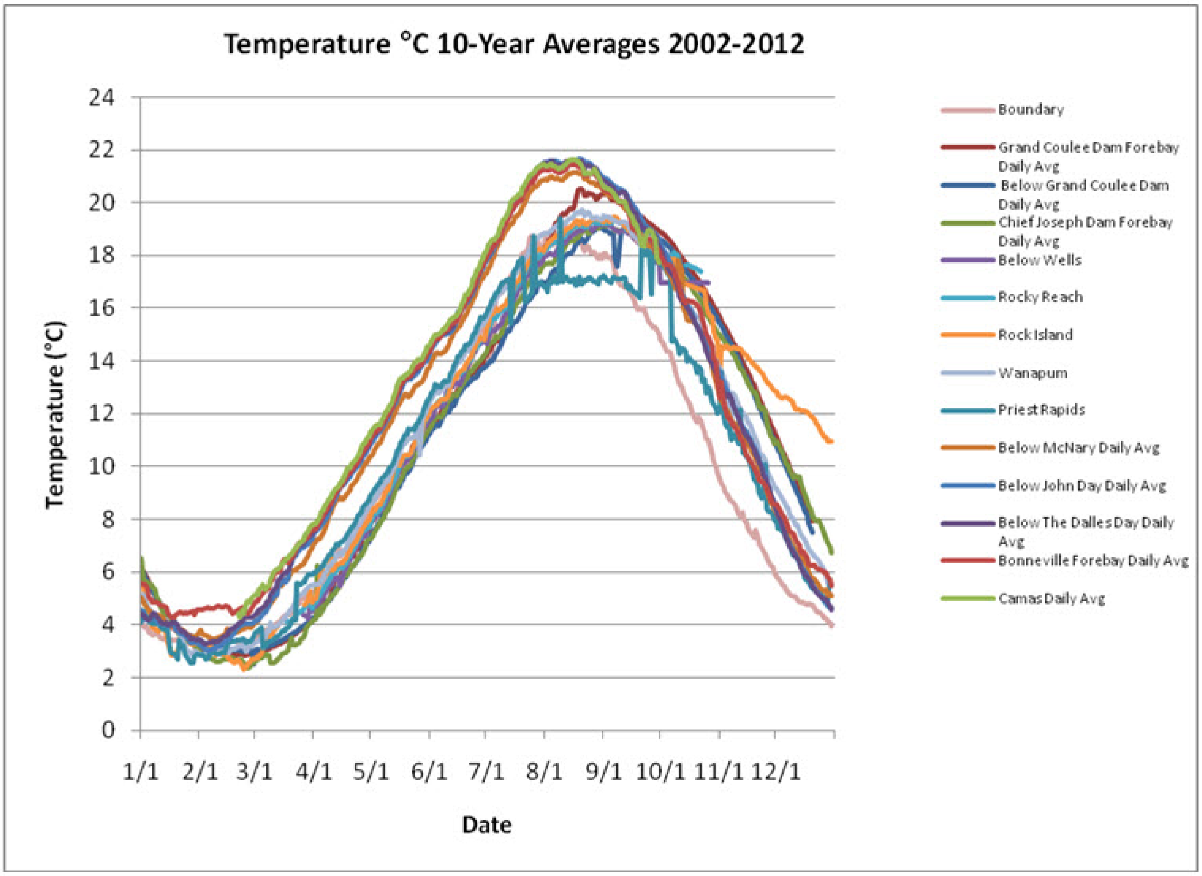

Figure 62. Average temperatures of the Columbia River, 2002-2012.

Average daily winter (January through March) temperatures throughout the Columbia River are relatively low, ranging from 3 to 6° C from the forebay of Grand Coulee to the Camas/Washougal monitoring location (Figure 63). Most of the reservoirs and impoundments are likely isothermal with relatively constant temperatures. The river begins to warm through August and September, exceeding bull trout tolerance levels as early as June 5 at the lower most monitoring location and throughout the whole mainstem by July 11 (Figure 64 and Figure 65). The tributaries entering the Columbia River below Priest Rapids clearly changes the temperature regime in the river with much warmer temperatures that the upper reaches of the river (Figure 64).

