Volume I

Klamath Facilities Removal
Final Environmental Impact Statement/ Environmental Impact Report

State Clearinghouse
2010062060

U.S. Department of the Interior

CA Department of Fish & Game

December 2012

Volume I

Klamath Facilities Removal
Final EIS/EIR

State Clearinghouse # 2010062060

Appendix AB of Volume III of the Final EIS/EIR contains the exact content changes made to the public Draft EIS/EIR. This comparison appendix includes changes to text, tables, and figures and does not include font and formatting changes. Please see Volumes I and II of this Final EIS/EIR for a version of the EIS/EIR where changes have been incorporated.

U.S. Department of the Interior
California Department of Fish & Game

December 2012

Mission Statements

U.S. Department of the Interior

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

California Department of Fish and Game

The mission of the Department of Fish and Game is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

Klamath Facilities Removal
~~Draft~~Final Environmental Impact Statement/Environmental Impact Report

Siskiyou County, California
Klamath County, Oregon

Lead Agencies: U.S. Department of the Interior, through the Bureau of Reclamation (Reclamation), and California Department of Fish and Game (CDFG), Sacramento, California.

State Clearinghouse # 2010062060

ABSTRACT

This Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) evaluates the potential impacts of the removal of the four PacifiCorp[1] dams on the Klamath River as contemplated in the Klamath Hydroelectric Settlement Agreement (KHSA). The Klamath Basin Restoration Agreement (KBRA), as well as the transfer of Keno Dam, will be treated and analyzed as a connected action. Together, these two agreements attempt to resolve long-standing conflicts in the Klamath River Basin, located in southern Oregon and northern California. The KHSA and KBRA provide for the restoration of native fisheries and sustainable water supplies throughout the Klamath River Basin. Specifically, the KHSA established a process for a Secretarial Determination. This process includes studies, environmental review, and a decision by the Secretary of the Interior regarding whether removal of J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams (1) will advance restoration of salmonid (salmon, steelhead, and trout) fisheries of the Klamath Basin, and (2) is in the public interest, which includes but is not limited to, consideration of potential impacts on affected local communities and Tribes.

This EIS/EIR has been prepared according to requirements of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Direct, indirect, and cumulative impacts resulting from the project alternatives on the physical, natural, and socioeconomic environment of the region are addressed.

~~Comments on this document must be submitted by November 21, 2011. Reclamation and CDFG will consider comments on the Draft EIS/EIR received during the 60-day review period.~~

FOR FURTHER INFORMATION CONTACT:

Elizabeth Vasquez
Bureau of Reclamation
2800 Cottage Way, Sacramento CA 95825
Phone: (916) 978–5040
Email: klamathsd@usbr.gov
Fax: (916) 978–5055

Gordon Leppig
California Department of Fish and Game
619 Second Street, Eureka CA 95501
Phone: (707) 441-2062
Email: KSDcomments@dfg.ca.gov
Fax: (707) 441-2021

[1] PacifiCorp refers to the current utility and all previous owners/names.

Executive Summary

ES.1 Introduction

This document, *Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report* (EIS/EIR), has been developed in accordance with the requirements of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) to analyze the potential impacts to the environment from ~~removing~~ the proposed removal of four PacifiCorp Dams (J.C.Boyle, Copco 1, Copco 2, and Iron Gate, collectively referred to herein as the Four Facilities) on the Klamath River under the Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA is one part of a basin-wide approach to address ~~the~~ continuing ~~and~~ unresolved ~~issues related to the basin resources that have resulted~~problems resulting from over-stressed water supplies and water quality concerns~~.~~ in the Klamath Basin, including impacts to basin fisheries.

~~Due to these unresolved issues, during the previous ten years, the federal government~~Since 2001, the Federal Government has faced events and taken unprecedented and extraordinary actions in the Klamath Basin largely because of these unresolved problems. The following are examples of some of these events and actions:

- In spring of 2001, the ~~federal government~~ Federal Government announced there would be no deliveries of water from Upper Klamath Lake or the Klamath River to the Bureau of Reclamation's (Reclamation's) Klamath Project due to the combined effects of severe drought and Federal Endangered Species Act (ESA) concerns - the first time project water deliveries were not made at a Reclamation project (very limited deliveries occurred later in the summer).
- In 2002, there was a major fish die-off in the Klamath River of adult fall-run Chinook salmon (at least 30,000 fish).
- In 2005, public health warnings ~~of~~to avoid contact with water in Iron Gate and Copco Reservoirs due to toxic algae blooms began being posted annually.
- In 2006, low abundance of Klamath Basin Chinook salmon lead to severe restrictions on commercial and recreational harvest along 700 miles of the California and Oregon coast, as well as major reductions in Klamath River recreational and tribal fisheries.
- ~~In 2009, Klamath area commercial salmon harvest was closed.~~
- In 2010, there was a significant reduction in water deliveries to Reclamation's Klamath Project due to dry hydrologic conditions.
- In 2010, the Klamath Tribes limited their harvest of suckers to ceremonial use for the 25th consecutive year and experienced their 92nd year without access to salmon.

These events and actions~~, plus others not mentioned, have demonstrated~~ demonstrate the need for long-term solutions that address these complex and basin-wide ~~issues~~problems. There have been limited and piecemeal approaches that have provided interim relief or some mitigation, but

the Klamath Basin faces substantial, long-term challenges that many believe call for different and more ~~comprehensive~~basin-wide approaches. As stated above, the KHSA is one part of a proposed basin-wide approach to resolve these issues.

~~**KHSA**~~

ES.1.1 Klamath Hydroelectric Settlement Agreement

The KHSA is ~~an~~a negotiated agreement to study the potential removal of four dams on the Klamath River and, should a decision be made to remove these dams, the agreement provides a path forward on undertaking this removal. The ~~potential removal of dams can be one of, or a part of, other long-term solutions to basin challenges. The~~ KHSA was ~~developed~~signed by representatives of 45 organizations including ~~f~~Federal agencies, the States of California and Oregon, PacifiCorp, Indian Tribes, counties, irrigators, and conservation and fishing groups in order to ~~end~~address one of the most economically, environmentally, and culturally devastating water disputes in the western United States. The terms of the KHSA acknowledge, however, that there are many unknown consequences regarding the potential removal of these facilities~~ and thus~~. Thus the agreement requires that the Secretary of the Interior undertake a series of scientific studies to determine whether dam removal would ~~be~~meet criteria including: being in the public interest and ~~would advance~~advancing restoration of the salmon fishery. If the Secretary, in cooperation with the Secretary of Commerce and other Federal agencies as appropriate**,** determines that dam removal fulfills these criteria~~,~~ and makes a positive determination(Affirmative Secretarial Determination), the States of Oregon and California will consider whether to concur in that determination.[1] If the governors concur, dam removal will proceed in accordance with the KHSA.

This joint EIS/EIR is intended to provide the required environmental review for both the Secretarial Determination and the gubernatorial concurrences. Consequently, this EIS/EIR has been prepared by the United States Department of the Interior (DOI), as lead NEPA agency, and the California Department of Fish and Game (CDFG), as lead CEQA agency (collectively referred to herein as Lead Agencies). Recognizing that elements of the Proposed Action would occur in California and Oregon, CDFG collaborated with DOI, with input from the State of Oregon, to make a reasonable, good faith effort in disclosing all significant environmental effects of the Proposed Action. Absent certain circumstances, CEQA does not apply to any project or portion thereof located outside of California which will be subject to environmental review pursuant to NEPA. (Public Resources Code § 21080(b)(14); CEQA Guidelines § 15277).

[1] There are certain conditions that must be met prior to the Secretary making this determination. One such condition is the enactment of federal law authorizing the KHSA which has not occurred as of this time. There are also other requirements. For a complete list of these requirements, please see ~~KlamathRestoration~~http://klamathrestoration.gov~~.~~/, which has the KHSA posted in its entirety.

ES.1.2 Klamath Basin Restoration Agreement

The Klamath Basin Restoration Agreement (KBRA) ~~The KBRA~~ is also a negotiated agreement that reflects a basin-wide approach to addressing the current resources challenges. The KBRA was negotiated concurrently with the KHSA and has been signed by most of the parties to the KHSA, but the Federal agencies are not yet parties to the KBRA. The KBRA will be signed by ~~the United States upon congressional authorization.~~[2] Federal agencies when Congress authorizes them to do so.[3] The complete KBRA package entails various commitments and actions that have been or will be proposed and/or undertaken in the basin by ~~federal, state~~Federal, State, local, tribal, and private interests. Some of the KBRA actions could have effects (whether adverse or beneficial) on the same environmental resources that would be affected by dam removal. Some KBRA actions are expressly preconditioned by and therefore hinge upon dam removal, and an ~~a~~Affirmative Secretarial Determination. Some KBRA actions are ~~f~~Federal but are not expressly linked to dam removal, and some actions ~~are completely between private~~involve only non-Federal parties.

NHPA Section 106 Process
DOI elected to utilize the NEPA pr re N (N S ur S re da S pr po tri 10 ar ef al ar re to S

~~**NHPA Section 106 Process**~~
~~DOI elected to utilize the NEPA process to meet the federal requirements of Section 106 of the National Historic Preservation Act (NHPA) as allowed under 36 CFR Section 800.8(c). DOI defines the undertaking, for purposes of Section 106 of the NHPA, as the removal of the four PacifiCorp dams which may be a result of the Secretarial Determination. The proposed undertaking has the potential to affect historic properties triggering compliance with Section 106 of the NHPA. The analysis and consultations concerning any effects of the Proposed Action and alternatives on historic properties are integrated into the NEPA review and documentation pursuant to the criteria identified in 36 CFR Section 800.8(c)(1)-(4).~~

ES.1.3 NEPA – Specific Analysis

The ~~federal lead agency~~Federal Lead Agency, the DOI, is analyzing the KBRA as a connected action~~.~~ to the proposed Secretarial Determination under the KHSA. NEPA defines connected actions as those actions that are closely related to or cannot or will not proceed unless other actions are taken previously or simultaneously (40 CFR 1508.25(a)(1)(ii)).[4] Some actions or component elements of the KBRA are independent obligations and thus have independent utility from the KHSA, but the implementation of several significant elements of the KBRA ~~package~~ would be different, if the ~~determination~~Secretarial Determination

[2] ~~Under the KHSA and KBRA (Agreements) the United Sta Determination under the KHSA, and obligated to implement the KBRA according t~~

[3] Under the KHSA and KBRA (Agreements) certain agencies of " " shall become parties to the KBRA upon enactment of authorizing le become parties (KBRA Section 1.1.2).

[4] We acknowledge, however, that the KBRA could also be analyzed as a cumulative or similar action under 40 CFR 1508.25(a)(2) and (3). We note that all three definitions (connected action, cumulative actions, and similar actions) are within the section that provides parameters for the "scope" of the action, which determines both the range of alternatives and the impacts to be considered in an EIS. Ultimately, however, we believe the important point is not the labeling but the analysis and whether the decision (in this case whether to remove four dams) is informed by a EIS that is proper in scope.

under the KHSA is not to pursue full dam removal. Recognizing that implementation of many elements of the KBRA are unknown and not reasonably foreseeable at this time, the connected action analysis under NEPA is being undertaken at a programmatic level. Consequently, appropriate ~~NEPA compliance~~future project-level analysis under NEPA will be completed for the KBRA in the future~~.~~ as project-specific proposals are developed.

For purposes of this analysis, the KBRA, a connected action, is viewed as a whole program even though some of its component parts are currently being implemented (those without a ~~f~~Federal nexus or not subject to environmental review) or could be implemented on an individual basis without dam removal. One of the reasons why the KBRA is treated as a whole for purposes of this ~~analysis under NEPA~~EIS/EIR is that the individual activities under the KBRA will be implemented, through adaptive management and in close coordination with committees comprised of stakeholders, in a manner that seeks to attain synergy and optimize benefits through a coordinated, holistic approach to restoration and water management. Implementing those KBRA activities that are not connected to facilities removal on an individual basis without the benefit of adaptive management and stakeholder input will likely not ~~provide the same level of optimization.~~ optimize benefits.

Consequently, for purposes of NEPA, in the EIS for alternatives where dams are not removed, the KBRA, as currently signed by the parties, would not be implemented. This is not a judgment about whether any particular measure in the KBRA will be implemented in the absence of dam removal. Rather, it is an assumption that in the absence of dam removal, the KBRA will not include all of the components present in their current form. This means that this document does not make decisions about implementing any specific program, plan, commitment, or activity under the KBRA if dams are not removed. Federal decisions on specific measures in the KBRA, including any necessary additional environmental review, will be made in a separate process. This document will be used to inform a decision related only to dam removal. In doing so, NEPA requires that we properly scope the EIS to include a discussion of connected actions. Further NEPA Section 40 CFR 1508.25 recognizes the interrelationship of scope to other statements and encourages ~~to tier~~tiering EISs, focusing on issues as they are ripe for decision.

ES.1.4 CEQA – Specific Analysis

CDFG, as ~~lead agency~~Lead Agency under CEQA, is also analyzing relevant parts of the KBRA in a programmatic fashion, as described in Section 15168 of the CEQA Guidelines. This decision was made because many of KBRA's component elements have not been specified to a degree where the associated impacts would be reasonably foreseeable for purposes of this environmental analysis. The parties recognize that future project-specific analysis may be required for various components of the KBRA as they become more clearly defined and when a public entity, as defined by CEQA Guidelines ~~s~~Section 15379, identifies a discretionary approval pursuant to CEQA Guidelines ~~s~~Section 15378, which would obligate subsequent review. A program-level document is appropriate when a project consists of a series of smaller projects or phases that may be implemented separately. Under the programmatic EIR approach, future projects or phases may require additional, project-specific environmental analysis. It should also be noted that this EIR makes certain assumptions about the foreseeable effects of KBRA based on existing information, including, among other things, how the fishery and water resources

programs may be designed and implemented. CDFG recognizes that subsequent environmental analysis may be required by any California public entity with an approval or permitting obligation if the circumstances specified by CEQA Guidelines ~~s~~Section 15162(a) are triggered.

Importantly, CDFG could have analyzed the associated impacts of the KBRA relative to the KHSA in the indirect and cumulative impacts analysis portion of the KHSA EIR as it is not affirmatively approving or carrying out any one aspect of the KBRA that would be subject to environmental review. CDFG recognizes it is not "approving" any discretionary portion of the KBRA that could alter the physical environment and that by signing the KBRA it has already executed and committed to the agreement itself. Thus, similarly to the EIS, there are no alternatives that consider what a new or revised KBRA might look in the event dams are not removed. Rather, to avoid confusion, duplication, and wasted resources, CDFG has determined that the concurrent and connected nature of the KBRA to the KHSA warrants a clear understanding of its potentially significant impacts and that the approach of programmatic analysis is equally, if not more, sufficient for providing that information to decision-makers.

Thus, out of an abundance of caution, and to ensure full transparency, CDFG has agreed to consider significance determinations for the KBRA in a programmatic fashion. Recognizing that elements of the Proposed Action would occur in California and Oregon, CDFG collaborated with DOI ~~to~~, with input from the State of Oregon, to make a reasonable, good faith effort in disclosing all significant environmental effects of the Proposed Action. Absent certain circumstances, CEQA does not apply to any project or portion thereof located outside of California which will be subject to environmental review pursuant to NEPA~~.~~ (Public Resources Code § 21080(b)(14); CEQA Guidelines § 15277). CDFG considers the ~~proposed actions~~Proposed Actions by California to be implementation of the KHSA and thus has crafted alternatives only for dam removal itself, assuming that absent full or partial facilities removal the relevant elements of the KBRA will no longer be ascertainable~~.~~. CDFG recognizes that in the event subsequent analysis is deemed appropriate, it will be required to consider any feasible alternatives, mitigation measures, and any other elements required by CEQA as the basis for any approval of such KBRA project or phase in accordance with existing law.

ES.1.5 Oregon Concurrence

The State of Oregon, and more specifically the "Klamath Team" consisting of Oregon Water Resources, Oregon Department of Fish and Wildlife, and Oregon Department of Environmental Quality, will follow a distinct process for determining concurrence with an Affirmative Determination by the Secretary of the Interior (as defined pursuant to Executive Order No. 10-10 by the Governor of Oregon~~).~~) should such a determination be made.

The ~~Oregon~~ Klamath Team will evaluate two questions in order to determine concurrence:

1. Whether significant impacts identified in its environmental review can be avoided or mitigated as provided under ~~s~~State law.

2. Whether the facilities removal will be completed within the State Cost Cap.

The Klamath Team will provide the results of its evaluation in a recommendation to the Governor, for transmittal to the Secretary of the Interior as a concurrence, if appropriate.

ES.2 Background

Figure ES-1 illustrates many of the existing features of the Klamath Basin in southern Oregon and northern California. The Klamath Basin's history, like numerous other river basins throughout the ~~w~~Western United States, is one of fish harvest, dam construction, timber harvest, farming, ranching, water diversion, and corresponding changes in the basin's water quality, hydrology, and natural resources.

Klamath Hydroelectric Project

The Klamath Hydroelectric Project was constructed between 1911 and 1962 and includes eight developments: the East and West Side power facilities, and Keno, J.C.Boyle, Copco 1, Copco 2, Fall Creek, and Iron Gate Dams. Located at the upstream boundary of the Klamath Hydroelectric Project, Link River Dam and Upper Klamath Lake are not part of the project.

All of the dams, excluding Link River Dam, are owned by PacifiCorp. Link River Dam was constructed to enhance hydroelectric production at the East and Westside power plants as well as control the storage and timing of water releases downstream to better control future power production at the lower river dams. The dam is owned by Reclamation, but operated by PacifiCorp under Reclamation's direction for regulating flows and storing water in Upper Klamath Lake for irrigation use in Reclamation's Klamath Project.

Keno Dam regulates water levels of the Klamath River upstream of the dam. The facility does not include power-generating equipment. PacifiCorp operates the dam under an agreement with Reclamation to maintain stable water levels in Keno Impoundment/Lake Ewauna for consistent water delivery to dependent water users.

The dams on the mainstem of the Klamath River include: J.C.Boyle, Copco 1, Copco 2, and Iron Gate Dams (the Four Facilities), which are currently owned by PacifiCorp. The portion of the Klamath River that includes these four most downstream dams is referred to as the Klamath Hydroelectric Reach. Fall Creek Dam is on a Klamath River tributary that flows into Iron Gate Reservoir.

The purpose of the Klamath Hydroelectric Project is power generation. The installed maximum capacity of the entire project is 169 megawatts and, on average since full installation in 1963, the project produced 82 megawatts, and annually generated 716,800 megawatt-hours of electricity.

Figure ES-1. The Klamath Basin

ES.2.1 Basin Timeline

Figure ES-2 displays a timeline of some of the events and activities within the basin which have contributed to current conditions related to water supply, fisheries, recreation, and stakeholder negotiations. Water diversions and planning for dam construction in the basin began prior to 1905, when the precursor to the Bureau of Reclamation ~~(Reclamation)~~ started construction of Reclamation's Klamath Project. Construction of the Klamath Hydroelectric Project, starting with Copco 1 Dam, began in 1911.

~~***Klamath Hydroelectric Project***~~

~~The Klamath Hydroelectric Project was constructed between 1911 and 1962 and includes eight developments: the East and West Side power facilities, and Keno, J.C. Boyle, Copco 1, Copco 2, Fall Creek, and Iron Gate Dams. Located at the upstream boundary of the Klamath Hydroelectric Project, Link River Dam and Upper Klamath Lake are not part of the project.~~

~~All of the dams, excluding Link River Dam, are owned by PacifiCorp. Link River Dam was constructed to enhance hydroelectric production at the East and Westside power plants as well as control the storage and timing of water releases downstream to better control future power production at the lower river dams. The dam is operated by PacifiCorp under Reclamation's direction for regulating flows and storing water in Upper Klamath Lake.~~

~~Keno Dam regulates water levels of the Klamath River upstream of the dam. The facility does not include power-generating equipment. PacifiCorp operates the dam under an agreement with Reclamation to maintain stable water levels in Keno Reservoir for consistent water delivery to dependent water users.~~

~~The dams on the mainstem of the Klamath River include: J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams (the Four Facilities), which are currently owned by PacifiCorp. The portion of the Klamath River that includes these four most downstream dams is referred to as the Klamath Hydroelectric Reach. Fall Creek Dam is on a Klamath River tributary that flows into Iron Gate Reservoir.~~

~~The purpose of the Klamath Hydroelectric Project is power generation. The installed maximum capacity of the entire project is 169 megawatts and, on average since full installation in 1963, the project produced 82 megawatts, and annually generated 716,800 megawatt-hours of electricity.~~

Figure ES-1. The Klamath Basin.