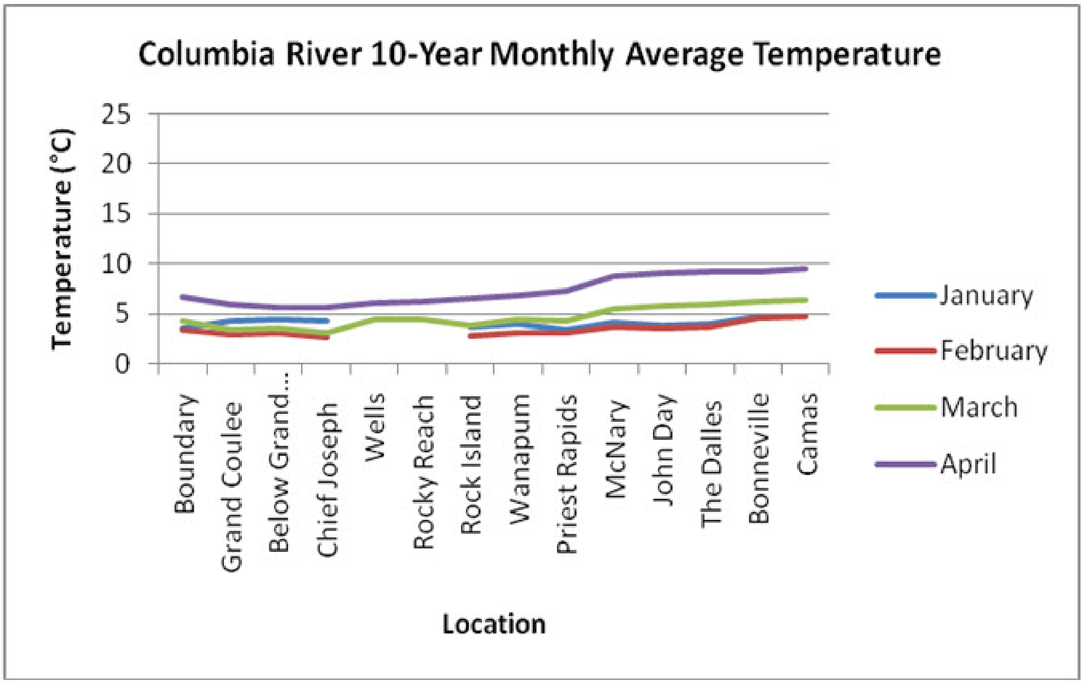

Figure 63. Monthly 10-year average temperature for the Columbia River, January through April.