Indian Tribe use of Klamath Basin since time immemorial

1855 Klamath River Reservation established (Yurok)

1864 Land for Hoopa Valley Indian Reservation set aside by Congress.

1864 Klamath Indian Reservation established (The Klamath Tribes)

1876 Boundaries of the Hoopa Valley Indian Reservation established by Executive Order

1905 Reclamation's Klamath Project Authorized by the Secretary of the Interior (May 15)

1906 Work on Reclamation's Klamath Project begins

1907 A-Canal completed

1908 President Theodore Roosevelt forms Lower Klamath Lake National Wildlife Refuge, the first in the nation

1910 Clear Lake Dam completed

1911 Clear Lake National Wildlife Refuge established

1912 Lost River Diversion Channel completed

1912 Wilson Diversion Channel completed

1917 Connection of Lower Klamath Lake to Klamath River blocked by a railroad embankment

1918 Copco 1 Dam completed; passage of salmon and steelhead to the Upper Basin blocked; harvest opportunities for Klamath tribes ends

1921 Anderson-Rose Dam on Lost River completed

1921 Link River Dam completed

1922 Copco 2 construction begins in order to meet additional electricity demand of timber industry and reregulate flows from Copco 1

1923 Malone Diversion Dam on Lost River completed

1924 Miller Diversion Dam on Miller Creek completed

1925 Copco 2 completed

1925 Gerber Dam completed

1928 Tule Lake (39,116 acres) and Upper Klamath Lake (15,000 acres) National Wildlife Refuges established

1930 Lost River Diversion Channel enlarged

1931 Keno Regulating Dam completed

1938 Land purchased for Resighini Rancheria

1939 Quartz Valley Indian Reservation established

1941 D-Pumping Plant completed

1941 Construction of Klamath Straits Drain which provided hydrologic connection between Lost River basin and Klamath River

1950 Lost River Diversion Channel enlarged

1954 Klamath Tribes' (Modoc, Klamath, and Yahooskins) federal recognition terminated

1956 FERC Relicensing for PacifiCorp or predecessor

1957 Klamath River Basin Compact ratified by California and Oregon "to facilitate …the orderly …development, use, conservation, and control" of Basin water for domestic and agricultural uses, as well as protection and enhancement of wildlife, fish, and recreational resources. To ensure equitable distribution and use of water between the two states and the Federal Government

1958 J.C. Boyle Dam completed, providing peaking power

1962 Iron Gate Dam completed

1966 Keno Dam replaced

1967 Lost River sucker listed as "Rare" by State of CA

1971 Shortnose sucker listed as "Rare" by State of CA

1971 Lost River and shortnose sucker identified as species of concern under the CESA

1975 Klamath Basin adjudication proceedings for State of Oregon begin

1975 North Coast Regional Water Quality Control Board adopts basin plan for the Klamath River Basin, including designation beneficial uses for the river

1979 Karuk Tribe becomes federally recognized

1981 Portion of the Lower Klamath River designated as a "Wild and Scenic" river

1984 Trinity River Restoration Program initiated

1986 Klamath Tribes reinstated as federally recognized tribes and close their sucker fisheries for conservation purposes. Hundreds of adult suckers are observed in a summer-time die-off in Upper Klamath Lake

1986 20 Year "Klamath River Basin Fishery Resources Restoration Act" - Public Law 99-552 (100 Stat. 3081, October 27, 1986), as amended by P.L. 100-580. Task Force Formed

1988 Lost River and shortnose sucker listed as endangered under ESA

1988 Hoopa-Yurok Act establishes an independent Yurok Reservation and Tribal government

1990 State of Oregon refuses to issue a permit for the federally-licensed Salt Caves Hydroelectric Project

1991 Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program completed by U.S. Fish and Wildlife Service

1993 Federal Government sets the Klamath tribal fishing to 50% of total available harvest for Fall Chinook

1994 Klamath River from J.C. Boyle Powerhouse to the California-Oregon state line designated "Wild and Scenic" river

1995 Adoption of the Klamath, Six Rivers, and Shasta-Trinity National Land and Resource Management Plans that included findings from the 1993 Forest Ecosystem Management Team and 1994 Record of Decision for the Northwest Forest Plan for the Aquatic Conservation Strategy that mandated watershed restoration, identified key watersheds as strongholds for salmon recovery, and standards and guidelines to protect and restore watershed conditions

Figure ES-2a. Klamath Basin Timeline.

Figure ES-2b. Klamath Basin Timeline.

ES.2.2 Activities Leading to the Development of the KHSA and the KBRA

While the construction and operation of reservoirs and dams on the Klamath River facilitated development, growth, and expansion of an agricultural economy in the region, it also contributed to declines in fisheries and water quality, as well as impacts on tribal resources and culture.

As described above, construction of the dams along the mainstem of the Klamath River resulted in fisheries declines. The construction of Copco 1 Dam resulted in decimation of the Klamath Tribes' anadromous fisheries by blocking fish passage to the Upper Basin. The 1980s and 1990s witnessed declining populations and closure of Lost River and shortnose sucker fisheries as well as the ~~f~~Federal listing under the Endangered Species Act of both sucker species and coho salmon.

Indian Tribe use of Klamath Basin since time immemorial

1855 Klamath River Reservation established (Yurok)

1864 Land for Hoopa Valley Indian Reservation set aside by Congress.

1864 Klamath Indian Reservation established (The Klamath Tribes)

1876 Boundaries of the Hoopa Valley Indian Reservation established by Executive Order

1905 Reclamation's Klamath Project Authorized by the Secretary of the Interior (May 15)

1906 Work on Reclamation's Klamath Project begins

1907 A-Canal completed

1908 President Theodore Roosevelt forms Lower Klamath Lake National Wildlife Refuge, the first in the nation

1910 Clear Lake Dam completed

1911 Clear Lake National Wildlife Refuge established

1912 Lost River Diversion Channel completed

1912 Wilson Diversion Channel completed

1917 Connection of Lower Klamath Lake to Klamath River blocked

1918 Copco 1 Dam completed; passage of salmon and steelhead to the Upper Basin blocked; harvest opportunities for Klamath tribes ends

1921 Anderson-Rose Dam on Lost River completed

1921 Link River Dam completed

1922 Copco 2 construction begins in order to meet additional electricity demand of timber industry and reregulate flows from Copco 1

1923 Malone Diversion Dam on Lost River completed

1924 Miller Diversion Dam on Miller Creek completed

1925 Copco 2 completed

1925 Gerber Dam completed

1928 Tule Lake (39,116 acres) and Upper Klamath Lake (15,000 acres) National Wildlife Refuges established

1930 Lost River Diversion Channel enlarged

1931 Keno Regulating Dam completed

1938 Land purchased for Resighini Rancheria

1939 Quartz Valley Indian Reservation established

1941 D-Pumping Plant completed

1950 Lost River Diversion Channel enlarged

1954 Klamath Tribes' (Modoc, Klamath, and Yahooskins) federal recognition terminated

1956 FERC Relicensing for PacifiCorp or predecessor

1957 Klamath River Basin Compact ratified by California and Oregon "to facilitate …the orderly …development, use, conservation, and control" of Basin water for domestic and agricultural uses, protection and enhancement of wildlife, fish, and recreational resources. To ensure equitable distribution and use of water between the two states and the Federal Government

1958 J.C. Boyle Dam completed, providing peaking power

1962 Iron Gate Dam completed

1966 Keno Dam replaced

1967 Lost River sucker listed as "Rare" by State of CA

1971 Shortnose sucker listed as "Rare" by State of CA

1971 Lost River and shortnose sucker identified as species of concern under the CESA

1975 Klamath Basin adjudication proceedings for State of Oregon begin

1979 Karuk Tribe becomes federally recognized

~~**Figure ES-2a. Klamath Basin Timeline**~~

1981 Portion of the Lower Klamath River designated as a "Wild and Scenic" river

1984 Trinity River Restoration Program initiated

1986 Klamath Tribes reinstated as federally recognized tribes and close their sucker fisheries for conservation purposes. Hundreds of adult suckers are observed in a summer-time die-off in Upper Klamath Lake

1986 20 Year "Klamath River Basin Fishery Resources Restoration Act" - Public Law 99-552 (100 Stat. 3081, October 27, 1986), as amended by P.L. 100-580. Task Force Formed

1988 Lost River and shortnose sucker listed as endangered under ESA

1988 Hoopa-Yurok Act establishes an independent Yurok Reservation and Tribal government

1991 Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program completed by U.S. Fish and Wildlife Service

1993 Federal Government sets the Klamath tribal Fishing to 50% of total available harvest for Fall Chinook

1994 Klamath River from J.C. Boyle Powerhouse to the California-Oregon state line designated "Wild and Scenic" river

1995 Adoption of the Klamath, Six Rivers, and Shasta-Trinity National Land and Resource Management Plans that included findings from the 1993 Forest Ecosystem Management Team and 1994 Record of Decision for the Northwest Forest Plan for the Aquatic Conservation Strategy that mandated watershed restoration, identified key watersheds as strongholds for salmon recovery, and standards and guidelines to protect and restore watershed conditions

1995-1997 Many thousands of adult suckers observed in summer-time die-off in Upper Klamath Lake

1997 Coho salmon listed under ESA

2000 PacifiCorp begins re-licensing proceedings for the Klamath Hydroelectric Project

2001 Water deliveries to Reclamation's Klamath project are curtailed to protect ESA listed species due to drought

2002 At least 33,000 returning adult salmon, primarily fall-run Chinook, die in the mainstem of the Klamath

2003 Construction of new A-Canal headgates and fish screen

2004 PacifiCorp initiates dam relicensing application with FERC

2004 Construction of Lost River and shortnose sucker friendly fish ladder at Link River Dam

2004 PacifiCorp files Final License Application with FERC to re-license Klamath Hydroelectric Project

2005 Coho salmon listed under the CESA

2005 KBRA/KHSA talks begin

2005 Commercial salmon ocean harvest restricted on California and Oregon Coast due to weak Klamath stocks

2005 Water quality studies show that Copco and Iron Gate Reservoirs have regular, prolonged blooms of toxic algae in the summertime. Warnings against human contact with the reservoir water begin to be routinely posted

2006 Federal Agencies release drafts of mandatory prescriptions for a new Klamath Hydroelectric Project license, which if finalized will require fishways, flow management changes, and other changes

2006 PacifiCorp challenges scientific foundations of Federal prescriptions in a trial-type hearing under the Energy Policy Act of 2005. Judge's rulings support scientific foundations of most Federal prescriptions

2006 KBRA/KHSA talks intensify

2006 PacifiCorp's license to operate the Klamath Hydroelectric Project expires. The relicensing process continues and the Project continues operation under annual license

2006 Agriculture's contracts for low power rates expire

2006 700 miles of Oregon and California coast closed to commercial salmon fishing due to weak Klamath stocks

2007 Federal agencies finalize mandatory prescriptions for a new Klamath Hydroelectric Project license, requiring fishways and flow management changes, among other things

2007 FERC issues a Final Environmental Impact Statement for the Klamath Hydroelectric Project

2007 Commercial salmon ocean harvest restricted on California and Oregon coasts due to weak Sacramento River salmon stocks

2008 California commercial ocean harvest closed due to weak Sacramento River salmon stocks

2008 Removal of Chiloquin Dam opens Lost River and shortnose sucker habitat

2009 Oregon legislature passes Senate Bill 76, which provides for $180 million in PacifiCorp rate-payer contributions to the cost of removing the lower four dams in the Klamath Hydroelectric Project

2009 California commercial ocean salmon harvest closed

2010 Oregon Public Utilities Commission approves Oregon rate-payer contributions of $180 million to dam removal fund

2010 Reclamation significantly decreased water deliveries from Upper Klamath Lake to its Klamath Project to reserve water in Upper Klamath Lake for ESA-listed suckers and provide flow augmentation for ESA-listed coho downstream of Iron Gate Dam to comply with USFWS and NOAA Fisheries Biological Opinions

2010 KHSA and KBRA signed

2011 California Public Utilities Commission approves California rate-payer contributions of $13.76 million to dam removal fund

~~**Figure ES-2b. Klamath Basin Timeline**~~

In 2008 and 2010, the United States Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, respectively, issued biological opinions on Reclamation's Klamath Project operations to better protect listed species. Project operations are ~~governed~~now conducted in ~~part by~~accordance with both opinions.

~~Concurrently with~~The Klamath Basin faced substantial, long-term challenges, such as the ~~progression~~decline of ~~these~~ fish species~~ and fisheries~~, posting of health advisories due to poor water quality conditions~~ in the basin~~, the water delivery curtailments and other unresolved natural resource issues described under Section ES.1~~, resulted in stressed natural resource availability throughout the basin. In 2006, power rates for irrigators began to climb,~~ and ~~Reclamation's Klamath Project irrigators faced more water shut-offs and curtailments.~~Figure ES-2. The likelihood that ~~such widely traumatic cycles~~similar hardships would continue to occur, coupled with upcoming changes PacifiCorp would need to make in order to continue operating their hydroelectric project, led basin stakeholders ~~and American Indian Tribes~~ to ~~collaborate for~~begin negotiation of a mutually beneficial agreement ~~as a sustainable option for solving the basin's problems~~to try to provide enduring solutions to these longstanding challenges.

While stakeholders began efforts to reach agreement on the multifaceted ~~issues in~~problems of the basin in the 1990s, the ~~prospect of settlement increased in 2001 and 2002 following the~~ water-related farming and fisheries crises experienced in ~~those years.~~2001 and 2002, and expiration of PacifiCorp's licenses for its hydroelectric project on the Klamath River, provided additional impetus to reach a negotiated settlement, as discussed further below. Official negotiations leading to the KHSA and KBRA began in 2005. The KHSA ~~was an outcome~~grew directly out of the Federal Energy Regulatory Commission's (FERC) Alternative Dispute Resolution Procedures ~~as outlined in the Energy Policy Act of 2005~~[5] (18 C.F.R. 385.601, et seq.) wherein the parties, including PacifiCorp, elected to ~~set aside differences to reach resolution on~~ negotiate a settlement that ~~is in furtherance~~comteplates the potential removal of ~~the interests of all of~~PacifiCorp's hydroelectric facilities on the ~~parties.~~ Klamath River as an alternative to relicensing those facilities. As ~~e~~sta~~blish~~ted in Section 1.2 of the KHSA, many of the parties to the settlement maintain that facilities removal will help restore basin resources and all ~~S~~signatory parties agree that settlement will help reduce conflicts among Klamath Basin communities. The draft KBRA was released in January 2008. The agreements were negotiated and written to be executed together and are referred to herein as the Klamath Settlement.

ES.2.2.1 FERC Relicensing

The KHSA and KBRA ~~negotiation process~~negotiations thus coincided with PacifiCorp's 2004 FERC relicensing application for the Klamath Hydroelectric Project. The company's original 1956 license expired in March 2006. The 1956 PacifiCorp license pre-dated many environmental laws, and did not include prescriptions (Section 18 of the Federal Power Act (FPA) [16 USC 811]) for fish passage over or around the dams. Currently, only J.C.Boyle and Keno Dams have fish passage facilities, but these fishways do not meet current passage criteria.

~~[5] Section 442 of the Energy policy Act of 2005, Pub. L. 109-58, SS 241, 119 Stat, 594, 67475 (Aug. 8, 2005) ("EPAct") (codified in 16 U.S.C. SS 797 (e) and 811), and the underlying procedural regulations codified in 50 C.F.R. Part 221.~~

~~The dams have been operating under an annual license since the original license expired.~~ PacifiCorp filed an application with FERC for a new operating license for the Klamath Hydroelectric Project in 2004. ~~During relicensing, several agencies, led by the~~ The NOAA Fisheries Service~~, in addition to other agencies with 10(a) authorities,~~ recommended to FERC ~~under Section 10(a) authority of the FPA,~~ removal of the Four Facilities as the ~~preferred measure~~best alternative to contribute to ~~protect declining~~ restoration of all fish species of concern in the Klamath ~~River fisheries.~~watershed under FPA Section 10(a). Concurrently, under Section 18 authority of the FPA, the ~~United States Department of Commerce (DOC)~~NOAA Fisheries Service (the Secretary of Commerce's authority under the FPA has been delegated to the NOAA Fisheries Service and DOI prescribed mandatory fishways and passage at each mainstem dam. Flows were conditioned from J.C.Boyle Dam downstream for riparian habitat, whitewater recreation, and fisheries by DOI under Section 4(e) authority. See the text box below that describes these sections of the FPA.

The fishway prescriptions by the ~~DOC~~NOAA Fisheries Service and DOI were supported by basin tribes, fishing interests, and conservation groups to address declining fish harvests in the lower Klamath River and to reopen blocked habitat. The fishway prescriptions and DOI's mandatory conditions were challenged by PacifiCorp and others under the Energy Policy Act of 2005, in a trial-type hearing that considered disputed issues of material fact relating to the prescriptions and conditions. The resulting Administrative Law Judge decision (*In the Matter of: Klamath Hydroelectric Project, Docket* Number 2006-NMFS-0001, September 27, 2006) found that ~~the agencies met their~~PacifiCorp failed to meet its burden of proof regarding most of the factual issues in dispute. FERC conducted environmental analysis of the proposed project, including the mandatory terms and conditions and prescriptions in 2007.~~ The NOAA Fisheries Service recommended to FERC, under its Section 10(a) authority of the FPA, removal of the mainstem PacifiCorp dams as the preferred measure to protect declining Klamath fisheries. Concurrently under Section 18 authority of the FPA, the Department of Commerce and DOI prescribed mandatory fishways and passage at each mainstem dam.~~ The dams have been operating under an annual license since March 2006, when the original license expired.

~~The Federal Power Act~~

~~The Federal Power Act (FPA) authorizes the Federal Energy Regulatory Commission (FERC) to license hydroelectric projects in the United States.~~

~~**Section 18** of the FPA states in pertinent part:~~

~~FERC "shall require the construction, maintenance, and operation by a licensee at its own expense of…such fishways as may be prescribed by the Secretary of the Interior or the Secretary of Commerce, as appropriate" Act Pub. L. 102-486, Title XVII, Section 1701(b), 106 Stat. 3008.~~

~~**What is a fishway?** Congress has defined fishways for the safe and timely upstream and downstream passage of fish to be limited to 'physical structures, facilities or devices necessary to maintain all life stages of such fish, and project operations and measures related to such structures, facilities, or devices which are necessary to ensure the effectiveness of such structures, facilities, or devices for such fish." 1992 Energy Policy~~

~~**Section 4(e)** of the FPA provides that FERC must consider environmental requirements for licensing the hydroelectric project located on a federal reservation. Specifically, FERC may issue a license within a reservation (including National Forests, National Parks, Land and Water Conservation Fund Act lands, National Wild and Scenic Rivers Act rivers, National Trails, Wilderness Areas, National Wildlife Refuges, and other public lands) only after finding that the license will not interfere or be inconsistent with the purposes for which such reservation was created or acquired and such license shall be subject to and contain such conditions that the federal agency with jurisdiction over the reservation deems necessary for the adequate protection and utilization of the reservation.~~

~~**Section 10(a)** of the FPA requires that: "In order to ensure that the project adopted will be best adapted to a comprehensive plan for development of the waterway, the Commission will consider:~~

~~A. The extent to which the project is consistent with a comprehensive plan (where one exists) for improving, developing, or conserving a waterway or waterways affected by the project, and~~

~~B. The recommendations of Federal and State agencies as well as Indian Tribes exercising administration over flood control, navigation, irrigation, recreation, cultural and other relevant resources of the State in which the project is located, and the recommendations (including fish and wildlife recommendations) of Indian tribes affected by the project."~~

~~**Section 10(j)** of the FPA requires FERC to solicit recommendations from the U.S. Department of Commerce's National Marine Fisheries Service, the U.S. Department of Interior's Fish and Wildlife Service and state fish and wildlife agencies. Such recommendations are pursuant to the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) FERC has to address and then either accept or refute recommendations from these resource agencies relative to the protection, mitigation, and enhancement of fish and wildlife resources impacted by the project.~~

Before FERC may issue any new license for the Klamath Hydroelectric Project, the ~~s~~States of Oregon and California must also separately issue water quality certifications under Section 401 of the Clean Water Act (CWA). The California State Water Resources Control Board (SWRCB) cannot issue certification until environmental documentation ~~sufficient for consideration of the alternative of conditioning certification on dam removal is completed~~ consistent with the requirements of CEQA~~.~~

, is completed. The ~~agencies'~~certification proceedings are currently being held in abeyance as requested in Section 6.5 of the KHSA. In a February 2009 letter from SWRCB addressing the CEQA Notice of Preparation for an EIR for 401 water quality certification of the Klamath Hydroelectric project, it was noted that failing to process the water quality certification in a timely manner risks a FERC determination that the SWRCB has waived certification (SWRCB 2009). The State of California would then have no regulatory authority to address water quality issues associated with the Klamath Hydroelectric Project during the FERC relicensing.

~~Reclamation's Klamath Project~~

~~In addition to the Klamath Basin's distinctive setting, biological resources, and cultural history, the basin is the site of one of the first developments authorized under the 1902 Reclamation Act. Development and construction of what is today known as Reclamation's Klamath Project took place between 1905 and 1966, with major features of the project completed by the early 1940s. As the largest water management effort in the Upper Klamath Basin, its features include a system of reservoirs, dams, canals, and pumps (Figure 1-3). Reclamation's Klamath Project was originally authorized for the purpose of providing irrigation water to farms at a time when the frontier of the American west was still developing and increasing numbers of farmers were drawn to the fertile land in northern California and southern Oregon. Link River Dam, completed in 1921, is a major feature of Reclamation's Klamath Project. This dam is owned by Reclamation, but is operated by PacifiCorp under agreement with Reclamation.~~

The Federal Power Act

The Federal Power Act (FPA) authorizes the Federal Energy Regulatory Commission (FERC) to license hydroelectric projects in the United States.

Section 18 of the FPA states in pertinent part:

FERC "shall require the construction, maintenance, and operation by a licensee at its own expense of…such fishways as may be prescribed by the Secretary of the Interior or the Secretary of Commerce, as appropriate"

What is a fishway? Congress has defined fishways for the safe and timely upstream and downstream passage of fish to be limited to 'physical structures, facilities or devices necessary to maintain all life stages of such fish, and project operations and measures related to such structures, facilities, or devices which are necessary to ensure the effectiveness of such structures, facilities, or devices for such fish." 1992 Energy Policy Act Pub. L. 102-486, Title XVII, Section 1701(b), 106 Stat. 3008.

Section 4(e) of the FPA provides that FERC may issue a license within a reservation (as defined in the FPA) only after finding that the license will not interfere or be inconsistent with the purpose for which such reservation was created or acquired and such license shall be subject to and contain such conditions that the federal agency with jurisdiction over the reservation deems necessary for the adequate protection and utilization of the reservation.

Section 10(a) of the FPA requires, in relevant part, that: "[i]n order to ensure that the project adopted will be best adapted to the comprehensive plan ..., the Commission shall consider each of the following:

(2)(A) The extent to which the project is consistent with a comprehensive plan (where one exists) for improving, developing, or conserving a waterway or waterways affected by the project that is prepared by i) an agency established pursuant to Federal law that has authority to prepare such a plan; or ii) the State in which the facility is or will be located.

(2)(B) The recommendations of Federal and State agencies exercising administration over flood control, navigation, irrigation, recreation, cultural and other relevant resources of the State in which the project is located, and the recommendations (including fish and wildlife recommendations) of Indian tribes affected by the project."

Section 10(j) of the FPA requires FERC to include conditions to adequately and equitably protect, mitigate damages to, and enhance fish and wildlife affected by the development, operation, and management of a project, based on recommendations received pursuant to the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) from the Department of Commerce's National Marine Fisheries Service, the Fish and Wildlife Service and State fish and wildlife agencies. If FERC believes a recommendation to be inconsistent with the FPA or other applicable law, it must attempt to resolve the inconsistency with the agency through a process defined in the FPA.

The mandatory prescriptions and conditions along with FERC's required conditions would result in significant operational changes to the hydroelectric project, substantially reducing power generation capacity (about 20 megawatts, or 24 percent of annual generation) and causing the Klamath Hydroelectric Project to operate at a net annual loss (FERC 2007). PacifiCorp estimates that it would incur relicensing capital costs in excess of $400 million (with the majority of costs resulting from implementation of aquatic resource protection, mitigation, and enhancement measures) and $60 million in operations and maintenance costs over a 40-year license term (Oregon Public Utilities Commission [OPUC] 2010). PacifiCorp would be allowed to recover these costs through customer charges, if approved through future Public Utilities Commission actions.

Reclamation's Klamath Project

In addition to the Klamath Basin's distinctive setting, biological resources, and cultural history, the basin is the site of one of the first developments authorized under the 1902 Reclamation Act. Development and construction of what is today known as Reclamation's Klamath Project took place between 1905 and 1966, with major features of the project completed by the early 1940s. As the largest water management effort in the Upper Klamath Basin, its features include a system of reservoirs, dams, canals, and pumps (Figure 1-4). Reclamation's Klamath Project was originally authorized for the purpose of providing irrigation water to farms at a time when the frontier of the American west was still developing and increasing numbers of farmers were drawn to the fertile land in northern California and southern Oregon. Link River Dam, completed in 1921, is a major feature of Reclamation's Klamath Project. This dam is owned by Reclamation, but is operated by PacifiCorp under agreement with Reclamation.

The KHSA sets a cost cap of $450 million for removal of the Four Facilities. Of this, an amount not to exceed $200 million would come from additional charges to PacifiCorp ratepayers residing in California and Oregon, and up to $250 million would come from the sale of bonds in California or other ~~means deemed~~ appropriate financing mechanisms to cover removal costs in excess of the rate-payer contributions. The United States government would not be responsible for the costs of facilities removal.

ES.2.2.2 The Four Facilities and PacifiCorp Involvement in the KHSA/KBRA

~~The economic reality~~PacifiCorp's decision to enter into the KHSA, which provides for the possible removal of ~~implementing fishways~~ the Four Facilities, reflects its assessment of a combination of regulatory requirements, including the cost and liability associated with meeting CWA ~~401 Certification~~ Section 401 certification in California and in Oregon for renewal of FERC license P-2082, the estimated construction and operation costs to provide fishways at the Four Facilities ~~combined with the prospect of annual loss of revenue, and the protection of prudent and reasonable utility rates for~~ , reductions in peaking power and overall hydropower generation, and the resulting increase to their operational costs for providing power from the Four Facilities. PacifiCorp's evaluation of the costs and risks associated with meeting those requirements under a new license lead to an assessment that the KHSA was in the best interest of its customers ~~encouraged~~ as compared to continuing the process of relicensing the Four Facilities (PacifiCorp ~~to enter into collaborative discussions with basin stakeholders to identify ways to~~

~~improve basin fisheries. These discussions resulted in PacifiCorp signing the KHSA.~~2012). As described below in Section ES.4.2, PacifiCorp is not a direct signatory of the KBRA.

Table ES-1 summarizes data about the Four Facilities. Figures ES-3 through ES-6 show the four dams and associated hydropower facilities.

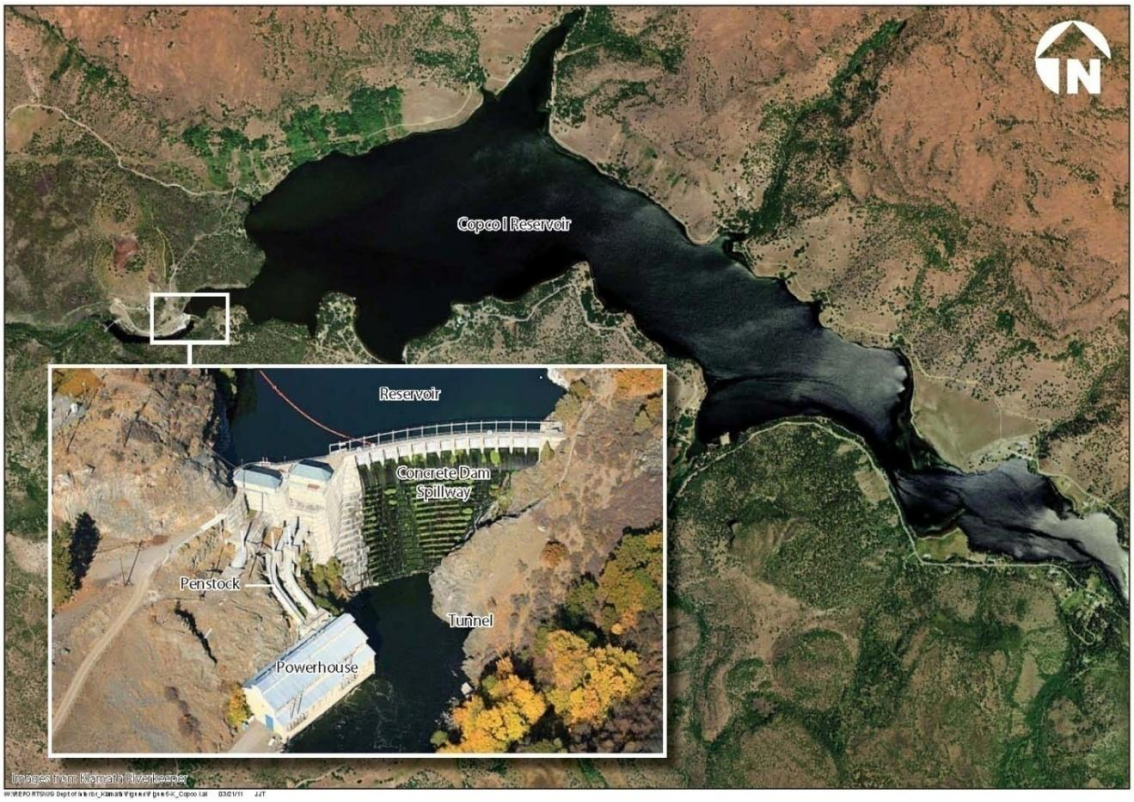
Table ES-1. Hydroelectric Dams (Four Facilities) on the Mainstem Klamath River

Dam	Year Operational	Maximum Power Generation Capacity (megawatts)	Annual Average Generation Rate (megawatts)	Dam Height (feet)
J.C.Boyle	1958	98	38	68
Copco 1	1918	20	12	126
Copco 2	1925	27	15	33
Iron Gate	1962	18	13	194
Total	--	**163**	**78**[1]	--

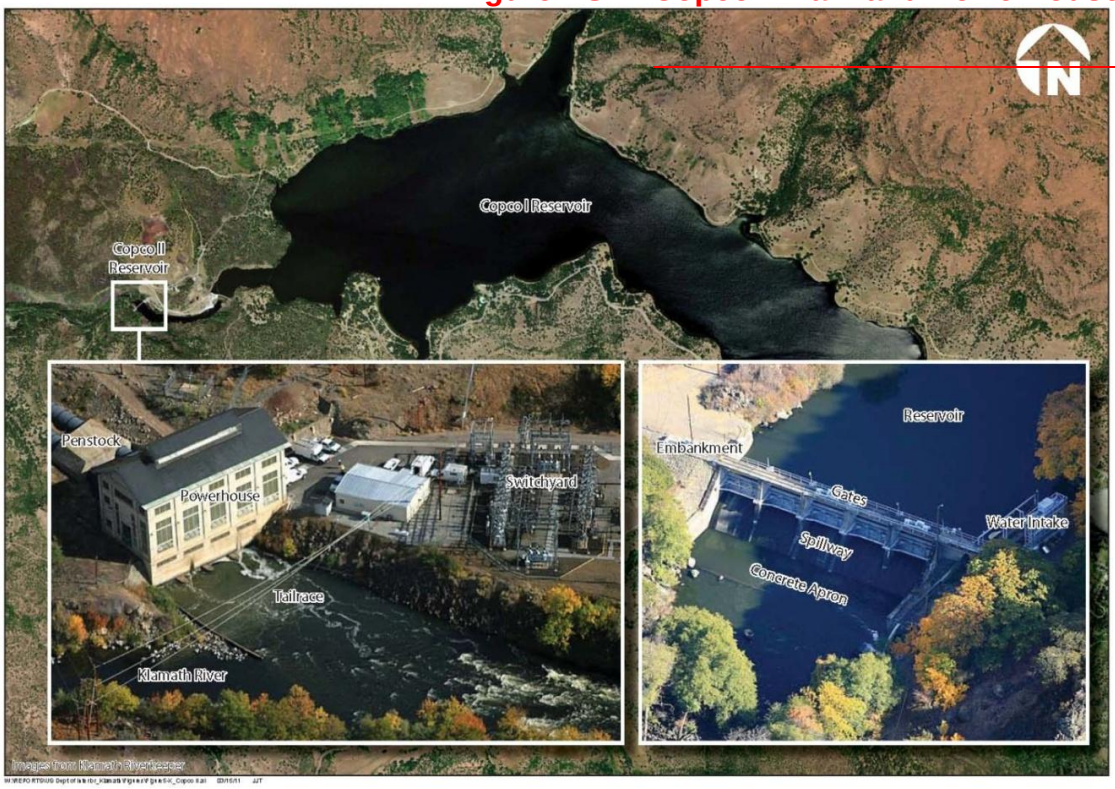
Source: FERC 2007

Notes: [1] This annual average generation rate is only for the Four Facilities and does not include the Fall Creek or East and West Side Facilities. Under the agencies' mandatory prescriptions and conditions, along with FERC's required conditions, average annual generation for the entire project would drop by approximately 20 megawatts.

~~Figure ES-3. J.C. Boyle Dam and Powerhouse~~



~~Figure ES-4. Copco 1 Dam and Powerhouse~~



~~Figure ES-5. Copco 2 Powerhouse (left photo) and Dam~~

~~Figure ES-6. Iron Gate Dam, Reservoir, and Power Generating Facilities~~

Figure ES-3. J.C.Boyle Dam and Powerhouse.

Figure ES-4. Copco 1 Dam and Powerhouse.

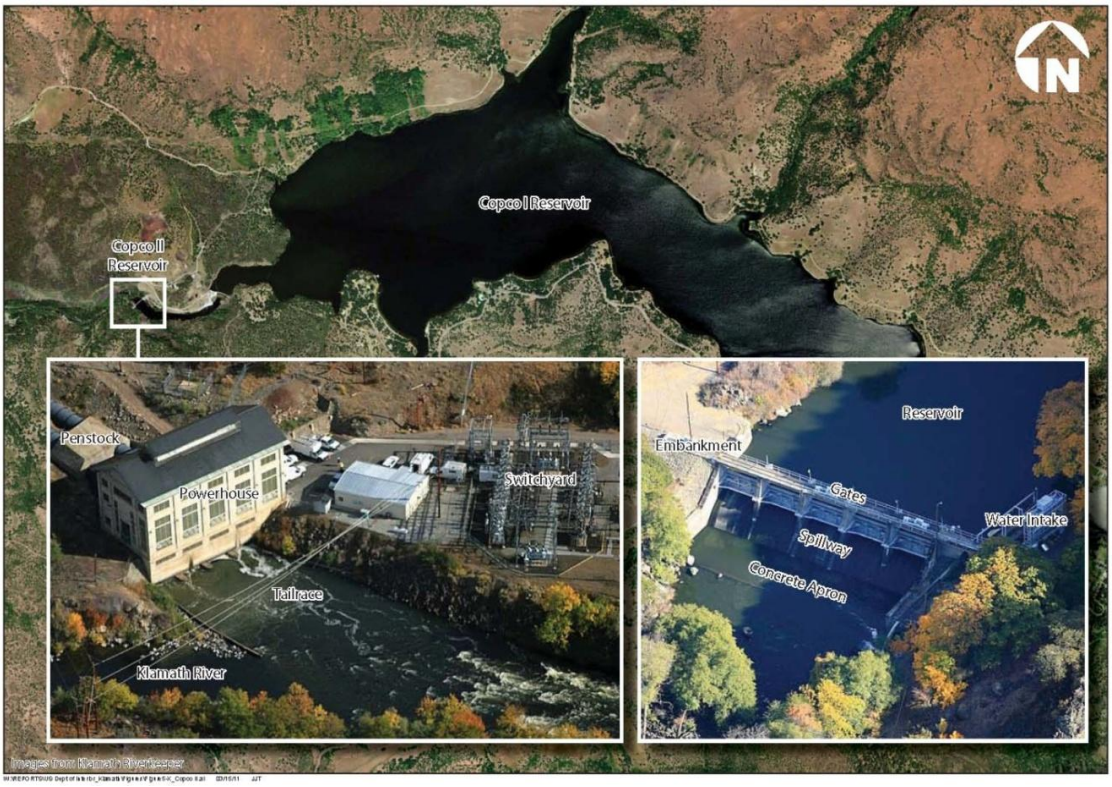


Figure ES-5. Copco 2 Powerhouse (left photo) and Dam.

Figure ES-6. Iron Gate Dam, Reservoir, and Power Generating Facilities.

ES.3 Environmental Review

As described above, this EIS/EIR is being prepared in compliance with NEPA and CEQA. The DOI is Lead Agency under NEPA, and the CDFG is Lead Agency under CEQA. DOI and the CDFG are referred to together in this EIS/EIR as the Lead Agencies. The Purpose and Need for the Proposed Action (NEPA) and the Project Objectives (CEQA) are described below, and together form the basis for alternatives development and impact analysis considered in this EIS/EIR.

~~NEPA Purpose and Need~~

~~The need for the Proposed Action is to advance restoration of the salmonid fisheries in the Klamath Basin consistent with the KHSA and the connected KBRA. The purpose is to achieve a free flowing river condition and full volitional fish passage as well as other goals expressed in the KHSA and KBRA. By the terms of the KHSA, the Secretary will determine whether the Proposed Action is appropriate and should proceed. In making this determination, the Secretary will consider whether removal of the Four Facilities will advance the restoration of the salmonid fisheries of the Klamath Basin, and is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes.~~

~~CEQA Project Objectives~~

~~As required by CEQA, a lead agency must identify the objectives sought by the proposed project. For this project, CDFG as lead agency has identified the following objectives:~~

1. ~~Advance restoration of the salmonid fisheries in the Klamath Basin.~~
2. ~~Restore and sustain natural production of fish species throughout the Klamath Basin in part by restoring access to habitat currently upstream of impassable dams.~~
3. ~~Provide for full participation in harvest opportunities for sport, commercial, and tribal fisheries.~~
4. ~~Establish reliable water and power supplies, which sustain agricultural uses and communities and NWRs.~~
5. ~~Improve long-term water quality conditions consistent with designated beneficial uses.~~
6. ~~Contribute to the public welfare and the sustainability of Klamath Basin communities.~~
7. ~~To be consistent with the goals and objectives of KHSA and KBRA.~~

ES.4 Klamath Settlement Agreements

ES.4.1 Klamath Hydroelectric Settlement Agreement

The KHSA establishes the process for additional studies, the development of a Detailed Plan for dam removal and environmental review to support the Secretary's Determination[6] as to whether removal of the Four Facilities on the Klamath River that are owned by PacifiCorp will accomplish the following two goals: 1) to advance restoration of the salmonid fisheries of the basin, and 2) be in the public interest, which includes, but is not limited to, consideration of the potential impacts on affected local communities and Indian Tribes.

The KHSA also includes provisions for the interim operation of the Four Facilities by PacifiCorp and the process to transfer, decommission, and remove the dams in the event of an Affirmative Determination.

ES.4.2 Klamath Basin Restoration Agreement

Concurrently with the signing of the KHSA, the same Parties, with the exception of the ~~two federal parties~~Federal Government and PacifiCorp, signed an accompanying agreement—the KBRA. The KBRA includes interrelated plans and programs intended to benefit fisheries throughout the basin, water and power users in the Upper Klamath Basin, counties, Indian Tribes, and basin communities. The KBRA brought many parties together to support one

Secretarial Determination and Connected Actions

If the Secretary publishes an Affirmative Determination, and the Governors of Oregon and California concur, the process for facilities removal will proceed. The Secretary will also concurrently designate the dam removal entity. The dam removal entity, once identified, would refine the Detailed Plan to create a Definite Plan for Facilities Removal including the methods for removal and estimated costs.

In addition to the decommissioning and removal of the four hydroelectric dams, actions ~~associated with~~connected to an Affirmative Determination would include the transfer of Keno Dam ownership from PacifiCorp to DOI~~—~~, Eastside/Westside Facilities, and the KBRA.

An Affirmative Secretarial Determination and federal authorizing legislation are two early key milestones towards full implementation of the KBRA.

A Negative Determination would be a potential termination event for the KHSA and facilities removal would likely not proceed~~.~~ as per the KHSA. The FERC relicensing process

[6] As defined in the KHSA, there are two different determinations on removal of the Four Facilities that the Secretary could reach: 1) Affirmative Determination: A determination by the Secretary under Section 3 of the KHSA that Facilities Removal should proceed; and, 2) Negative Determination: A determination by the Secretary under Section 3 of the KHSA that Facilities Removal should not proceed. The Secretary bases his determination on whether the conditions of Section 3.3.4 of the KHSA have been met and whether, in his judgment, Facilities Removal will accomplish the two goals stated above in Section ES.2.1. In the event of an Affirmative Determination, California and Oregon each shall provide Notice to the Secretary and other Parties as to whether the ~~s~~State concurs with the Affirmative Determination. In its concurrence, each ~~s~~State shall consider whether: 1) significant impacts identified in its environmental review can be avoided or mitigated as provided under ~~s~~State law; and 2) Facilities Removal will be completed within the State Cost Cap (KHSA Section 3.3.5A). If the Secretary determines not to proceed with Facilities Removal, the KHSA terminates unless the Parties agree to a cure for this potential termination event (KHSA Section 3.3.5B).

another's efforts to restore fisheries in the Klamath Basin and provide for sustainable ~~agricultural~~ communities and National Wildlife Refuges.

Implementation of the KBRA is intended to accomplish the following:

1. Restore and sustain natural fish production and provide for full participation in ocean and river harvest opportunities of these fish.

2. Establish reliable water and power supplies for agricultural uses, communities, and National Wildlife Refuges (NWRs).

3. Contribute to public welfare and sustainability of all communities through reliable water supply; affordable electricity; programs to offset potential property tax losses and address economic development issues in counties; and efforts to support tribal fishing and long-term economic self-sufficiency.

The key negotiated outcomes of the KBRA include ~~mutually-beneficial~~reciprocal agreements ~~for~~under which the Klamath, Karuk, and Yurok Tribes would not ~~to~~ exercise water right claims that would conflict with water deliveries to Reclamation's Klamath Project water users ~~and for project water users to accept reduced water deliveries.~~; and project water users accept a limitation on diversions from Upper Klamath Lake and Klamath River and develop a program that will allow them to operate within those limitations through the use of other supplies, efficiency measures, voluntary reductions in demand, and other measures. As a result, there would be more support for fisheries restoration programs, greater certainty about water deliveries at the beginning of each growing season, and agreement and assurances that certain of the parties will work collaboratively to resolve outstanding water-right contests pending in the Oregon Klamath Basin Adjudication ~~process~~. In addition, the KBRA includes an Off-Project voluntary Water Use Retirement Program in the Upper ~~Basin,~~Klamath Basin(the portion of the Klamath Basin located upstream of Iron Gate Dam) three restoration projects intended to increase the amount of water storage in the Upper Klamath Basin, regulatory assurances, county and tribal economic development programs, and tribal resource management programs.

Copies of the KHSA and KBRA in their entirety are available electronically at: http://klamathrestoration.gov/.

ES.5 Alternatives Development

As part of the environmental review process, the Lead Agencies developed a full range of alternatives. A detailed description of this process can be found in this EIS/EIR, Appendix A, titled Final Alternatives ~~Formulation~~ Report.

ES.5.1 Public Scoping and Alternatives Identification

The Lead Agencies held seven public scoping meetings in locations around the Klamath Basin to receive input on alternatives and concerns regarding the project purpose, needs and objectives. Written and verbal comments were accepted at each meeting and comments were also received

by mail and electronically throughout the scoping period of June 14, 2010, through July 21, 2010. A Scoping Report that summarizes all comments received through July 21, 2010, was published in September 2010 and is available on the project ~~website~~Web site (http://klamathrestoration.gov/~~).~~) (DOI 2010).

Following the scoping process, the Lead Agencies, along with the cooperating and responsible agencies, identified a wide range of alternatives that represent diverse viewpoints and needs, including alternatives suggested during the EIS/EIR public scoping process. This resulted in a set of 18 ~~possible~~potential alternatives to be considered for detailed analysis (the initial list of action alternatives is described in Appendix A, Final Alternatives ~~Formulation~~ Report). The Lead Agencies applied a screening process to the 18 potential alternatives to determine which alternatives should move forward for further analysis. In order to determine which alternatives met all or most of the purpose and need/
project objectives, and were potentially feasible, specific screening considerations were created based on NEPA (40 CFR Part 1502.14(a)) and CEQA guidance (CEQA Guidelines, §15126.6 (a~~).~~)). Under CEQA, alternatives do not need to meet all of the project objectives; alternatives should be included if they can meet most of the objectives and avoid or substantially lessen significant environmental impacts of the project. Figure ES-7 illustrates the process that the Lead Agencies conducted to identify and screen alternatives and to select alternatives for more detailed analysis.

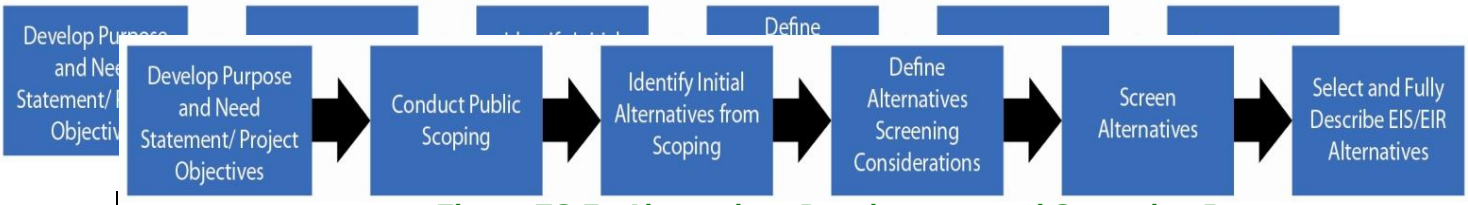


Figure ES-7. Alternatives Development and Screening Process.