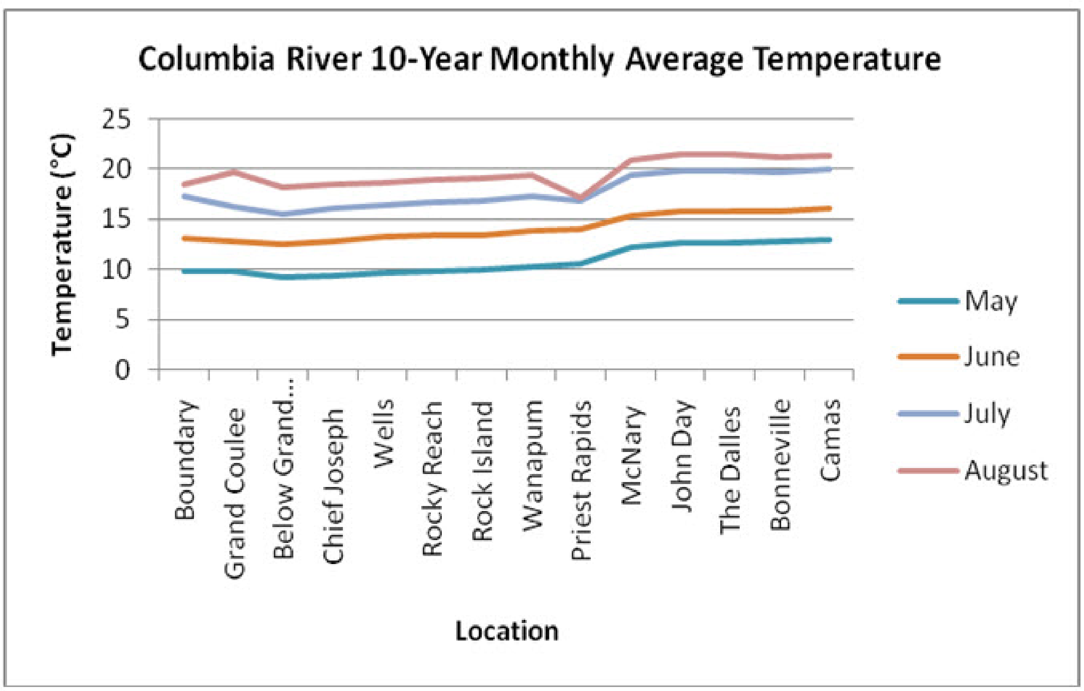

Figure 64. Monthly 10-year average temperature for the Columbia River, May through August.

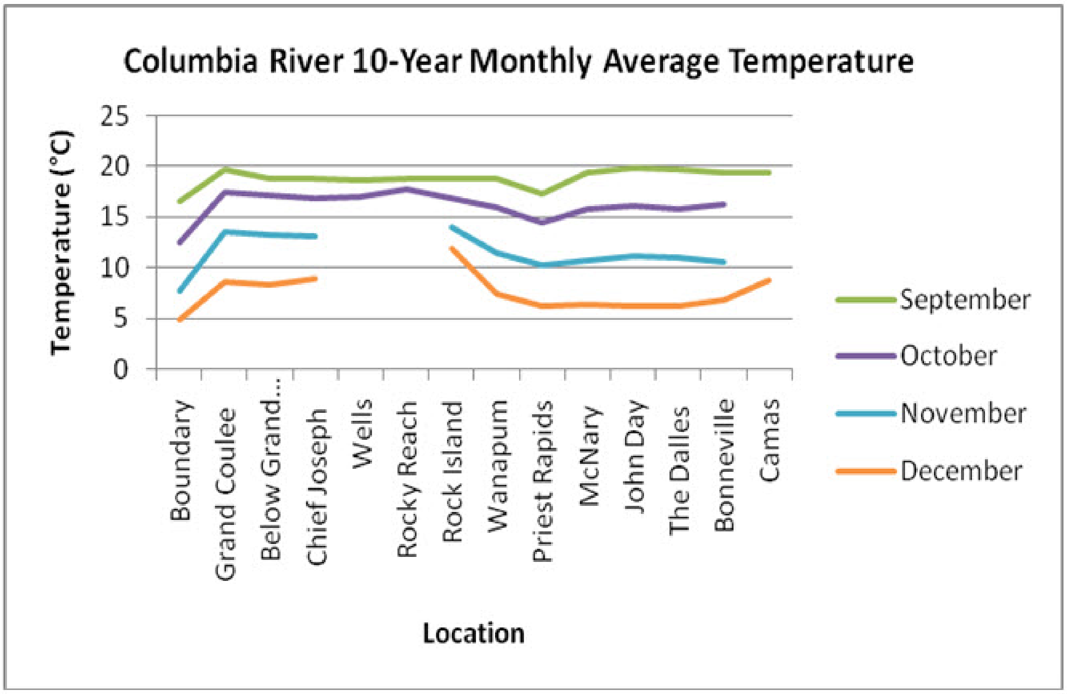

Figure 65. Monthly 10-year average temperature for the Columbia River, September through December.