~~**Figure ES-7. Alternatives Development and Screening Process**~~

After the process of initial alternative screening, four action alternatives in addition to the No Action/No Project Alternative (Alternative 1) were selected to move forward for more detailed analysis in the EIS/EIR. Alternatives 2 and 3, the Proposed Action and Partial Facilities Removal, both fully meet the purpose and need/project objectives. While Alternative 4, Fish Passage at Four Dams and Alternative 5, Remove Copco 1 and Iron Gate Dams, Construct Fish Passage at J.C.Boyle and Copco 2 Dams, do not fully meet the purpose and need/project objectives, both alternatives were moved forward to the EIS/EIR for further review because at the time of developing a reasonable range of alternatives the Lead Agencies recognized the potential for Alternatives 4 and 5 to have fewer short-term adverse environmental impacts than the Proposed Action. Consideration of these alternatives would give the Secretary a reasonable range of alternatives to inform ~~decision-making.~~a Secretarial Determination. Analysis of these alternatives will provide the Secretary with information needed to make a decision, and

potentially to mix and match elements of the alternatives, if needed, to create an alternative that would reduce environmental impacts and increase environmental benefits.

ES.6 Alternatives Receiving Full Analysis in the EIS/EIR

The EIS/EIR analyzes five alternatives in detail, including the No Action/No Project Alternative.

ES.6.1 Alternative 1 - No Action/No Project Alternative

NEPA requires an EIS to "include the alternative of no action" (40 CFR Part 1502.14(d)). CEQA requires an EIR to include a No Project Alternative. CEQA Guidelines Section 15126.6(e)(2) states that "The 'no project' analysis shall discuss the existing conditions at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services." For the Klamath Facilities Removal EIS/EIR, NEPA's No Action Alternative and CEQA's No Project Alternative describe the same conditions, and this alternative is referred to as the No Action/No Project Alternative.

The No Action/No Project Alternative represents the state of the environment without the Proposed Action or any of the alternatives. For the purposes of this analysis, the No Action/No Project Alternative will continue current operations with the Four Facilities remaining in place and PacifiCorp operating under the current annual license. The existing license has no requirements for additional fish passage or implementation of the agencies' mandatory prescriptions and conditions that are currently before FERC in the relicensing process. PacifiCorp would continue to coordinate with Reclamation to operate the Klamath Hydroelectric Project in compliance with the existing NOAA Fisheries Service and USFWS biological opinions issued for Reclamation's Klamath Project Operation Plan. PacifiCorp would also continue to ~~operate~~fund the operation of the Iron Gate Hatchery under its current operations.

The KBRA is not included in the No Action/No Project Alternative. However, the No Action/No Project Alternative would include the ongoing resource management activities (these actions are described in further detail in Chapter 2 of this EIS/EIR). These resource management actions were started or were under consideration before the KBRA was developed and will move forward at some level even without the KBRA.

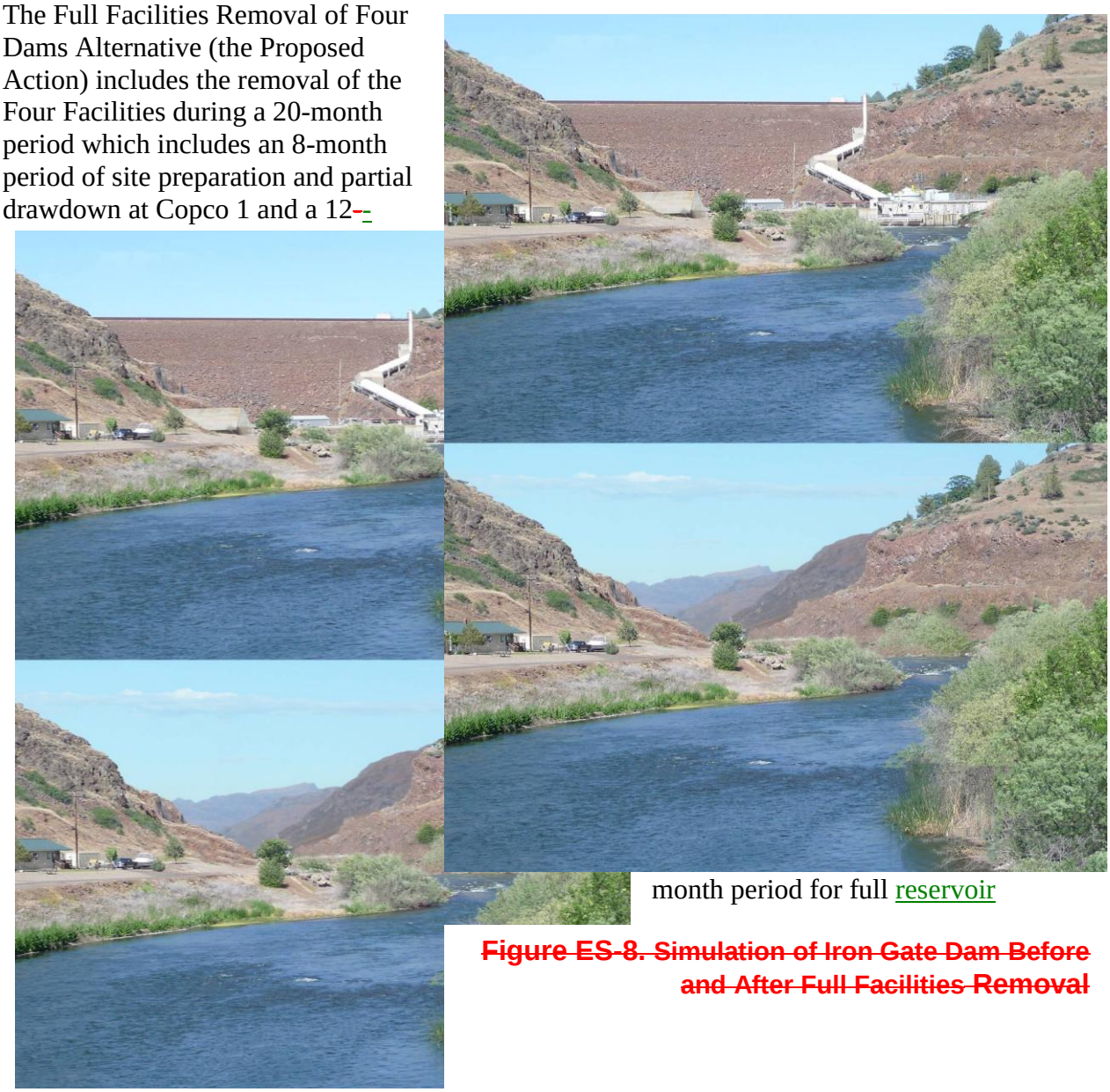
The No Action/No Project Alternative also includes "reasonably foreseeable actions" that are independent of FERC licensing and are expected to occur throughout the period of analysis (2012 to 2061). Reasonably foreseeable actions include full implementation of the Total Maximum Daily Load (TMDL) provision of the Clean Water Act (Section ~~401)~~303(d)) issued by the Oregon Department of Environmental Quality (ODEQ) and California North Coast Regional Water Quality Control Board (CNCRWQCB) for impaired water bodies. There are currently nine TMDLs established in the Klamath Basin (see Section 3.2.2.4). Under the No Action/No Project Alternative, full attainment of these TMDLs would result in long-term water quality

improvements in the basin; however, implementation mechanisms, funding, and timing are currently unknown.

The ongoing resource management activities, TMDLs, Interim Measures, biological opinions, and other regulatory conditions described for this alternative would also occur under Alternatives 2, 3, 4, and 5.

ES.6.2 Alternative 2 - Full Facilities Removal of Four Dams (Proposed Action)

The Full Facilities Removal of Four Dams Alternative (the Proposed Action) includes the removal of the Four Facilities during a 20-month period which includes an 8-month period of site preparation and partial drawdown at Copco 1 and a 12-



month period for full reservoir

Figure ES-8. Simulation of Iron Gate Dam Before and After Full Facilities Removal

Figure ES-8. Simulation of Iron Gate Dam Before and After Full Facilities Removal.

drawdown and removal of facilities.the Four Facilities. This alternative would

include the complete removal of the dams, power generation facilities, water intake structures, canals, pipelines, ancillary buildings, and dam foundations to create a free-flowing river. Preparation for dam removal would begin in May 2019 for Iron Gate Dam and June 2019 for Copco 1 Dam. Deconstruction efforts for the J.C.Boyle and Copco 2 Facilities would commence after January 1, 2020, and all four dams would be completely removed by December 31, 2020. This alternative would include implementation of the KBRA and the transfer of Keno Dam to DOI as connected actions. Figure ES-8 illustrates what full facilities removal would look like at Iron Gate Dam.

~~Table ES-2. KBRA Program Summary~~

~~**Fisheries Program:**~~
~~Fish Habitat Restoration Activities~~[1]
~~Fisheries Restoration Phase I Plan~~
~~Fisheries Restoration Phase II Plan~~
~~Fisheries Reintroduction Plan – Phase I, Oregon~~
~~Fisheries Reintroduction Plan – Phase II, Oregon~~
~~Fisheries Reintroduction Plan – California~~
~~Fisheries Monitoring Plan~~
~~***Additional Water Storage Projects:***~~
~~Williamson River Delta Project~~
~~Agency Lake and Barnes Ranches Project~~
~~Wood River Wetland Restoration Project~~
~~Future Storage Opportunities~~[2]
~~**Water and Power Programs:**~~
~~Water Diversion Allocations for Reclamation's Klamath Project and National Wildlife Refuges~~[3]
~~Groundwater Technical Investigations~~
~~On-Project Plan~~
~~Winter Shortage Plan~~
~~Water Use Retirement Program~~
~~Off-Project Water Settlement~~
~~Off-Project Reliance Program~~
~~Power for Water Management Program~~
~~Drought Plan~~
~~Emergency Response Plan~~
~~Climate Change Assessment~~
~~Environmental Water Management~~
~~Interim Flow and Lake Level Program~~
~~**Regulatory Assurances Programs:**~~
~~Fish Entrainment Reduction~~
~~General Conservation Plan or Habitat Conservation Plan~~
~~**County and Tribal Programs:**~~
~~Klamath County Economic Development Plan~~
~~California Water Bond (Siskiyou County Economic Development Funding)~~
~~Tribal Programs Fisheries and Conservation Management~~
~~Tribal Programs Economic Revitalization~~
~~Mazama Forest Project~~
~~Klamath Tribes Interim Fishing Site~~

~~Notes:~~

1. ~~While on-going fish habitat restoration activities are not part of the Proposed Action because they are conducted under current authorities and funding levels, the scope of these activities would be increased in magnitude and accelerated through implementation of the KBRA. Habitat restoration under the Proposed Action would be guided by the Fisheries Restoration Plan to be developed under the KBRA.~~
2. ~~Development of additional storage is also intended to restore habitats for endangered suckers, and would occur with implementation of KBRA and associated funding.~~
3. ~~During the Interim Period, water diversion limitations to Reclamation's Klamath Project water users would conform to the limits described in the Diversion Limitations section as closely as possible. However, before full implementation of the On-Project Plan, it might not be possible to~~

ES.6.2.1 KBRA

The KBRA is being analyzed in this EIS/EIR as a connected action to the Proposed Action. ~~Implementation~~ Full implementation of the KBRA and the KHSA is dependent on an Affirmative Determination.

Table ES-2 provides a summary of KBRA programs. The programs with sufficient detail to investigate for potential environmental effects are analyzed in this EIS/EIR. These programs include the following (a more detailed description of the approach to analysis of the KBRA is in Section 3.1 of this EIS/EIR):

ES.6.2.1.1 Fisheries Program

~~-~~The Fisheries Program includes habitat restoration throughout the basin; a fisheries reintroduction and management plan; a fisheries monitoring plan; and actions intended to improve flow conditions and water quality for fish. Full attainment of the TMDLs described under the No Action/No Project Alternative would result in long-term water quality improvements in the basin and implementation of the KBRA is anticipated to accelerate these TMDLs.

ES.6.2.1.2 Water and Power Programs

Table ES-2. KBRA Program Summary

Fisheries Program:
Fish Habitat Restoration Activities[1]
Fisheries Restoration Phase I Plan
Fisheries Restoration Phase II Plan
Fisheries Reintroduction Plan – Phase I, Oregon
Fisheries Reintroduction Plan – Phase II, Oregon
Fisheries Reintroduction Plan – California
Fisheries Monitoring Plan
Additional Water Storage Projects:
Williamson River Delta Project
Agency Lake and Barnes Ranches Project
Wood River Wetland Restoration Project
Future Storage Opportunities[2]
Water and Power Programs:
Water Diversion Allocations for Reclamation's Klamath Project and National Wildlife Refuges[3]
Groundwater Technical Investigations
On-Project Plan
Water Use Retirement Program
Off-Project Water Settlement
Off-Project Reliance Program
Power for Water Management Program
Drought Plan
Emergency Response Plan
Climate Change Assessment
Environmental Water Management[4]
Interim Flow and Lake Level Program
Regulatory Assurances Programs:
Fish Entrainment Reduction
General Conservation Plan or Habitat Conservation Plan
County and Tribal Programs:
Klamath County Economic Development Plan
California Water Bond (Siskiyou County Economic Development Funding)
Tribal Programs Fisheries and Conservation Management
Tribal Programs Economic Revitalization
Mazama Forest Project
Klamath Tribes Interim Fishing Site

Notes:

1. While on-going fish habitat restoration activities are not part of the Proposed Action because they are conducted under current authorities and funding levels, the scope of these activities would be increased in magnitude and accelerated through implementation of the KBRA. Habitat restoration under the Proposed Action would be guided by the Fisheries Restoration Plan to be developed under the KBRA.
2. Development of additional storage is also intended to restore habitats for endangered suckers, and would occur with implementation of KBRA and associated funding.
3. During the Interim Period, water diversion limitations to Reclamation's Klamath Project water users would conform to the limits described in the Diversion Limitations section as closely as possible. However, before full implementation of the On-Project Plan, it might not be possible to fully comply with the diversion limitations in all years.
4. The Environmental Water Management program would support the development and implementation of TMDLs on the Klamath River and actions that protect water quality generally (KBRA Section 20.5.4).

The Water and Power Programs include an agreement regarding limitations on water diversions to Reclamation's Klamath Project, ~~which includes a water diversion plan for the~~and delivery commitments for Tule Lake and Lower Klamath Lake NWRs. The programs also include a voluntary Water Use Retirement Program in the Upper Basin to increase inflow into Upper Klamath Lake and to provide a basis for further efforts among certain parties to work collaboratively for more reliable sources of water for fish harvests and agriculture. Additionally, there are agreements and assurances to resolve outstanding water right contests in the Oregon Klamath Basin Adjudication process.

ES.6.2.1.3 County and Tribal Programs

~~–~~County and tribal programs include economic development for local governments and tribes; regulatory assurances that adverse impacts on local communities would be minimized; and tribal fisheries and natural resource conservation.

ES.6.3 Alternative 3 - Partial Facilities Removal of Four Dams

The Partial Facilities Removal of Four Dams Alternative would include removal of enough of each dam to allow free-flowing river conditions and volitional fish passage for all Klamath River anadromous species at all times. Under this alternative, portions of each dam facility would remain in place, including ancillary buildings and structures such as powerhouses, foundations, tunnels, and pipes ~~(Figure ES-9).~~. Some of these remaining features would require perpetual maintenance and security measures to prevent unauthorized entry and safety hazards. All tunnel openings would be sealed and all potentially hazardous materials found in powerhouses and machinery would be removed prior to final decommissioning and securing of buildings.

~~Figure ES-9. Simulation of Partial Facilities Removal~~

The schedule for Partial Facilities Removal of Four Dams would be the same as for the Proposed Action (the Full Facilities Removal of Four Dams Alternative). The Partial Facilities Removal of Four Dams Alternative also includes the connected actions of the transfer of Keno Dam to DOI and implementation of the KBRA (as in the Proposed Action).

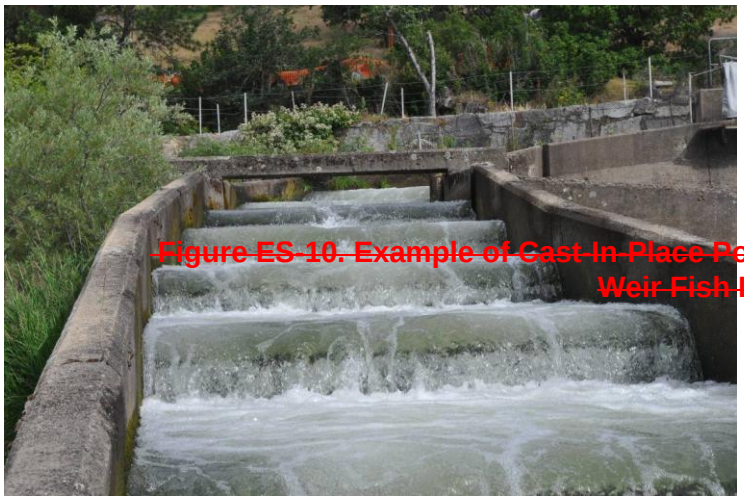
Under Alternative 3, full attainment of the TMDLs, as described under the Proposed Action would result in long-term water quality

improvements in the basin; implementation of the KBRA is anticipated to accelerate these TMDLs through the provision of environmental water (KBRA Section 20.5.4) and other KBRA programs.

ES.6.4 Alternative 4 - Fish Passage at Four Dams

The Fish Passage at Four Dams Alternative would include construction of fish passage facilities at each of the Four Facilities. This alternative would retain all hydropower generating facilities and operations; although it is assumed that operations would change in response to DOI mandatory flow conditions and the ~~DOC~~NOAA Fisheries Service and DOI fishway prescriptions. The Lead Agencies used the prescriptions developed during the FERC relicensing process to describe the facilities needed to achieve fish passage and required flow conditions. The prescriptions also included flow and operational

~~requirements that are included in this alternative. Figure ES-10~~requirements that are included in this alternative. For the purposes of analysis in this EIS/EIR, however, Alternative 4 has been developed with some assumptions regarding details and feature designs for purposes of this analysis that are not included or not yet determined for the fishway prescriptions and do not reflect any final decision by NOAA Fisheries Service or USFWS regarding any differences from the express text of the fishway prescriptions or how any decision may be made under the terms of the fishway prescriptions. Figure ES-9 shows an example of a cast-in-place pool and weir fish ladder that is similar to that proposed for upstream fish passage at all four dams under this alternative. Typical downstream passage fish would include screening the away from the intake structures for the power generation facilities and the spillway modifications (if they are unsuitable for downstream passage).



~~Figure ES-10. Example of Cast-In-Place Pool and Weir Fish Ladder~~

Figure ES-9. Example of Cast-In-Place Pool and Weir Fish Ladder.

~~The Hydropower Licensee would need to re-enter the FERC process to implement this alternative and would be responsible for its long-term operation and maintenance.~~Implementation of this alternative would require licensure of the project by FERC to a Hydropower Licensee including 401 certifications. To meet essential flows in the bypass reaches, less water would pass through the power generating facilities than under current conditions, reducing power production. In addition, this alternative would result in restricted project ramping rates and would only allow peaking one day per week.

The Fish Passage at Four Dams Alternative would not satisfy the conditions in the KHSA. Consequently, it is assumed that the KBRA and the Keno Dam Transfer would not be fully implemented. For the purposes of this analysis, alternatives that would not result in full implementation of the KHSA do not include the KBRA as a connected action to the alternative. Additionally, the transfer Keno Dam to DOI would not move forward as a connected action.

This alternative would follow the schedule ~~proposed~~prescribed in the FERC relicensing process. The prescriptions include a schedule for implementation and ~~recommend~~prescribe that downstream facilities be installed prior to upstream passage facilities (DOI and NOAA Fisheries Service 2007). Table ES-3 shows the schedule for construction of the fish passage facilities at each dam, based on these constraints.

Under Alternative 4, full attainment of the TMDLs described under the No Action/No Project Alternative would result in long-term water quality improvements in the basin; but, the pace of achieving these improvements and the implementation mechanisms are unknown.

Table ES-3. Timetable for Fish Passage Improvements at each Dam from Date of FERC License Renewal

Dam	Upstream Fish Passage	Spillway Modifications[1]	Tailrace Barrier[1]	Screens ~~&~~and Bypass
J.C.Boyle	4 years	4 years	4 years	4 years
Copco 1	6 years	6 years	~~N/A~~8 years	6 years
Copco 2	6 years	6 years	8 years	6 years
Iron Gate	5 years	5 years	N/A	5 years

Key:
N/A: Not Applicable
Notes:
1. The prescriptions require studies to determine the need for and design of spillway modifications and tailrace barriers. ~~For the purposes of analysis in this EIS/EIR, Alternative 4 includes some specific fishway facility design and construction details that are beyond those required in the prescriptions.~~ The modified prescriptions provide that the applicant is allowed to perform site-specific studies to determine if spillway modifications and tailrace barriers are necessary at the developments where these are prescribed. However, the modified prescriptions provide that spillway modifications and tailrace barriers shall be constructed and operated unless and until USFWS and NOAA Fisheries Service determine based on any such site-specific studies that any prescribed spillway modifications or tailrace barriers are unnecessary.

ES.6.5 Alternative 5 - Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate

The Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative includes the full removal of the Iron Gate and Copco 1 facilities and installation of upstream and downstream fish passage facilities at both the J.C.Boyle and Copco 2 Dams. Implementation of this alternative would provide fish passage while retaining some hydropower generation capacity, and would improve water quality (specifically, dissolved oxygen, water temperatures, and algal toxins) through removal of the two largest reservoirs. To meet essential flows in the bypass reaches, less water would pass through the power generating facilities at the J.C.Boyle and Copco 2 developments and power production would be reduced as compared to current conditions.

Similar to the Fish Passage at Four Dams Alternative, the Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would incorporate most of the DOI and ~~DOC~~NOAA Fisheries Service prescriptions from the FERC relicensing process related to fish passage at J.C.Boyle and Copco 2 Dams (see Attachment B of Appendix A for a list of conditions and prescriptions). Alternative 5 would not incorporate the conditions and

prescriptions related to peaking power at J.C.Boyle and recreation releases. In Alternative 5, Copco 2 Dam would be the only dam remaining downstream from J.C.Boyle Dam. Copco 2 Reservoir is very small, and does not have adequate capacity to reregulate flows associated with peaking operations so that they are suitable for fish downstream. Therefore, Alternative 5 would not include peaking operations or recreation releases on any days at J.C.Boyle Dam.

~~The Hydropower Licensee would need to re-enter the FERC process to implement~~ Implementation of this alternative ~~and would be responsible~~would require licensure by FERC, including 401 certifications, for the ~~long-term operation and maintenance of the dams and fish passage~~ facilities~~.~~ that will continue to generate power. The Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would not satisfy the purposes of the KHSA to restore free flowing river conditions. Consequently, it is

assumed in this analysis that the KBRA and Keno Dam Transfer would not be fully implemented. This alternative would follow a schedule similar to that of the Proposed Action, and could be completed by December 2020.

Under Alternative 5, full attainment of these TMDLs would result in long-term water quality improvements in the basin; but, the pace of achieving these improvements and the implementation mechanisms are unknown.

ES.7 Effects of the No Action/No Project, Proposed Action, and Action Alternatives

This section describes the significant and unavoidable adverse impacts~~, as well as the~~ under NEPA and CEQA; provides a comparison of the beneficial effects~~,~~ under each of the ~~five~~ alternatives; presents the environmentally preferable/superior alternative; and, summarizes the major controversies and issues raised by agencies and the public.

ES.7.1 Significant ~~and Unavoidable Adverse Impacts~~Environmental Effects that Cannot be Avoided

Significant ~~and unavoidable adverse impacts refer to the~~ environmental ~~consequences of an action~~effects that cannot be avoided by redesigning the project, changing the nature of the project, or implementing mitigation measures~~. NEPA regulations require a discussion of any adverse impacts that cannot be avoided as a result of the proposed action (40 Code of Federal Regulations Part 1502.16). NEPA also requires a discussion of means to mitigate adverse impacts.~~ must be disclosed in an EIS/EIR. CEQA Guidelines (Section 15126.2 (b)) require discussion of significant environmental effects that cannot be avoided, as well as significant environmental effects that can be mitigated but not reduced to an insignificant level.~~ These impacts are summarized in Table ES-4. Table ES-5 summarizes the adverse environmental impacts of the resources analyzed in this EIS/EIR specific to NEPA including Socioeconomics, and Environmental Justice resources[7].~~ NEPA regulations also require a discussion of any adverse impacts that cannot be avoided as a result of the Proposed Action (40 Code of Federal Regulations Part 1502.16). By satisfying the CEQA requirements on discussion of significant environmental effects that cannot be avoided, the NEPA requirement to disclose adverse impacts is also met. These impacts are summarized in Table ES-4 for the purposes of NEPA and CEQA.

~~A full listing of all impacts, including those that can be reduced to a less than significant level, is presented in Chapter 5 of this EIS/EIR.The specific approach used to evaluate environmental effects of each alternative relative to each environmental resource is explained in Section 3.1 and in the resource sections throughout Chapter 3.~~

~~[7] Effects relative to tribal trust resources are not displayed in this table given that no new adverse effects were identified relative to the alternatives analyzed in this EIS/EIR. Section 3.12, Tribal Trust of this EIS/EIR does however summarize the existing and ongoing tribal trust impacts present in the Klamath Basin.~~

~~**Table ES-4. Summary of Significant and Unavoidable Impacts**~~

Several categories of resources discussed in this EIS/EIR are analyzed pursuant only to NEPA. The adverse environmental effects specific only to NEPA that cannot be avoided as a result of the Proposed Action are summarized in Table ES-5.[8]

[8] Effects relative to tribal trust resources are not displayed in this table given that no new adverse effects were identified relative to the alternatives analyzed in this EIS/EIR. Section 3.12, Tribal Trust. of this EIS/EIR does, however, summarize the existing and ongoing tribal trust impacts present in the Klamath Basin.

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
3.2 Water Quality				
~~***Water Temperature***~~				
~~**Upper Klamath Basin**~~				
~~Dam removal and/or elimination of hydropower peaking operations at J.C. Boyle Powerhouse could cause short-term[9] and long-term[10] alterations in daily water temperatures and fluctuations in the J.C. Boyle bypass and peaking reaches.~~	~~2, 3, 5~~	~~S~~	~~None~~	~~S~~
~~Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term increases in spring time water temperatures and decreases in late summer/fall water temperatures in the Hydroelectric Reach downstream of Copco 1 Reservoir.~~	~~2, 3, 5~~	~~S for springtime~~	~~None~~	~~S for springtime~~
~~***Lower Klamath Basin***~~				
~~Dam removal and conversion of the reservoir areas to a free flowing river could result in short-term and long-term increases in spring water temperatures and decreases in late summer/fall water temperatures in the Lower Klamath River.~~	~~2, 3, 5~~	~~S – Iron Gate Dam to Salmon River for springtime~~	~~None~~	~~S – Iron Gate Dam to Salmon River for springtime~~
Suspended Sediments				
Upper Klamath Basin (in the Hydroelectric Reach)				
Draining the reservoirs and release of sediment could cause short-term increases in suspended material in the Hydroelectric Reach downstream ~~of~~from J.C.Boyle Dam.	2, 3, 5	~~S~~S (short term[1])	None	~~S~~S (short term)
Lower Klamath Basin				
Draining the reservoirs and release of sediment could cause short-term increases in suspended material in the ~~l~~Lower Klamath River and the Klamath Estuary.	2, 3, 5	~~S~~S (short term)	None	~~S~~S (short term)
Dissolved Oxygen				
Upper Klamath Basin				
Draining the reservoirs and release of sediment could cause short-term increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the Hydroelectric Reach downstream ~~of~~from J.C.Boyle Reservoir.	2, 3, 5	~~S~~S (short term)	None	~~S~~S (short term)
Lower Klamath Basin				

~~[9] Short-term is defined as <2 years following dam removal.~~
~~[10] Long-term is defined as 2-50 years following dam removal.~~

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)		Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Dam removal and sediment release could cause short-term increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.		2, 3, 5	S (short term) lower Klamath River from Iron Gate Dam to Clear Creek~~)~~	None	S (short term) lower Klamath River from Iron Gate Dam to Clear Creek~~)~~

[1] Short term is defined as <2 years.

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
3.3 Aquatic Resources				
Critical Habitat				
Reservoir drawdown associated with dam removal could alter the quality of critical habitat.	2, 3, 5	S (short-term) for coho)	None	S (short-term) for coho)
Essential Fish Habitat				
Reservoir drawdown associated with dam removal could alter the quality of EFH.	2, 3, 5	S (short-term for) Chinook and coho)	None	S (short-term) for Chinook and coho)
Species Impacts				
Coho Salmon				
Reservoir drawdown associated with dam removal could alter SSCs and bedload sediment transport and deposition and affect coho salmon.	2, 3, 5 (would only remove Copco 1 and Iron Gate)	S (short term) Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units	AR-1: Protection of mainstem spawning; AR-2: Protection of outmigrating juveniles; AR-3: Fall flow pulses; AR-4: Hatchery management	S (short term) Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units)
Steelhead				

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Reservoir drawdown associated with dam removal could alter SSCs and bedload sediment transport and deposition and affect steelhead in the short -term.	2, 3, 5	~~S~~ S (short term) summer and winter steelhead	AR-1: Protection of mainstem spawning; AR-2: Protection of outmigrating juveniles; AR-3: Fall flow pulses; AR-4: Hatchery management	~~S~~ S (short term) summer and winter steelhead
Pacific Lamprey				
Reservoir drawdown associated with dam removal could alter SSCs and bedload sediment transport and deposition and affect Pacific lamprey in the short -term.	2, 3, 5	S (short term)	AR-2: Protection of Outmigrating Juveniles; AR-5: Pacific lamprey capture and relocation.	~~S~~S (short term)
Green Sturgeon				
Reservoir drawdown associated with dam removal could alter SSCs and bedload sediment transport and deposition and affect green sturgeon.	2, 3, 5	~~S~~S (short term)	AR-3: Fall flow pulses	~~S~~S (short term)

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Freshwater mussels				
Reservoir drawdown associated with dam removal could alter SSCs and bedload sediment transport and deposition and affect freshwater mussels in the short -term.	2, 3, 5	SS (short term)	AR-7: Freshwater mussel relocation	SS (short term)
Benthic Macroinvertebrates				
Reservoir drawdown associated with dam removal could alter SSCs and bedload sediment transport and deposition and affect macroinvertebrates. below Iron Gate.	2, 3, 5	SS (short term)	None	SS (short term)
3.4 Algae				
Hydroelectric Reach				
Dam removalConversion of the reservoir areas to a free-flowing river, and the elimination of hydropower peaking operations could result incause long-term increasedincreases in nutrient levels and biomass of nuisance periphyton (attached algae) in low-gradient channel margin areas within the Hydroelectric Reach.[11] downstream from J.C.Boyle Dam.[2]	2, 3, 5[3]	SS (long term[4])	None	S (long term)

[11] Increased periphyton biomass would not affect levels of algal toxins in the Klamath River. The noxious blooms of phytoplankton (suspended algae) occurring in the calm, lake-like waters of Copco 1 and Iron Gate Reservoirs are responsible for the production of algal toxins, such as microcystin, in the Klamath River downstream of Iron Gate Dam (see Section 3.4). Noxious phytoplankton would not thrive in the free-flowing river following dam removal.

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~**3.9 Air Quality**~~				
~~Vehicle exhaust and fugitive dust emissions from dam removal activities could increase emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ to levels that could exceed Siskiyou County's thresholds of significance.~~	~~2, 3~~	~~S~~	~~AQ-1: MY 2015 or newer engines for offroad construction equipment~~ ~~AQ-2: MY 2000 or newer engines for on-road construction equipment~~ ~~AQ-3: MY 2010 or newer engines for haul trucks~~	~~S~~
~~Reservoir restoration actions could result in short-term and temporary increases in criteria pollutant emissions from the use of helicopters, trucks, and barges that could exceed Siskiyou County's thresholds of significance.~~	~~2, 3, 5~~	~~S~~	~~AQ-1: MY 2015 or newer engines for offroad construction equipment~~ ~~AQ-2: MY 2000 or newer engines for on-road construction equipment~~ ~~AQ-3: MY 2010 or newer engines for haul trucks~~	~~S~~
~~***Trap and Haul Operations***~~				

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~Implementation of trap and haul measures could result in temporary increases in air quality pollutant emissions from vehicle exhaust.~~	~~4, 5~~	~~S~~	~~AQ-1: MY 2015 or newer engines for offroad construction equipment~~ ~~AQ-2: MY 2000 or newer engines for on-road construction equipment~~ ~~AQ-3: MY 2010 or newer engines for haul trucks~~	~~S~~
~~***KBRA***~~				
~~Construction activities associated with the KBRA programs could result in temporary increases in air quality pollutant emissions from vehicle exhaust and fugitive dust.~~	~~2, 3~~	~~S~~	~~AQ-1: MY 2015 or newer engines for offroad construction equipment~~ ~~AQ-2: MY 2000 or newer engines for on-road construction equipment~~ ~~AQ-3: MY 2010 or newer engines for haul trucks~~	~~S~~[12]

[12] ~~While Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce impacts to LTS, emissions from any construction actions completed in the same year as hydroelectric facility removal actions may not be reduced to a less than significant level. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate.~~

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)		Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~Operational activities associated with the Fisheries Reintroduction and Management Plan could result in temporary increases in air quality pollutant emissions from vehicle exhaust associated with trap-and-haul activities.~~		~~2, 3~~	~~S~~	~~AQ-1: MY 2015 or newer engines for offroad construction equipment AQ-2: MY 2000 or newer engines for on-road construction equipment AQ-3: MY 2010 or newer engines for haul trucks~~	~~S~~[9]
~~**3.10 Greenhouse Gases/Global Climate Change**~~					
~~Removing or reducing a renewable source of power by removing the dams or developing fish passage could result in increased GHG emissions from possible non-renewable alternate sources of power.~~		~~2, 3, 4, 5~~	~~S~~	~~CC-1: Market Mechanisms); CC-2: Energy Audit Program; and CC-3: Energy Conservation Plan~~	~~S~~

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~**3.13 Cultural and Historic Resources**~~				
~~The Proposed Action could result in direct effects/impacts to J.C. Boyle Dam, Copco 1 Dam, Copco 2 Dam, and Iron Gate Dam, their associated hydroelectric facilities, and on the KHHD, which is considered eligible for inclusion on the National Register and California Register.~~[2] Periphyton are algae that grow attached to rocks and other substrates on a riverbed. Although sometime these species cause nuisance conditions, they are rarely considered toxic. Increased non-toxic periphyton biomass would not lead to increases in algal toxins in the Klamath River. Blooms of phytoplankton (suspended algae) occurring in the calm, lake-like waters are responsible for the production of algal toxins, such as microcystin, in the Klamath River downstream from Iron Gate Dam. Noxious phytoplankton would not thrive in the free flowing river following dam removal. [3] An editorial clarification was made to this determination for Alternative 5 in Section 3.4, Algae. As indicated by the analysis under the Proposed Action in Section 3.4, Algae, the determination for Alternative 5 in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir should also have been a significant effect. [4] Long term is defined as 2-50 years.	~~2, 3, 5~~	~~S~~	~~CHR-1: Update the Klamath Hydroelectric Project Request for Determination~~ ~~CHR-2: MOU Under Section 106 and Preparation of Monitoring and Cultural Resources Management Plan~~ ~~CHR-3: Respect and Maintain Confidentiality of Sensitive Information~~ ~~CHR-4:Treatment of Indian Human Remains~~	~~S~~
~~***KBRA***~~				

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)		Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~Implementation of the KBRA programs including the Phase 1 and 2 Fisheries Restoration Plans, Fisheries Reintroduction and Management Plan, Wood River Wetland Restoration Project, On-Project Plan, Water Use Retirement Program, Fish Entrainment Reduction, Klamath Tribes Interim Fishing Site, and Mazama Forest Project could result in impacts/effects to archaeological and historic sites, TCPs, and cultural landscapes that are eligible for inclusion on the National Register and/or California Register and possibly Indian human remains.~~		~~2, 3~~	~~S~~	~~CHR-1: Update the Klamath Hydroelectric Project Request for Determination CHR-2: MOU Under Section 106 and Preparation of Monitoring and Cultural Resources Management Plan CHR-3: Respect and Maintain Confidentiality of Sensitive Information CHR-4:Treatment of Indian Human Remains~~	~~S~~[13]

[13] ~~Studies will be conducted to identify cultural resources and reduce significant impacts to these resources. Implementation of specific plans and projects associated with the KBRA will require future environmental compliance as appropriate.~~

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
3.9 Air Quality				
Vehicle exhaust and fugitive dust emissions from dam removal activities could increase emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ to levels that could exceed Siskiyou County's thresholds of significance.	2, 3	S (short term)	AQ-1: MY 2015 or newer engines for offroad construction equipment AQ-2: MY 2000 or newer engines for on-road construction equipment AQ-3: MY 2010 or newer engines for haul trucks	S (short term)
KBRA – Programmatic Measures				
Construction activities associated with the KBRA programs could result in temporary increases in air quality pollutant emissions from vehicle exhaust and fugitive dust.	2, 3	S(short term)	AQ-1: MY 2015 or newer engines for offroad construction equipment AQ-2: MY 2000 or newer engines for on-road construction equipment AQ-3: MY 2010 or newer engines for haul trucks	S[5] (short term)
Operational activities associated with the Fisheries Reintroduction and Management Plan could result in temporary increases in air quality pollutant emissions from vehicle exhaust associated with trap-and-haul activities.	2, 3	S(short term)	AQ-1: MY 2015 or newer engines for offroad construction equipment AQ-2: MY 2000 or newer engines for on-road construction equipment AQ-3: MY 2010 or newer engines for haul trucks	S (short term)
3.10 Greenhouse Gases/Global Climate Change				
Removing or reducing a renewable source of power by removing the dams or developing fish passage could result in increased GHG emissions from possible non-renewable alternate sources of power.	2, 3, 4, 5	S(long term)	CC-1: Market Mechanisms); CC-2: Energy Audit Program; and CC-3: Energy Conservation Plan	S(long term)

[5] While Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce impacts to LTS, emissions from any construction actions completed in the same year as hydroelectric facility removal actions may not be reduced to a less than significant level. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate.

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
3.13 Cultural and Historic Resources				
Dam removal and construction of fish passage facilities could result in direct effects/impacts to J.C.Boyle Dam, Copco 1 Dam, Copco 2 Dam, and Iron Gate Dam, their associated hydroelectric facilities, and on the KHHD, which is considered eligible for inclusion on the National Register and California Register.	2, 3, 4, 5	S(long term)	CHR-1: Update the Klamath Hydroelectric Project Request for Determination CHR-2: MOU Under Section 106 and Preparation of Monitoring and Cultural Resources Management Plan CHR-3: Respect and Maintain Confidentiality of Sensitive Information CHR-4:Treatment of Indian Human Remains	S(long term)
KBRA – Programmatic Measures				

Implementation of the KBRA programs including the Phase 1 and 2 Fisheries Restoration Plans, Fisheries Reintroduction and Management Plan, Wood River Wetland Restoration Project, On-Project Plan, Water Use Retirement Program, Fish Entrainment Reduction, Klamath Tribes Interim Fishing Site, and Mazama Forest Project could result in impacts/effects to archaeological and historic sites, TCPs, and cultural landscapes that are eligible for inclusion on the National Register and/or California Register and possibly Indian human remains.	2, 3	S(long term)	CHR-1: Update the Klamath Hydroelectric Project Request for Determination CHR-2: MOU Under Section 106 and Preparation of Monitoring and Cultural Resources Management Plan CHR-3: Respect and Maintain Confidentiality of Sensitive Information CHR-4:Treatment of Indian Human Remains	S[6] (long term)
3.19 Scenic Quality				
Ongoing fish habitat restoration actions could result in short-term ~~and long-term~~ impacts on scenic resources.	1	S (short - term ~~from construction~~)	None	S (short - term ~~from construction~~ and long term)
~~The removal of historic structures could result in impacts on scenic resources.~~	~~2, 3, 5~~	~~S~~	~~None~~	~~S~~
~~Dam removal could result in short and long-term impacts on scenic resources in formerly inundated reservoir areas.~~	~~2, 3, 5~~	~~S~~	~~None~~	~~S~~
~~Deconstruction and restoration activities could result in short-term impacts on scenic resources in the immediate vicinity of the Four Facilities.~~	~~2, 3, 5~~	~~S (short-term)~~	~~None~~	~~S (short-term)~~
~~Construction~~The removal of ~~a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the Klamath River~~historic structures could result in short and long-term impacts on scenic resources.	2, 3, 5	S(short-term and long term)	None	S ~~(short-~~ (long term)
~~Replacement of the existing wooden Lakeview Bridge just downstream of Iron Gate Dam with a concrete bridge could result in short and long-term impacts on scenic resources.~~	~~2, 3~~	~~S (short-term)~~	~~None~~	~~S (short-term)~~
~~Relocation of existing recreation facilities, such as campgrounds and boat ramps, from the reservoir banks to the new river shoreline would result in short and long-term impacts on scenic resources.~~ [6] Studies will be conducted to identify cultural resources and reduce significant impacts to these resources. Implementation of specific plans and projects associated with the KBRA will require future environmental compliance as appropriate.	~~2, 3~~	~~S (short-term)~~	~~None~~	~~S (short-term)~~

~~Sediment release during dam and reservoir removal could cause temporary changes in water quality and the appearance of the Klamath River in the area of the dams and downstream from Iron Gate Dam.~~	~~2, 3, 5~~	~~S~~	~~None~~	~~S~~
~~Demolition, construction, and restoration activities for the fishways could cause short-term adverse effects on the scenic vistas in the immediate vicinity of the Four Facilities.~~	~~4, 5~~	~~S~~	~~None~~	~~S~~
~~Fishways could cause substantial long-term impacts on scenic resources.~~	~~4, 5~~	~~S~~	~~None~~	~~S~~
~~***Trap and Haul Operations***~~				
~~Construction activities associated with fish collection facilities would introduce new features into the landscape.~~	~~4, 5~~	~~S~~	~~None~~	~~S~~

~~***KBRA***~~				
~~Construction activities associated with fish collection facilities would introduce new features into the landscape.~~	~~2, 3~~	~~S~~	~~None~~	~~S~~

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Dam removal could result in short and long-term impacts on scenic resources in formerly inundated reservoir areas.	2, 3, 5	S (short term and long term)	None	S (short term and long term)
Deconstruction and restoration activities could result in short-term impacts on scenic resources in the immediate vicinity of the Four Facilities.	2, 3, 5	S (short term)	None	S (short term)
Replacement of the existing wooden Lakeview Bridge just downstream from Iron Gate Dam with a concrete bridge could result in short -term impacts on scenic resources.	2, 3	S (short term)	None	S (short term)
Demolition of existing recreation facilities, such as campgrounds and boat ramps, from the reservoir banks to the new river shoreline would result in short-term impacts on scenic resources.	2, 3	S (short term)	None	S (short term)
Sediment release during dam and reservoir removal could cause temporary changes in water quality and the appearance of the Klamath River in the area of the dams and downstream from Iron Gate Dam.	2, 3, 5	S (short term)	None	S (short term)
Demolition, construction, and restoration activities for the fishways could cause short-term adverse effects on the scenic vistas in the immediate vicinity of the Four Facilities.	4, 5	S (short term)	None	S (short term)
Fishways could cause substantial long-term impacts on scenic resources.	4, 5	S (long term)	SQ-1: Measures to Minimize Scenery Disturbances	S (long term)
City of Yreka Water Supply Pipeline Relocation – Programmatic Measure				
Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the Klamath River could result in short and long-term impacts on scenic resources.	2, 3, 5	S (short term and long term)	SQ-1: Measures to Minimize Scenery Disturbances	S (short term and long term)
KBRA – Programmatic Measures				