Total Dissolved Gas

High temperatures and elevated gas saturation appear to be the main water quality concerns below Grand Coulee Dam and throughout much of the lower Columbia River (Pickett et al. 2004; Beeman et al. 2003; Vermeyen 2000) (Figure 66). Water can be spilled at Grand Coulee Dam over drum gates when the reservoir is above elevation 1265.5 feet and through a series of outlet works conduits when the reservoir is below elevation 1265.5 feet (Beeman et al. 2003). Production of TDG saturation is greater when water is spilled through the outlet works than over the drum gates due to the energy of the outlet works jet that increase the depth of plunge. Although the drum gates are higher in elevation, the spill is spread out over a wide area which dissipates some of the energy so the plunge is not as deep. In addition to TDG generation through the outlet works and drum gates, TDG generated at upstream locations is generally passed through the system via the generation units. Little stripping of gas occurs in this route through the reservoir.

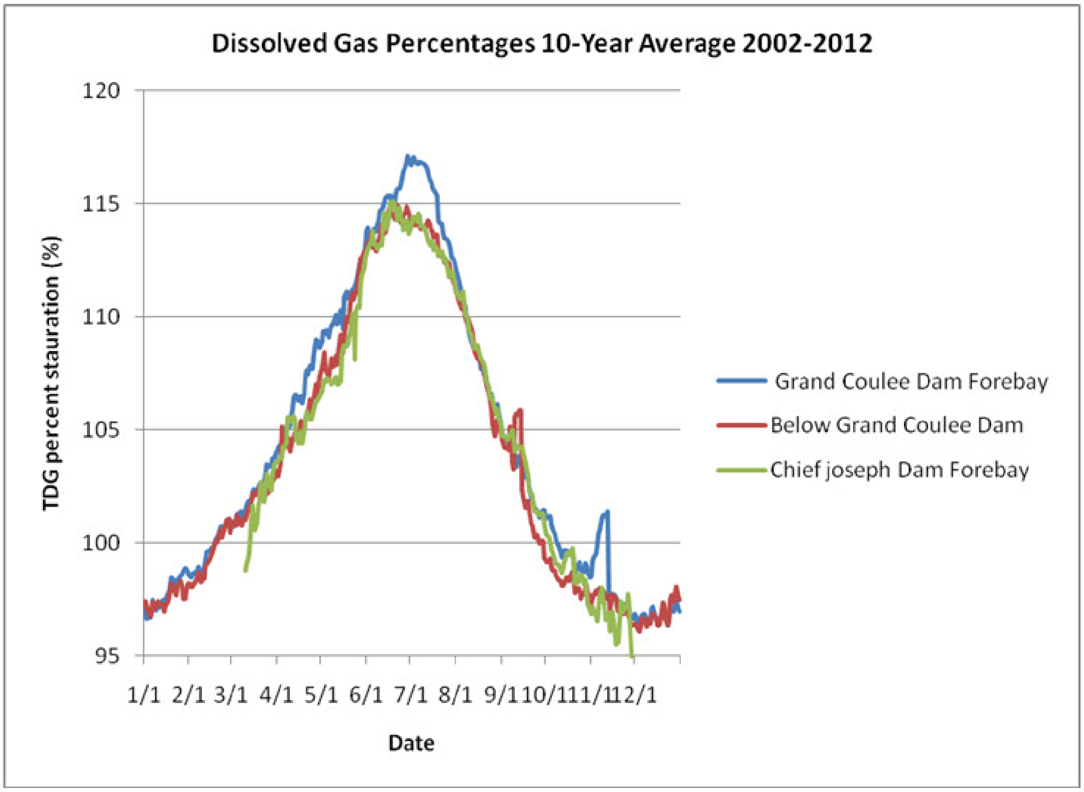

Figure 66. Total dissolved gas levels, 20-year average, 2002-2012.

Some TDG dissipates as water moves through Lake Rufus Woods due to wind mixing the surface waters, allowing the supersaturation to dissipate. The reduction of TDG between projects is limited and generally TDG delivered from Grand Coulee to Chief Joseph has nearly the same saturation.

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