Construction of fish management structures would introduce new features into the landscape.	2, 3	S (long term)	SQ-1: Measures to Minimize Scenery Disturbances	S (long term)
Trap and Haul – Programmatic Measure				
Construction activities associated with fish collection facilities would introduce new features into the landscape.	4, 5	S (long term)	SQ-1: Measures to Minimize Scenery Disturbances	S (long term)

Table ES-4. Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
3.20 Recreation				
Changes in flows could decrease the number of days with acceptable flows for whitewater boating and recreational fishing in the Hells Corner Reach.	2, 3, 4, 5	S (long term) whitewater boating~~)~~	None	S (long term) whitewater boating~~)~~
3.23 Noise and Vibration				
Construction and deconstruction activities at the dam sites could cause a temporary increase in noise levels at Copco 1 Dam that could affect residents in the area.	2, 3, 5	~~S~~S (short term)	NV-1: Noise and Vibration Control Plan	~~S~~S (short term)
Construction and deconstruction activities at the dam sites could cause a temporary increase in nighttime noise levels at Iron Gate Dam.	2, 3, 5	~~S~~S (short term)	NV-1: Noise and Vibration Control Plan	~~S~~S (short term)
Reservoir restoration activities could result in short-term increases in noise levels in the project vicinity.	2, 3, 5	~~S~~S (short term)	NV-1: Noise and Vibration Control Plan	~~S~~S (short term)
Blasting activities at Copco 1 Dam could increase vibration levels.	2, 3, 5	~~S~~S (short term)	NV-1: Noise and Vibration Control Plan	~~S~~S (short term)
Construction activities at the dam sites could increase short-term vibration levels.	2, 3,5	~~S~~ S (short term)	NV-1: Noise and Vibration Control Plan	~~S~~ S (short term)

Key:
BLM = Bureau of Land Management
BOD = biological oxygen demand
CEQA = California Environmental Quality Act
CO = carbon monoxide
DOC = United States Department of Commerce
DOI = Department of the Interior
DRE = Dam Removal Entity
EFH = Essential Fish Habitat
FERC = Federal Energy Regulatory Commission
GHG = Greenhouse Gases
IOD = immediate oxygen demand
KBRA = Klamath Basin Restoration Agreement
KHHD= Klamath Hydroelectric Historic District
KHP = Klamath Hydroelectric Project
MSAE = Microcystis aeruginosa
NAGPRA = Native American Graves Protection and Repatriation Act
ODEQ = Oregon Department of Environmental Quality
PM_{10} = particulate matter < 10 microns
$PM_{2.5}$ = particulate matter < 2.5 microns
SO_2= sulfur dioxide
SSC = suspended sediment concentrations
TN = Total Nitrogen
TP = Total Phosphorus
USFWS = United States Fish and Wildlife Service
VOC = volatile organic compounds
VRM = Visual Resource Management Methodology
WQ = Water quality
WSR = Wild and Scenic River
Significance:
NCFEC = No Change From Existing Conditions
B = Beneficial
LTS = Less than Significant
S = Significant
N/A = Not Applicable
Alternatives:
1 = No Action/No Project
2 = Full Facilities Removal of Four Dams Alternative (Proposed Action)
3 = Partial Facilities Removal of Four Dams Alternative
4 = Fish Passage at Four Dams Alternative
5 = Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

~~**Key**:~~
~~BLM = Bureau of Land Management~~
~~BOD = biological oxygen demand~~
~~CEQA = California Environmental Quality Act~~
~~CO = carbon monoxide~~
~~DOC = United States Department of Commerce~~
~~DOI = Department of the Interior~~
~~DRE = Dam Removal Entity~~
~~EFH = Essential Fish Habitat~~
~~FERC = Federal Energy Regulatory Commission~~
~~GHG = Greenhouse Gases~~
~~IOD = immediate oxygen demand~~
~~KBRA = Klamath Basin Restoration Agreement~~
~~KHHD= Klamath Hydroelectric Historic District~~
~~KHP = Klamath Hydroelectric Project~~
~~MSAE = Microcystis aeruginosa~~
~~NAGPRA = Native American Graves Protection and Repatriation Act~~
~~ODEQ = Oregon Department of Environmental Quality~~
~~PM_{10} = particulate matter < 10 microns~~
~~$PM_{2.5}$ = particulate matter < 2.5 microns~~
~~SO_2= sulfur dioxide~~
~~SSC = suspended sediment concentrations~~
~~TN = Total Nitrogen~~
~~TP = Total Phosphorus~~

~~USFWS = United States Fish and Wildlife Service~~
~~VOC = volatile organic compounds~~
~~VRM = Visual Resource Management Methodology~~
~~WQ = Water quality~~
~~WSR = Wild and Scenic River~~
~~**Significance**:~~
~~NCFEC = No Change From Existing Conditions~~
~~B = Beneficial~~
~~LTS = Less than Significant~~
~~S = Significant~~
~~N/A = Not Applicable~~
~~**Alternatives**:~~
~~1 = No Action/No Project~~
~~2 = Full Facilities Removal of Four Dams Alternative (Proposed Action)~~
~~3 = Partial Facilities Removal of Four Dams Alternative~~
~~4 = Fish Passage at Four Dams Alternative~~
~~5 = Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative~~

Table ES-5. Summary of Adverse Environmental Effects Relative to NEPA~~1~~

Potential Impact	Alternative(s)	Effect Pursuant to NEPA	Mitigation
3.15 Socioeconomics			
Four Facilities			

Table ES-5. Summary of Adverse Environmental Effects Relative to NEPA[1]

Potential Impact	Alternative(s)	Effect Pursuant to NEPA	Mitigation
Changes in annual O&M expenditures required to continue the operation of the existing facilities could affect employment, labor income, and output in the regional economy.	2, 3, 5	Adverse(long-term)	None
Recreation			
Changes to reservoir recreation expenditures could affect employment, labor income, and output in the regional economy.	2, 3, 5	Adverse (long-term)	None
Changes to whitewater boating opportunities could affect recreational expenditures and employment, labor income, and output in the regional economy.	2, 3, 4, 5	Adverse (long-term)from reduced whitewater boating expenditures in the Upper Klamath River and Hell's Corner Reach)	None
~~***PacifiCorp Hydroelectric Service***~~			
~~Energy rates for PacifiCorp customers could change.~~	~~1, 4, 5~~	~~Unknown[2]~~	~~None~~
Property Values and Local Government Revenues			
Property values surrounding Iron Gate and Copco Reservoirs could change.	2, 3, 5 (around Copco 1 and Iron Gate Reservoirs)	Adverse (short-term~~); Unknown (~~ and long-term)[2]	None
Changes in real estate values around ~~Copco 1 and~~ Iron Gate and Copco Reservoirs and downstream could affect property tax revenues to Siskiyou County.	2, 3, 5	Adverse (short-term); Unknown (long-term)[3~~2~~]	None
Changes in visitation for recreation activities could affect sales tax revenues.	2, 3	~~Unknown[4]~~Unknown (short term and long term)	None

[1] Effects relative to tribal trust resources are not displayed in this table given that no new adverse effects were identified relative to the alternatives analyzed in this EIS/EIR. Section 3.12, Tribal Trust, of this EIS/EIR does however summarize the existing and ongoing tribal trust impacts present in the Klamath Basin.

[2] Changes in recreation expenditures and associated sales taxes vary by recreation activity. The net effect of changes in recreation expenditures is unknown.

KBRA – Programmatic Measures			
Increases in on-farm pumping costs could affect household income and reduce employment, labor income, and output in the regional economy.	2, 3	Adverse (long term)	None
Water acquisitions via short-term water leasing could decrease farm revenues and reduce employment, labor income, and output in the regional economy.	2, 3	Adverse (short - term)	None
3.16 Environmental Justice			
Increased traffic, air quality emissions, and noise associated with construction activities could disproportionately affect county residents and tribal people.	2, 3, 4, 5	Disproportionate Effects (short - term)	AQ-1: MY 2015 or newer engines for offroad construction equipment AQ-2: MY 2000 or newer engines for on-road construction equipment AQ-3: MY 2010 or newer engines for haul trucks AQ-4: Dust control measures during blasting operations NV-1: Noise and Vibration Control Plan
Release of sediment from reservoirs could cause disproportionate short term impacts on county residents and tribal people.	2, 3, 5	Disproportionate Effect (short term)	None
Changes in county revenues could decrease county funding of social programs used by county residents.	2, 3, 5	Disproportionate Effects	None
Traffic on associated haul roads could disproportionately affect county residents and tribal people.	2, 3, 4, 5	Disproportionate Effects (short - term)	TR-1: Relocate Jenny Creek Bridge and Culverts

KBRA – Programmatic Measures			
Implementation of the Water Use Retirement Program, Off-Project Reliance Program, and Interim Flow and Lake Level Program could disproportionately affect low income and minority farm workers.	2, 3	Disproportionate Effects (short - term)	None

KEY:
Significance:
NCFEC = No Change From Existing Conditions
B = Beneficial
LTS = Less than Significant
S = Significant
N/A = Not Applicable
Alternatives:
1 = No Action/No Project
2 = Full Facilities Removal of Four Dams Alternative (Proposed Action)
3 = Partial Facilities Removal of Four Dams Alternative
4 = Fish Passage at Four Dams Alternative
5 = Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

~~**Notes:**~~
~~1- Effects relative to tribal trust resources are not displayed in this table given that no new adverse effects were identified relative to the alternatives analyzed in this EIS/EIR. Section 3.12, Tribal Trust of this EIS/EIR does however summarize the existing and ongoing tribal trust impacts present in the Klamath Basin.~~
~~2 - Many factors affect setting customer electricity rates, including regulatory approval; therefore, it is difficult to assess how rates may change, if at all.~~
~~3 - It is unknown how the real estate value of properties with existing reservoir views may change in the long term from river restoration activities.~~
~~4 - Changes in recreation expenditures and associated sales taxes vary by recreation activity. The net effect of changes in recreation expenditures is unknown.~~

~~ES.7.2 Balancing Impacts and Benefits of the Alternatives~~

A full listing of all impacts, including those that can be reduced to a less than significant level, is presented in Chapter 5 of this EIS/EIR.

The specific approach used to evaluate environmental effects of each alternative relative to each environmental resource is explained in Section 3.1 and in the resource sections throughout Chapter 3.

ES.7.2 Synopsis of Major Impacts and Benefits of the Alternatives

This section presents a synopsis of major impacts and benefits for each alternative with a focus on aquatic resources and water quality. (All of the significant adverse impacts that cannot be avoided for all resource categories are listed in Table ES-4 and Table ES-5). This summary section presents impacts and benefits incrementally to illustrate potential key benefits and impacts that may occur under each alternative. Though impacts to all resources will ultimately be considered by the Secretary of the Interior when making the Determination on whether or not the Proposed Action is in the public interest, this summary focuses on restoring fisheries and improving water quality (fishery and water quality benefits are also summarized in Table ES-6). A synthesis of this information is particularly important to address the question of whether and to what degree an alternative may advance the restoration of the salmonid fisheries of the Klamath Basin and to determine which alternative may be environmentally preferable. In addition, the Affected Environment/Existing Conditions is summarized because it is a valuable point of comparison. (For more detail on each alternative and how alternatives were selected refer to ES.5 Alternatives Development and Chapter 2 Proposed Action and Description of Alternatives).

The structure of the section is as follows:

- Affected Environment/Existing Conditions;
- Alternative 1 (No Action/No Project Alternative);
- Alternative 4 (Fish Passage at Four Dams Alternative);
- Alternative 5 (Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate);
- Alternatives 2 (Full Facilities Removal of Four Dams (Proposed Action)) and 3 (Partial Removal of Four Dams);
- Comparison of Alternative 2 and 3

Under NEPA (40 CFR Part 1502.16, Environmental Consequences), a discussion of the environmental impacts of the alternatives, including the ~~proposed action~~Proposed Action,

should be included. A discussion of the potential beneficial effects of the alternatives is also valuable for decision-makers when comparing and contrasting alternatives and determining the best course of action~~ to be undertaken.~~.

CEQA Guidelines require the balancing, as applicable, of the economic, legal, social, technological, or other benefits of a proposed project against its unavoidable environmental risks when determining whether to approve a project (Section 15093 (a)-(c)). If the specific benefits, including region-wide or statewide environmental benefits of a proposed project outweigh the unavoidable adverse environmental effects, the adverse environmental effects may be considered "acceptable." When a lead agency approves a project which will result in the occurrence of significant effects which are identified, but not avoided or substantially lessened, the lead agency under CEQA shall state in writing the specific reasons to support its action based on the final EIS/EIR or other information in the record. This statement becomes the statement of overriding considerations as required under CEQA.

As illustrated throughout this Executive Summary, ~~the dominant factors~~many measures agreed upon in the KHSA and KBRA centered on improving and resolving issues of low or declining fish populations and fisheries, inadequate water supplies, and degraded water quality. The primary goal of these agreements is to improve the condition and reliability of these basin resources and thereby benefit the communities who rely on them, or historically ~~relied~~depended on them, for a way of life. This includes tribal, fishing, farming, and recreational communities throughout the Klamath Basin.

One example of the inter-relatedness of basin resources and communities can be ~~seen~~illustrated by evaluating the impacts and benefits of the alternatives on tribal communities where environmental justice ~~communities in the basin.~~is a concern. Reversing the consequences of barriers to fish passage, degraded fish habitat, and degraded water quality throughout the basin could result in great benefit to tribal communities relying on fish, shellfish, riparian plants, clean water, and other resources for their subsistence, ceremonies, physical health, way of life, and spiritual well-being. While sediment release and other construction related activities during dam removal could cause short-term (1 to 2 years) adverse impacts on fisheries downstream ~~of~~from the Hydroelectric Reach, salmon and other aquatic resources would be expected to return to ~~existing 2010~~ population levels observed prior to dam removal (in 2010 when the Notice of Preparation was issued) within 5 years, and would provide long-term benefits to Indian Tribes for 50 years and beyond (these effects for Indian Tribes are analyzed in Section 3.16).

~~In addition to benefits to fisheries and water quality, over the period of analysis, dam removal combined with undertaking the programs in the KBRA would have beneficial effects on the following basin resources:~~

- ~~**Terrestrial Resources** (analyzed in Section 3.5) through enhanced habitat connectivity and animal movement.~~

- ~~**Socioeconomic Resources** (analyzed in Section 3.15) through changes in commercial, recreational, and tribal fishing harvests and refuge recreation, as well as local and regional increases in economic output, employment, and labor income from construction and mitigation spending.~~
- ~~**Scenic Quality** (analyzed in Section 3.19) through returning areas around the dams closer to the scenic quality characteristics of the natural landscape.~~
- ~~**Recreation** (analyzed in Section 3.20) through improvements in water-contact-based recreation and benefits to the Wild and Scenic River Act designation of the Klamath River.~~

Because restoring fisheries, improving water quality, and helping communities are major goals of the Proposed Action and of the action alternatives, ~~a summary of~~ the major long-term benefits and impacts of each alternative ~~and their impacts is~~are summarized below relative to these goals ~~(these are also summarized in Table ES-5). In addition, the baseline (existing) condition is summarized because it is the benchmark against which the five alternatives are compared~~.

~~**Baseline**~~

ES.7.2.1 Existing Conditions/Affected Environment

The Klamath Basin currently suffers from degraded fisheries, excessive exposure of salmon to disease, degraded habitat quality (including altered flows, water temperatures, ~~and~~ river channel structure~~),~~, and invasive species), blocked access to historical habitat ~~limitations (barriers to fish passage),~~, and degraded water quality (including problems with dissolved oxygen, pH, nutrient enrichment, algal growth, and algal toxins). Major water quality problems exist in Upper Klamath Lake, Keno ~~Reservoir~~Impoundment/Lake Ewauna, and the reservoirs in the Hydroelectric Reach~~.~~, as well as the Lower Klamath Basin downstream from Iron Gate Dam.

~~One result~~Results of these impaired water quality and habitat conditions ~~has been~~include fish die-offs, listings under ~~federal~~ESA and the California ~~endangered species acts~~Endangered Species Act (CESA), health advisory postings for algal toxins in Copco 1 and Iron Gate reservoirs since 2005, and commercial fishing closures. Circumstances for salmonid fisheries and threatened and endangered species in the Klamath Basin are not improving. In addition, basin water supplies are over-allocated and do not meet all user needs; these challenges have been particularly acute in dry years. Water shortages, combined with the need to ~~balance supplies among~~provide water to address the needs of ESA-listed species (suckers in Upper Klamath Lake and coho salmon in the Klamath River), national wildlife refuges, and farming communities have led to the reduction of irrigation water deliveries to farmers in dry years. In short, existing conditions represent a continued hardship for fishing, farming, tribal, and recreational communities. In particular, the Klamath Tribes have had to bear the hardship of being without salmon in the Upper Basin for nearly 100 years and without harvestable sucker populations for 25

years; these species are fundamental to their diet, their ceremonies, and their cultural well-being.

ES.7.2.2 Alternative 1 (No Action/No Project Alternative)

Alternative 1 (No Action/No Project Alternative) is continued operation of the Klamath ~~hydroelectric project~~Hydroelectric Project under an annual license issued by FERC and would result in the continuation of many of the ~~existing~~ conditions described under ~~Baseline.~~Existing Condition/Affected Environment. This alternative would continue to block anadromous fish access to over 420 miles of historical habitat, including low gradient habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate reservoirs. Also, access to cold water springs (areas of groundwater discharge), particularly in the Upper Basin, would continue to be blocked. These cold water springs offer some protection to aquatic species against the future changes associated with climate change and improve winter growth opportunities for rearing fish. Disease problems associated with crowding of fish below Iron Gate Dam, atypically stable flows, disrupted sediment transport processes, and over-abundance of intermediate hosts for fish disease would persist. Iron Gate hatchery juvenile production as mitigation for 16 miles of habitat loss would continue, but would also exacerbates fish disease. For resident fish in the Hydroelectric Reach, the current adverse effects of peaking and those of entrainment into hydroelectric facilities would continue. Implementation of TMDLs in Oregon and California over the next 50 years would be expected to help alleviate some of ~~the~~ basin-wide water quality problems~~. However, the concurrent processes and~~, although the implementation and timing of TMDL-related actions is unknown and effective improvements could take decades to achieve. Furthermore, to date there are no proposed management actions that would achieve the temperature allocations assigned to Copco 1 and Iron Gate reservoirs under the TMDLs. The effects of climate change over the next 50 years could ~~further challenge the survival of ESA-listed fish, push more fish into ESA listing, or cause~~dampen potential benefits from TMDLs, which would continue current conditions responsible for depressed populations of certain species like Chinook or steelhead ~~to further decline.~~and would reduce opportunities to improve survival of ESA-listed fish.

As the FERC relicensing process would ~~resume~~continue following a ~~negative determination~~Negative Determination on dam removal from the Secretary, Alterative 1 ~~could~~is not likely to continue ~~for decades~~ as the status quo; however, ~~over~~if a new long-term FERC license is issued, it would be contingent on facility operations being compliant with all other applicable laws and regulations, including the Clean Water Act and the Endangered Species Act, making it difficult to predict when a new license might be implemented. For this analysis, the assumption for the next 50 years~~, this alternative would likely retain the majority of~~ is that all the dams and the associated reservoirs remain and continue to operate under annual licenses and without construction of any new fish passage facilities. This would preserve the existing hydroelectric power generation capacity and ~~the~~allow use of reservoirs ~~would remain in place~~ and ~~would continue to be used~~peaking flows for recreational purposes (the significance of these effects is analyzed in Sections 3.18 and 3.20, respectively). The recreational value of

these reservoirs, however, has been diminished in recent years (since 2005) due to the documented growth of toxic algae in Copco 1 and Iron Gate ~~R~~reservoirs and health advisory postings to that effect, conditions that can be expected to persist in the future without significant progress on nutrient reduction in the reservoirs such as through the TMDL process.

Alternative 1 would not result in the short-term negative impacts related to construction activities or short-term impacts to fish from the downstream transport of sediment during reservoir drawdown. Also Alternative 1 does not include the full implementation of KBRA. The ongoing resource management activities, ongoing Interim Measures, TMDLs, biological opinions, and other regulatory conditions described for this alternative would also occur under Alternatives 2, 3, 4, and 5

ES.7.2.3 Alternative 4 (Fish Passage at Four Dams Alternative)

Alternative 4 would require the long-term licensure of the Hydroelectric Project by FERC to a Hydropower Licensee; although, it is assumed that operations of the Four Facilities would change in response to DOI mandatory flow conditions and NOAA Fisheries Service and DOI fishway prescriptions. Alternative 4 would eventually result in the same benefits to water quality from TMDL implementation as Alternative 1; however the same limitations as Alternative 1 on achieving water quality objectives in the Hydroelectric Reach and downstream would also apply. Specifically, there are no proposed management actions that would achieve the temperature allocations assigned to Copco 1 and Iron Gate reservoirs under the TMDLs, and control of toxic blooms of cyanobacteria would not be expected to diminish in the future without significant progress on nutrient reduction in the reservoirs, which could take decades to achieve. The creation of volitional fish passage for salmonids at each of the Four Facilities under this alternative would ~~open Upper Basin~~provide access to at least 420 miles of historical habitat above Iron Gate Dam to anadromous fish. Consequently, the size and diversity of these populations would increase. Implementation of Alternative 4 and access to Upper Basin habitat would ~~decrease crowding of adult salmon and~~ reduce the ~~prevalence of~~concentration of fish carcasses which are linked to the transmission of fish disease ~~for~~ from adult salmon to juvenile salmon. In addition, fish would gain access to ~~thermal refuge areas~~cold water springs, particularly in the Upper Basin, offering some protection against the predicted future changes associated with climate change~~.~~ and improved winter growth opportunities for rearing fish. The adverse effects of peaking would be largely eliminated (only one day a week) and those of entrainment into hydroelectric facilities would be largely eliminated.

Iron Gate Hatchery would continue to mitigate for the loss of production of salmonids from the 16 miles of habitat lost between Iron Gate and Copco 2 dams.

NOAA Fisheries Service and DOI prescriptions include a measure to trap and haul fall-run Chinook salmon upstream and downstream around Keno Impoundment. The prescriptions call for seasonal trap and haul operations from June 15 to November 15 when water quality conditions are not suitable for fish (dissolved oxygen concentration

less than 6 milligrams per liter [mg/L] or temperature above 20 degrees Celsius) (DOI 2007; NOAA Fisheries Service 2007).

Alternative 4 would retain the majority (80%) of hydroelectric power generation capacity and project reservoirs would remain in place and would continue to be used for recreational purposes (the significance of these effects is analyzed in Sections 3.18 and 3.20, respectively~~).~~) over the next 50 years. Alternative 4 would not result in short-term impacts to fish from downstream transport of sediment during reservoir drawdown and dam removal.

ES.7.2.4 Alternative 5 (Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate)

Alternative 5 would result in the same benefits as Alternative 4 for anadromous fish; however, removal of Copco 1 and Iron Gate Dams would provide additional benefits. Fish would be able to migrate upstream and downstream more efficiently through a greater length of natural river channel and through fewer constructed fish passage facilities ~~in order to use habitat in the Upper Basin.~~ to use habitat in the Upper Basin. Alternative 5 would create access to at least 420 miles of historical habitat above Iron Gate Dam for anadromous fish. This would include access to low gradient historical habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate Reservoirs. This additional habitat would facilitate greater dispersion of spawning adult salmonids than under Alternative 4, thereby reducing the incidence of disease. Disease risks to resident fish would be low and the establishment of a disease hot spot for *C. shasta* above the current location of Iron Gate Dam would be unlikely. In addition, fish would gain access to cold water springs, particularly in the Upper Basin, offering improved winter growth opportunities for rearing fish and some protection against future changes associated with climate change. The adverse effect of peaking flows, stranding, and entrainment of fish into hydroelectric facilities would also be eliminated.

The Hydropower Licensee would continue to fund operating Iron Gate Hatchery to meet current mitigation requirements until Iron Gate Dam is removed, after which time the hatchery would not be funded by Hydropower Licensee and is assumed to be closed.

NOAA Fisheries Service and DOI prescriptions would also be applicable to Alternative 5. Therefore, Alternative 4 and 5 include a measure to trap and haul fall-run Chinook salmon upstream and downstream around Keno Impoundment. The prescriptions call for seasonal trap and haul operations from June 15 to November 15

when water quality conditions are not suitable for fish (dissolved oxygen concentration less than 6 mg/Lor temperature above 20 degrees Celsius) (DOI 2007; NOAA Fisheries Service 2007).

By removing the two largest reservoirs in the Hydroelectric Reach, many of the water quality impairments caused by impounding water, including high pH, ~~elevated fall~~altered patterns for water temperatures, elevated water temperatures in the fall, low dissolved oxygen, and the presence of algal toxins, would be largely eliminated within and below the Hydroelectric Reach. ~~Alternative 5 would also eliminate peaking and stranding in the Hydroelectric Reach, which currently has adverse effects on biological communities.~~

While water quality problems would improve as a result of draining Copco 1 and Iron Gate ~~R~~reservoirs, Alternative 5 would also eliminate recreational uses ~~of~~such as flatwater fishing in these reservoirs and could decrease the value of property with access to, or views of, the reservoirs~~, at least in the short term.~~. Decreased recreational opportunities could have related effects on other resources analyzed in this EIS/EIR (i.e., Socioeconomics and Recreation, analyzed in detail in Sections 3.15 and 3.20, respectively).

The release of sediments stored behind Copco 1 and Iron Gate dams would have negative impacts on fish and water quality in the short term (< 2 years) but would provide longer term benefits in the form of increased habitat complexity and increased movement of larger sediment substrate along the river bed (bedload transport), reductions in fish disease, and the nearly complete elimination of toxic algal blooms in the Hydroelectric Reach and downstream. Some chemicals are present in reservoir sediments at concentrations below critical screening levels for freshwater and marine disposal and do not preclude sediment release downstream.

Removal of Copco 1 and Iron Gate ~~Dams~~dams and the loss of peaking flows at J.C.Boyle dam would significantly decrease the amount of hydroelectric power generated by the Klamath Hydroelectric Project. However this alternative does maintain reservoir recreation opportunities at J.C.Boyle Reservoir.

ES.7.2.5 Alternatives 2 (Full Facilities Removal of Four Dams (Proposed Action)) and Alternative 3 (Partial Removal of Four Dams)

Alternatives 2 and 3 would have the benefits of ~~Alternative~~ Alternatives 4 and 5 for anadromous fish; however, Alternatives 2 and 3 would provide additional fisheries and water quality benefits. Table ES-6 below summarizes the expected major benefits to salmonids and water quality for all five alternatives in this EIS/EIR as compared to existing conditions.

All action alternatives would provide access to at least 420 miles of historical habitat above Iron Gate Dam for anadromous fish. Additionally under Alternatives 2 and 3, anadromous fish would access low gradient historical habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate Reservoirs. Consequently, the size and diversity of these populations would increase. Removing all Four Facilities would

provide for a free-flowing river below Keno dam and would optimize the efficiency of fish migration to and from the Upper Basin as well as through the entire Hydroelectric Reach. In addition, fish would gain access to cold water springs in the Hydroelectric Reach and the Upper Basin, offering improved winter growth opportunities for rearing and some protection against future changes associated with climate change. The entire river from Keno Dam to the Pacific Ocean would therefore become a well-connected, free-flowing river and would provide new fish habitat in the Hydroelectric Reach. Dam removal would maximize the recruitment of gravel within and below the Hydroelectric Reach, which would benefit fish spawning~~.~~ and rearing. Additionally, Alternatives 2 and 3 would create a more natural flow pattern and ~~a more mobile stream bed. Both of these conditions are anticipated to reduce the~~more bedload transport. The occurrence of juvenile salmon fish disease ~~and would~~is anticipated to be reduced as a result of changes in the overall dispersal of adult salmon carcasses, increases in bedload and sediment transport, and reductions in food resources for the intermediate fish disease host. While there is some uncertainty associated with the cycle of disease in juvenile salmon, a reduction in fish disease is likely and this would create better conditions for fish migration, rearing, and spawning. These alternatives would likely eliminate concentrations of carcasses and disease associated with Iron Gate Hatchery. Similarly to Alternative 5, the adverse effects of peaking and entrainment into hydroelectric facilities would also be eliminated. Disease risks to resident fish would be low and the establishment of a disease hot spot for *C. shasta* above the current location of Iron Gate Dam would be unlikely. Also, Alternatives 2 and 3 include implementation of all Interim Measures funded by PacifiCorp for the period 2012 through 2020 to improve fish habitat, water quality, and to fund monitoring and critical research.

Similarly to Alternative 5, the release of sediments stored behind Copco 1 and Iron Gate dams would have negative impacts on fish and water quality in the short term (< 2 years) but would provide longer term benefits in the form of increased habitat complexity and increased movement of larger sediment substrate along the river bed (bedload transport), reductions in fish disease, and the nearly complete elimination of toxic algal blooms in the Hydroelectric Reach and downstream. Some chemicals are present in reservoir sediments but at concentrations below critical screening levels for freshwater and marine disposal and do not preclude sediment release downstream.

Alternatives 2 and 3 would eliminate the recreational benefits of project reservoirs such as fishing and some white water recreation opportunities related to peaking flows in the Hydroelectric Reach; however partial and full facilities removal would create new recreational benefits along the Hydroelectric Reach including additional river access and rafting opportunities in the bypassed reaches (the significance of these effects is analyzed in Section 3.20). Because of the elimination of the reservoirs and changes to recreational amenities, Alternatives 2 and 3 would decrease the value of properties with access to or views of the reservoirs. Alternatives 2 and 3 eliminate all hydropower production from the Four Facilities beginning in 2020.

Implementation of KBRA projects and programs under Alternatives 2 and 3 would ~~achieve faster~~accelerate basin-wide habitat restoration for fish~~, faster~~ and accelerate

improvement of basin-wide water quality. In the Upper Basin, the KBRA would support water quality improvements~~, and direct support for improving water quality~~ in Upper Klamath Lake and Keno Reach, which would benefit migrating salmon and steelhead populations and resident sucker populations in Upper Klamath Lake. The KBRA Fisheries Reintroduction and Management Plans could have direct benefits for salmon by accelerating their reintroduction to the Upper Basin and by providing for fish population monitoring to optimize adaptive management of restoration activities.

~~This alternative~~Within 6 months of an Affirmative Determination by the Secretary of the Interior, PacifiCorp would ~~eliminate the recreational~~propose a post Iron Gate Dam Mitigation Hatchery Plan that would ensure hatchery mitigation goals are met for 8 years following dam removal. After 8 years, continued hatchery operations would depend largely on: 1) realized and projected benefits of ~~project reservoirs and could decrease the value of properties with~~ restored access to~~, or views of~~ additional habitat above the ~~reservoirs, at least~~current location of IGD; 2) the success of habitat restoration efforts through the KBRA; and 3) the success of the reintroduction program identified in the ~~short term~~KBRA.

Following dam removal seasonal trap and haul operations, primarily for fall-run Chinook salmon may occur around Keno Dam and Keno Impoundment/Lake Ewauna until water quality conditions are sufficiently improved to allow for safe passage of fish. A variety of release and rearing strategies would be utilized to optimize success; however, ~~full facilities removal would create new recreational benefits along the Hydroelectric Reach (the significance~~the KBRA does not contain specifics on the development nor implementation of these ~~effects~~ strategies.

Effects downstream from Iron Gate Dam would include increased production of Chinook salmon due to more favorable flows associated with KBRA and improved habitat condition. In particular, these alternatives would also improve survival of smolts emigrating from downstream tributaries, such as the Scott and Shasta rivers, due to improved Klamath River flows and disease conditions. Restoration of runs in these two tributaries is ~~analyzed in Section 3.20). Finally,~~the goal of extensive restoration programs.

Both Alternatives 2 and 3 ~~would eliminate all of the hydroelectric power generation from the Four Facilities (the significance of these effects is analyzed in Section 3.18).~~fulfill three key criteria described in the Purpose and Need (Sections ES.3 and 1.5.2.1):

- ~~Comparing~~ Establishes a free-flowing condition on the Klamath River from the Keno Dam (River Mile 240) to the Pacific Ocean.
- Allows for full volitional fish passage from the Upper Basin to the Lower Basin of the Klamath River.

- Leads to implementation of KBRA.

Alternatives 2 and 3~~There are many similarities in the benefits and potential impacts of Alternatives 2 and 3. The main difference~~ have effectively the same in-river effects (i.e., fisheries, habitat, or water quality); any differences between ~~the alternatives is that Alternative 3 would leave some facilities in place, but both~~these alternatives ~~would create a free-flowing river and eliminate any passage barriers to fish from Keno Dam to the Pacific Ocean.~~

~~Given the fact that fewer structures would be removed under Alternative 3 compared to Alternative 2, there would be fewer short-term environmental impacts associated with construction activities and the use of heavy equipment. Thus, impacts~~are related to ~~the release of greenhouse gases, noise, and ground and land disturbance would be diminished and there would be less likelihood of displacing cultural resources or human remains (impacts to Cultural Resources are analyzed in Section 3.13). However, leaving various appurtenant power generation facilities in place has the potential to interfere with wildlife movement and aesthetic quality, and would require some level of long-term maintenance.~~societal aspects (scenic, economic, or recreation), as described in Section ES.7.2.6.

~~Table ES-6 below summarizes the expected major benefits to salmonids and water quality for all five alternatives in this EIS/EIR as compared to existing (baseline) conditions.~~

~~Table ES-6. Summary of Major Long-Term Benefits for Salmonid Restoration and Water Quality~~

~~Major long-term benefits of alternatives for water quality and salmonids as compared to existing conditions (baseline)~~	~~Alternative 1~~	~~Alternatives 2 and 3~~	~~Alternative 4~~	~~Alternative 5~~

Table ES-6. Summary of Major Long-Term Benefits for Salmonid Restoration and Water Quality

Major long-term benefits of alternatives for water quality and salmonids as compared to existing conditions (baseline)	Alternative 1	Alternatives 2 and 3	Alternative 4	Alternative 5
Water Quality Benefits				
River no longer exceeds OR and CA water temperature, nutrient, dissolved oxygen, pH, and chlorophyll-a TMDL allocations (may not occur by 206~~2~~1), improving water quality basin wide	X[1]	X	X	X

Table ES-6. Summary of Major Long-Term Benefits for Salmonid Restoration and Water Quality

Major long-term benefits of alternatives for water quality and salmonids as compared to existing conditions (baseline)	Alternative 1	Alternatives 2 and 3	Alternative 4	Alternative 5
Accelerates when river no longer exceeds OR and CA water temperature, nutrient, dissolved oxygen, pH, and chlorophyll-a TMDL allocations through the KBRA Fisheries Restoration Plan, improving water quality basin wide		X		
Largely eliminates in 2020 elevated late summer/fall water temperatures in and below the Hydroelectric Reach by removing the largest reservoirs		X		X
Largely eliminates 2020 dissolved oxygen and pH problems produced in reservoirs in the Hydroelectric Reach and transported downstream		X		X
Largely eliminates in 2020 algal toxins produced in the Hydroelectric Reach and transported downstream[3]		X		X
Salmonid Benefits				
Iron Gate hatchery smolt production as mitigation for 16 miles of habitat loss would continue	X		X	
~~Provides slightly cooler water temperatures in spring and early summer benefiting migration of both adult and juvenile salmonids~~ Expands access to at least 420 miles of anadromous salmonid habitat and associated smolt production above Iron Gate Dam and development of diverse life histories	~~X~~	X	X	X
Anadromous fish would access low gradient historical habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate Reservoirs		X		X
Provides fish with access to thermal refuge areas that are buffered from future effects from climate change		X	X	X
Provides for natural recruitment of spawning gravel and river processes within and below the Hydroelectric Reach through dam removal		X		**Partial**[2]
~~Expands access to salmonid habitat to the Upper Basin (above J.C. Boyle Reservoir)~~		~~X~~	~~X~~	~~X~~
~~Expands salmonid habitat to a "free-flowing" hydroelectric reach~~		~~X~~		~~**Partial**~~
Accelerates in 2012 restoration of fish habitat throughout the basin through the KBRA Fisheries Restoration Plan		X		
Accelerates the reintroduction of anadromous fish through the KBRA Fisheries Reintroduction Plan and is consistent with the optimal production from habitat for these species		X		

Expands opportunity to create springtime flushing flows (KBRA Environmental Water Program) and to increase flow variability and bed movement (with dam removal), which ~~are hypothesized to~~ reduce juvenile salmon disease below the Hydroelectric Reach		X			Partial
Provides opportunity to reduce juvenile salmon disease by allowing volitional fish passage through the Hydroelectric Reach and decreasing crowding of adult salmon/carcasses		X	X		X
KBRA funding would increase habitat restoration funding, coordination, and monitoring in the Klamath River watershed.		X			
Improves survival of smolts emigrating from tributaries downstream from Iron Gate Dam, such as the Scott and Shasta rivers, where extensive investment in restoration is underway and continuing		X	Partial		Partial
Provides volitional fish passage through the Hydroelectric Reach		X	X		X
Provides optimal efficiency beginning in 2020 of upstream and downstream salmonid migration through the Hydroelectric Reach by creating a free-flowing river		X			
Accelerates the effective use of the Upper Basin by salmonids through the KBRA Fisheries Reintroduction and Management Plan		X			
Improves base flows for salmonids, particularly in drought years, through KBRA Water Resources Program		X			
Eliminates adverse effects of hydroelectric peaking and stranding of fish in the Hydroelectric Reach		X	Partial		X
Eliminates entrainment mortality of resident fish		X	X		X
Reduces concentration of myxospores associated with carcasses accumulating below hatchery facilities, thus reducing disease		X			X

Notes:
1 "X" means the alternative provides this benefit.
2 "Partial" means the alternative provides only some of the benefit.
3 Periphyton are algae that grow attached to rocks and other substrates on a riverbed. Although sometime these species cause nuisance conditions, they are rarely considered toxic. Increased non-toxic periphyton biomass would not ~~affect levels of~~ lead to increases in algal toxins in the Klamath River. ~~The noxious blooms~~ Blooms of phytoplankton (suspended algae) occurring in the calm, lake-like waters ~~of Copco 1 and Iron Gate Reservoirs~~ are responsible for the production of algal toxins, such as microcystin, in the Klamath River downstream ~~of~~from Iron Gate Dam ~~(see Section 3.4).~~ . Noxious phytoplankton would not thrive in the free -flowing river following dam removal.

ES.7.2.6 Comparing Alternatives 2 and 3

There are many similarities in the benefits and potential impacts of Alternatives 2 and 3. The main difference between the alternatives is that Alternative 3 would leave some ancillary structures in place, such as powerhouse buildings, pipelines, and penstocks, but

both alternatives would create a free-flowing river from Keno Dam to the Pacific Ocean and eliminate any passage barriers to fish on the main stem Klamath River.

Given the fact that fewer structures would be removed under Alternative 3 compared to Alternative 2, there would be fewer short-term environmental impacts associated with construction activities and the use of heavy equipment. Thus, impacts related to the release of greenhouse gases, noise, and ground and land disturbance would be diminished and there would be less likelihood of displacing cultural resources or human remains (impacts to Cultural Resources are analyzed in Section 3.13). However, leaving various ancillary structures in place has the potential to interfere with wildlife movement, aesthetic quality, public safety, and would require some level of long-term maintenance.

Table ES-7 below compares the effect of Alternative 2 and 3 for all resource categories in this EIS/EIR.

Table ES-7. Detailed Comparison of Alternative 2 & Alternative 3

Resource Category:	Alternative 2 (Alt 2) - Full Facilities Removal	Alternative 3 (Alt 3) - Partial Facilities Removal
Water Quality (Section 3.2)	Both Alt 2 and Alt 3 result in a sediment release from reservoir drawdown which will have similar short-term water quality impacts. In the long-term, both Alt 2 and Alt 3 would result in increased spring time water temperatures and changes in daily variation in water temperature. These changes would mean that water temperature patterns in the Klamath River would be restored to normal pre-dam conditions.	
Aquatic Resources (Section 3.3)	Both Alt 2 and Alt 3 result in a sediment release from the drawdown of the reservoir which will have similar short-term aquatic resource impacts. In the long-term, the increase in the total amount of habitat, reestablishment of bedload sediment transport, reduced transmission of disease, and the improvements in water quality condition will benefit aquatic resources.	
Algae (Section 3.4)	Both Alt 2 and Alt 3 result in increased spring time water temperatures and change daily variation in water temperature. These changes would mean that water temperature patterns in the Klamath River Hydroelectric Reach would be restored to more natural conditions. Similarly the dominant algae would shift from noxious, and at times toxic, lake algae to algae found in moving water.	
Terrestrial Resources (Section 3.5)	Short-term construction impacts to terrestrial resources from Alt 2 maybe higher due to effects from more truck trips and reduction in bat habitat.	Reduced impacts to terrestrial plants and wildlife through reduced construction truck trips. Retained structures for use as a bat habitat.
Flood Hydrology (Section 3.6)	Both Alt 2 and Alt 3 result in a small increase in the peak 100 year flood and change in flood timing. However with mitigation this impact is less than significant.	
Groundwater (Section 3.7)	The dam removal and drawdown described in both Alt 2 and Alt 3 have a decline in the water table surrounding the reservoirs potentially affecting adjacent wells. However with mitigation this impact is less than significant.	
Water Rights/Water Supply (Section 3.8)	Both Alt 2 and Alt 3 result in a sediment release which has a similar very slight impact on water supply in-takes located in the Klamath River downstream from Iron Gate Dam. However with mitigation this impact is less than significant.	

Table ES-7. Detailed Comparison of Alternative 2 & Alternative 3

Resource Category:	Alternative 2 (Alt 2) - Full Facilities Removal	Alternative 3 (Alt 3) - Partial Facilities Removal
	Removal of the Four Facilities would also require the relocation of the City of Yreka's water supply pipeline. The programmatic analysis of this action showed that design measures incorporated into the project description reduce the potential effects of this action to a less than significant level. Additional environmental compliance will be required for the pipeline relocation.	
Air Quality (Section 3.9)	Greater emissions from short-term construction activities.	Reduced VOC, NOx, CO, SO2, PM10 and PM2.5 emissions due to shorter duration construction activities.
Greenhouse Gases/Climate Change (Section 3.10)	Greater emissions from short-term construction activities.	Short-term reduction in greenhouse gas emissions due to reduced construction activities.
Geology, Soils, and Geologic Hazards (Section 3.11)	The dam removal and drawdown described in both Alt 2 and Alt 3 could cause instability surrounding the reservoirs. However with mitigation this impact is less than significant.	
Tribal Trust (Section 3.12)	Both Alt 2 and Alt 3 result in benefits to aquatic resources and water quality which benefit Indian Trust Assets.	
Cultural/Historic Resources (Section 3.13)	Greater disturbance to archaeological and historic sites given wider and deeper APE footprint. No retention of historic structures.	Reduced disturbance to archaeological and historic sites given less aerial extent of excavation. Some historic structures at Copco 1(built in 1918) are retained.
Land Use, Agricultural, and Forest Resources (Section 3.14)	Slightly more open space for public use through removal of all facilities; however buried facilities may have some associated access restrictions.	Slightly less open space for public use; retained facilities will be fenced off from public use limiting access to some additional areas.
	Fisheries: Improvements to commercial, recreational and tribal fisheries due to habitat expansion and improvement.	Fisheries: Same as Alt 2.
Socioeconomics (Section 3.15)	Community economic impacts (employment, labor income, output): Positive short- and medium-term impacts due to construction, mitigation and KBRA expenditures. Some long-term negative impacts due to reduced expenditures for reservoir and whitewater recreation and dam operations and maintenance. Some long-term positive impacts due to increased expenditures for commercial and recreational fisheries, irrigated agriculture, and refuge recreation.	Community economic impacts (employment, labor income, output): Same as Alt 2
	Tribes: Improvements to tribal fisheries and to cultural practices involving fish or water contact.	Tribes: Same as Alt 2.
	Costs: Most probable estimate of construction and mitigation costs (2020 dollars) = $292 million. Costs to be divided between PacifiCorp	Costs: Most probable estimate of construction, life cycle and mitigation costs (2020 dollars) = $247 million. Life cycle costs pertain to perpetual

Table ES-7. Detailed Comparison of Alternative 2 & Alternative 3

Resource Category:	Alternative 2 (Alt 2) - Full Facilities Removal	Alternative 3 (Alt 3) - Partial Facilities Removal
	ratepayers ($200 million) and State of California. KBRA is connected action which will require Federal funding.	maintenance and security for ancillary structures that are not removed. Costs to be divided between PacifiCorp ratepayers ($200 million) and State of California. KBRA costs are the same as Alt 2.
Environmental Justice (Section 3.16)	Greater traffic, noise, and vibration could disproportionally effect tribal communities.	Reduced traffic, noise, and vibration could reduce disproportionate effects.
Population & Housing (Section 3.17)	The availability of housing is slightly reduced during construction. However because Alt 2 and Alt 3 have identical peak worker totals the effects are similar.	
Public Utilities (Section 3.18)	Higher volume of construction waste for disposal which would result in greater effects on area landfills.	Lower volume of construction waste for disposal which would result in reduced effects on area landfills.
Public Safety (Section 3.18)	Slightly more short term public safety effects associated with greater traffic. No retained above ground structures improves public safety in the long term.	Reduced traffic would reduce the public safety effects from short-term construction traffic. Under Alt 3 in the long term, there is the risk that facilities that were secured in place could cause an attractive nuisance and public safety effects. Resolving an attractive nuisance issue would fall to the entity ultimately responsible for management of those lands.
Scenic Quality (Section 3.19)	Removal of all structures could improve scenery however some historic properties provide positive scenery attributes.	Retaining some structures could conflict with the surrounding terrain, however some historic properties provide positive scenery* attributes.
Recreation (Section 3.20)	Removal of JC Boyle dam will permanently reduce the number of days with acceptable flows for whitewater boating at Hell's Corner Reach. Both Alt 2 and Alt 3 result in the elimination of reservoir related recreation.	
Toxic/ Hazardous Materials (Section 3.21)	Both Alt 2 and Alt 3 require disposal of a similar amount of hazardous materials.	
Traffic and Transportation (Section 3.22)	Greater traffic and road wear generation.	Reduced traffic and road wear generation due to reduced construction activities
Noise and Vibration (Section 3.23)	Greater noise and vibration generation.	Reduced noise and vibration generation due to reduced construction activities
Color Code Description Key	**Less preferred condition for this resource category**	**Preferred condition for this resource category**

ES.7.3 NEPA Environmentally Preferable/~~Superior~~Preferred Alternative

ES.7.3.1 Environmentally Preferable Alternative

NEPA requires ~~the Lead Agency to~~that DOI identify the alternative or alternatives that are environmentally preferable in the Record of Decision (ROD) (40 CFR Part 1505.2(b)). The environmentally preferable alternative generally refers to the alternative that would result in the fewest adverse effects to the biological and physical environment.

It is also the alternative that would best protect, preserve, and enhance historic, cultural, and natural resources. Although this environmentally preferable alternative must be identified in the ROD, it need not be selected for implementation. For the purposes of NEPA, DOI will identify an Environmentally Preferable Alternative in the ROD associated with this EIS/EIR.

ES.7.3.2 Preferred Alternative

Both Alternative 2 and Alternative 3 include removal of the Four Facilities and implementation of KBRA and both alternatives more fully meet the Purpose and Need (Sections ES.3 and 1.5.2.1). Some key benefits provided by implementation of Alternative 2 and Alternative 3 include (for a full discussion of the Alternatives, see Chapter 3):

- Largely eliminates in 2020 elevated late summer/fall water temperatures in and below the Hydroelectric Reach by removing the largest reservoirs
- Largely eliminates 2020 dissolved oxygen and pH problems produced in reservoirs in the Hydroelectric Reach and transported downstream
- Largely eliminates in 2020 algal toxins produced in the Hydroelectric Reach and transported downstream3
- Anadromous fish would access low gradient historical habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate Reservoirs
- Provides for natural recruitment of spawning gravel and river processes within and below the Hydroelectric Reach through dam removal
- Provides optimal efficiency beginning in 2020 of upstream and downstream salmonid migration through the Hydroelectric Reach by creating a free-flowing river
- Reduces concentration of myxospores associated with carcasses accumulating below hatchery facilities, thus reducing disease

Removal of the Four Facilities and implementation of KBRA are important components of a durable, long-term solution for local communities and tribes regarding the development, administration, allocation, and advancement of water and native fishery resources of the Klamath Basins. Alternative 2 and Alternative 3 provide a greater opportunity for expanding restoration of salmonids, which, over time would improve harvest opportunities of salmonids, and when compared to the other alternatives, resolve more societal hardships and conflicts that result from over-allocation of scarce natural resources.

Although Alternative 2 and Alternative 3 are similar, Alternative 2 would remove nearly all structures associated with the Four Facilities, while Alternative 3 would allow some structures to remain. By leaving no structures along the shore of the Klamath River, Alterative 2 leads to positive permanent changes in the human environment such as improvements to scenic quality, less long-term maintenance by land-management agencies, and is more protective of public safety. For these reasons Alternative 2 is the preferred alternative.

ES.7.4 CEQA Environmentally Superior Alternative

Section 15126.6(e)(2) of the CEQA Guidelines requires agencies to identify the environmentally superior alternative in a ~~d~~Draft EIR. If the No Project Alternative is the environmentally superior alternative, an additional environmentally superior alternative must be identified among the other alternatives.

CDFG has identified Alternative 3 (Partial Facilities Removal of Four Dams) as the environmentally superior alternative. All of the alternatives evaluated in the EIS/EIR, including for the No Action/No Project Alternative, have significant unavoidable environmental impacts as identified in Section 5.5. Alternative 2 (Full Facilities Removal of Four Dams, the Proposed Action), Alternative 3, and Alternative 5 (Fish Passage at J.C.Boyle and Copco 2, Remove Copco 1 and Iron Gate) would have the most short-term significant and unavoidable impacts among the alternatives. These impacts would largely be limited to the time frame of direct dam deconstruction actions and sediment release. After dam deconstruction, impacts would include the loss of reservoir recreation and local economic impacts. Alternatives 2, 3, and 5 would significantly improve water temperature, dissolved oxygen, and algal toxins for aquatic resources and reduce the incidence of fish disease in juvenile salmon by removing the two largest reservoirs—Copco I and Iron Gate. Alternatives 4 and 5 would maintain some power production and recreational benefits thereby reducing local economic impacts.

Although the No Action/No Project Alternative will have no change from existing conditions resulting from construction, this alternative is not the environmentally superior alternative when compared to the Proposed Action, which is intended to improve environmental conditions. Alternative 3 is the environmentally superior alternative when compared with the Proposed Action (Alternative 2) because it would:

- Reduce the air quality impacts from emissions of volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter < 10 microns (PM_{10}), and particulate matter < 2.5 microns ($PM_{2.5}$) from reduced construction activities;
- Reduce the contribution to greenhouse gas emissions from reduced construction activities;
- Reduce noise and vibration from reduced construction activities;
- Reduce impacts to terrestrial plants and wildlife from fewer truck trips;
- Reduce disturbance to archaeological and historic sites from fewer truck trips;
- Retain structures for roosting bats; and
- Retain some historically significant structures at ~~Copco 1.~~the Four Facilities.

Alternative 3 would provide similar long-term benefits when compared with Alternative 2, but would reduce short-term impacts because it involves less construction. Alternative 3 would result in superior long-term beneficial environmental effects. In summary, Alternative 3 is considered the environmentally superior alternative among all the alternatives because it provides long-term beneficial environmental effects, while

reducing some of the short-term significant effects of the Proposed Action (Alternative 2).

ES.7.~~4~~ 5 Controversies and Issues Raised by Agencies and the Public

CEQA requires disclosure of the controversial project issues raised by agencies and the public. ~~Table ES-6 presents a summary of some of the controversial project issues identified during the scoping period, which are addressed in this EIS/EIR. These are opinions and issues raised during scoping by agencies and members of the public and do not necessarily represent the position of the Lead Agencies. Additionally, Table ES-7 is not a summary of findings or determinations from the analysis in this EIS/EIR. Chapter 5 of this EIS/EIR, *Other Required Disclosures*, presents the full list of controversial project~~ Table ES-8 (also Chapter 5, Table 5-4) presents a summary of some of the controversial issues and the timeline or process in which they will be addressed, or the document in which they are addressed. ~~See the Scoping Report (located online at:~~ The issues were identified during the scoping period and in other forums for public involvement. These are opinions and issues raised by agencies and members of the public and do not necessarily represent the position of the Lead Agencies. Additionally, Table ES-8 is not a summary of findings or determinations from the analysis in this EIS/EIR. See the Scoping Report (located online at: http://klamathrestoration.gov/) for further information on issues identified by agencies and the public during the public scoping process~~.~~ (DOI 2010).

Table ES-~~7.~~8. Summary of Controversies and Issues Raised by Agencies and the Public[1]

Issue	Summary of Issue	Timeline for Addressing or Document/Section Addressing Issue
Loss of Renewable Power Supply	Loss of the Klamath Hydroelectric Project will result in the loss of renewable power. The specific makeup of new power supplies is not certain and may come from non-renewable sources.	Greenhouse Gases/Global Climate Change (Section 3.10.4.3) Public Health and Safety, Utilities and Public Services, Solid Waste, Power (Section 3.18.4.3)
Regional Economic Impacts	Loss of the Klamath Hydroelectric Project ~~and~~, lost power generation, and impacts to the local real estate market will negatively and disproportionally affect resource-based economies of local communities, many of which are struggling economically.	Socioeconomics (Section 3.15.4.3)
Sediment Impacts from Dam Removal	Sediment release during dam removal will have significant and deleterious effects on the aquatic environment from Iron Gate Dam to the Pacific Ocean during the period of dam removal.	Water Quality (Section 3.2.4.3) Aquatic Resources (Section 3.3.4.3) Appendix C

Table ES-~~7.~~8. Summary of Controversies and Issues Raised by Agencies and the Public[1]

Issue	Summary of Issue	Timeline for Addressing or Document/Section Addressing Issue
Historic Anadromous Fish Distribution in the Upper Klamath Basin	Dam removal would open large areas of the Upper Klamath Basin watershed to anadromous fish. The historical distribution of anadromous fish above the dams has been questioned.	Chapter 1, Introduction Aquatic Resources (Section 3.3.4.3)
KBRA Effects	The KBRA may not produce enough social and economic benefits from implementation.	Socioeconomics (Section 3.15.4.3)
KBRA Effects on Environmental Justice and Federal Trust Responsibilities	The KBRA would result in the "termination" of tribal fishing and water rights and the Federal trust responsibilities for those rights and resources, further exacerbating the environmental justice issues associated with declining anadromous fisheries and water quality in the Klamath Basin that have affected tribal practices, health, and cultural traditions	Water Rights and Water Supply (Section 3.8) Indian Trust Assets(Section 3.16)
Loss of Reservoir Environment	Dam removal will result in a loss of the three largest reservoirs, affecting individuals that live on or near the reservoirs and who value the reservoirs' aesthetic and recreational value.	Land Use, Agricultural, and Forest Resources (Section 3.14.4.3) Scenic Quality (Section 3.19.4.3) Recreation (Section 3.20.4.3)
Flood Risk	Dam removal will increase the incidence and magnitude of flooding to downstream communities.	Flood Hydrology (Section 3.6.4.3)
FERC Relicensing	In the event of a Negative Secretarial Determination, PacifiCorp would continue to seek a new license from FERC for operation of the Klamath Hydroelectric Project. The outcome of this process is not known but could be the continued operation of the dams under a new license that includes the agencies' mandatory conditions and prescriptions.	Chapter 2, Proposed Action and Description of Alternatives
Agriculture and Refuge Management contributes to poor water quality in Keno and Upper Klamath Lake	Runoff from agriculture and refuges results in poor water quality in Keno Impoundment/ Lake Ewauna and in the mainstem Klamath River. This causes fish stress, disease and mortality. Continued farming and ranching in the Tule Lake National Wildlife Refuge and Lower Klamath Lake National	Water Quality (Section 3.2.4.3) Aquatic Resources (Section 3.3.4.3)

Table ES-~~7.~~8. Summary of Controversies and Issues Raised by Agencies and the Public[1]

Issue	Summary of Issue	Timeline for Addressing or Document/Section Addressing Issue
	Wildlife Refuge under the KBRA would inhibit fish species reintroduction and survival.	
Water Quality Conditions in Keno Impoundment and Upper Klamath Lake would not allow sound fish passage	Low levels of dissolved oxygen and high water temperatures during certain times of year would adversely affect passage of fish through Keno Impoundment and Upper Klamath Lake.	Water Quality (Section 3.2.4.3) Aquatic Resources (Section 3.3.4.3)
Changes in Types and Amounts of Whitewater Boating	Peaking flows from operation of the hydroelectric project currently allow for commercial whitewater boating in mid- to late-summer.	Socioeconomics (Section 3.15.4.2) Recreation (Section 3.20.4.3)
Resolution 10-185 of Siskiyou County Board of Supervisors Calling for an Advisory Election with Respect to the Removal of the Dams on the Klamath River on November 2, 2010 (Measure G).	Siskiyou County held an advisory vote on November 2, 2010 regarding dam removal. The ballot asked " Should the Klamath River Dams (Iron Gate, Copco 1, and Copco 2) and associated hydroelectric facilities be removed – Yes or No?" Of the 25,922 registered voters in the County, 17,206 (66.4%) participated in this vote. The results: Of the 17,206 who voted, 13,566 residents (78.84%) voted No to dam removal, while 3,640 (21.86 %) voted Yes.	While this is not an environmental impact issue and is not specifically addressed as part of this EIS/EIR, the Secretary of the Interior will consider this when making his determination.
"Siskiyou County Water Users Association, Inc. v. California Natural Resources Agency, et al." (Other Defendants are Lester Snow, Secretary of California Natural Resources Agency, Governor Schwarzenegger, DFG, DFG's Director, Humboldt County, Tule Lake Irrigation District, and Westside Improvement District).	This case was originally filed in Sacramento Superior Court on August 16, 2010. The original lawsuit asserted that approval of the KHSA and KBRA violated CEQA, and that DFG is the wrong Lead Agency. The trial court ruled that appellant's claims were time barred because a valid Notice of Determination had been filed, and that a challenge to the Lead Agency designation was not ripe for review. That ruling has been appealed to the Third Appellate District Court of Appeal. Siskiyou County Water Users Association's opening brief was filed on February 15, 2012.	This is not an environmental impact issue and is not specifically addressed as part of this EIS/EIR. It is not yet known how the results of this case may affect the overall project.

~~Table ES-7. Summary of Controversies and Issues Raised by Agencies and the Public~~[1]

~~Issue~~	~~Summary of Issue~~	~~Timeline for Addressing or Document/Section Addressing Issue~~
~~FERC Relicensing~~	~~In the event of a negative Secretarial Determination, PacifiCorp would re-enter the FERC relicensing process. The outcome of this process is not known but could be the continued operation of the dams under a new license that includes the agencies' mandatory conditions and prescriptions.~~	~~Chapter 2, Proposed Action and Description of Alternatives~~
~~Agriculture and Refuge Management contributes to poor water quality in Keno and Upper Klamath Lake~~	~~Runoff from agriculture and refuges results in poor water quality in Keno Reservoir and in the mainstem Klamath River. This causes fish stress, disease and mortality. Continued farming and ranching in the Tule Lake National Wildlife Refuge and Lower Klamath Lake National Wildlife Refuge under the KBRA would inhibit fish species reintroduction and survival.~~	~~Water Quality (Section 3.2.4.3)~~ ~~Aquatic Resources (Section 3.3.4.3)~~
~~Water Quality Conditions in Keno Impoundment and Upper Klamath Lake would not allow sound fish passage~~	~~Low levels of dissolved oxygen and high water temperatures during certain times of year would prohibit passage of fish through Keno Impoundment and Upper Klamath Lake.~~	~~Water Quality (Section 3.2.4.3)~~ ~~Aquatic Resources (Section 3.3.4.3)~~

~~Notes:~~

[1] CEQA requires disclosure of the controversial project issues raised by agencies and the public. Table ES-~~7~~8 presents a summary of some of the controversial project issues identified during the scoping period, which are addressed in this EIS/EIR. These are opinions and issues raised ~~during scoping~~ by agencies and members of the public and do not necessarily represent the position of the Lead Agencies. Additionally, Table ES-~~7~~8 is not a summary of findings or determinations from the analysis in this EIS/~~R~~EIR.

ES.8 References

Department of ~~Interior~~the Interior (DOI). 2007. The Department of the Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082). January 26, 2007. Sacramento, CA. 650 p.

DOI. 2010. Scoping Report for the *Environmental Impact Statement/Environmental Impact Report on the Klamath Hydroelectric Settlement Agreement including the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon*. September 2010. Available online at: http://klamathrestoration.gov/sites/klamathrestoration.gov/files/Secretarial%20Determina

tion/Compiled%20Klamath%20Sec.%20Det.%20EIS%20EIR%20Public%20Scoping%20Report.pdf.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service~~s~~. 2007. ~~United States Department of the Interior and~~ National Marine Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis ~~Pursuant to Section 18 and Section 33 of the Federal Power Act for the~~ for the Klamath Hydroelectric Project (FERC Project No. 2082). January 26, 2007. Sacramento, CA. 151 p.

~~Docket Number 2006-NMFS-0001. Decision of Administrative Law Judge in the Matter of Klamath Hydroelectric Project, September 27, 2006~~

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.

Oregon Public Utilities Commission~~,~~ (OPUC). 2010. In the Matter of PacifiCorp, dba Pacific Power. Application to Implement the Provisions of Senate Bill 76. Order No. 10-364. September 16, 2010.

PacifiCorp. 2012. PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho Salmon. Prepared by PacifiCorp Energy, Inc., Portland, OR. Submitted to the National Marine Fisheries Service, Arcata Area Office, Arcata, CA. February 16, 2012. Available at: http://swr.nmfs.noaa.gov/nepa/PacifiCorp_Klamath_Coho_HCP_021612_Final.pdf. Accessed on July 5, 2012.

State Water Resources Control Board (SWRCB). 2009. Klamath Hydroelectric Project (FERC 2082), Water Quality Certification, Request to Extend the February 23, 2009, Comment Deadline for Scoping Comments. February 21, 2009.

40 Code of Federal Regulations Part 1502.16. Protection of the Environment. Part 1502: Environmental Impact Statement. 1502.16: Environmental Consequences.

Contents

Volume I – Final EIS/EIR

Page

Executive Summary **ES-1**

ES.

Chapter 1 ..... Introduction ES- 1

ES.2 Background ES-5

ES.2.-1 ..... Basin TimelineES-7

ES.2.2 Activities Leading to the Development of the KHSA and the KBRA ES-7

ES.3 Environmental Review ES-17

ES.4 Klamath Settlement Agreements ES-18

ES.4.1 ..... Klamath Hydroelectric Settlement Agreement ES-18

ES.4.2 ..... Klamath Basin Restoration Agreement ES-19

ES.5 Alternatives Development ES-19

ES.5.1 Public Scoping and Alternatives IdentificationES-19

ES.6 Alternatives Receiving Full Analysis in the EIS/EIR....ES-21

ES.6.1 Alternative 1.1 ..... Purpose and Approach of this Document 1-2

1 – No Action/No Project Alternative ES-21

ES.6.2 Alternative 2 - Full Facilities Removal of Four Dams (Proposed Action) ES-22

ES.6.3 Alternative 3 - Partial Facilities Removal of Four DamsES-24

ES.6.4 Alternative 4 - Fish Passage at Four DamsES-24

ES.6.5 Alternative 5 - Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate ES-26

ES.7 Effects of the No Action, Proposed Action, and Alternatives ES-27

ES.7.1 Significant and Unavoidable Adverse ImpactsES-27

ES.7.2 Balancing Impacts and Benefits of the Alternatives ES-40

ES.7.3 Environmentally Preferable/Superior Alternative ES-45

ES.7.4 Controversies and Issues Raised by Agencies and the Public ES-46

ES.8 References ES-48

Chapter 1 Introduction 1-1

1.1 Physical and Biological Setting 1-24

1.1.2.1 Geography and Topography 1-24

1.1.2 .2 ..... Climate and Hydrology 1-26

1.12.3 Biology 1-56

1.2-.3.1 Vegetation 1-6

1.2.3.2 Wildlife 1-6

1.2.3.3 National Wildlife Refuges 1-7

1.2.3.4 Fish 1-7

1.3 People and Historic Setting 1-810

1.23.1- Tribes 1-810

1.3.1.1 The Klamath Tribes 1-10
1.3.1.2 Quartz Valley Indian Community..... 1-10
1.3.1.3 Karuk Tribe..... 1-10
1.3.1.4 Hoopa Valley Tribe..... 1-10
1.3.1.5 Yurok Tribe..... 1-11
1.3.1.6 Resighini Rancheria 1-11
1.3.2 Early Euroamerican Settlement and Hydroelectric History..... 1-~~10~~11
1.~~2~~3.3 Water Use and Management..... 1-~~10~~12
1.~~2.~~3.3.1 Water Management 1-12
1.3.4 Reclamation's Klamath Project ..... 1-~~13~~16
1.~~2~~3.5 Oregon Water Rights Adjudication ..... 1-~~15~~18
1.~~2.~~3.6 Klamath Hydroelectric Project and Relicensing..... 1-~~16~~19

1.3-.6.1 Klamath Hydroelectric Project 1-19
1.3.6.2 Federal Energy Regulatory Commission Relicensing..... 1-19
1.4 KHSA and KBRA ..... 1-~~18~~21
1.~~3~~4.1- KHSA..... 1-~~19~~22
1.4.1.1 Detailed Plan and Other Studies 1-22
1.4.1.2 State Cost Cap..... 1-23
1.4.1.3 Secretarial Determination 1-23
1.4.1.4 KHSA Implementation 1-24
1.4.2 KBRA ..... 1-~~23~~26
1.~~4~~ 5 NEPA/CEQA ..... 1-~~28~~31
1.~~4~~5.1– NEPA/CEQA Requirements..... 1-~~28~~31
1.~~4~~5.2– Purpose and Need/Project Objectives..... 1-~~29~~32
1.5.2.1 Purpose and Need 1-32

Contents (continued)

Page

1.5.2.2 Project Objectives 1-33
1.5.3 Oregon Concurrence 1-33
1.6 References ..... 1-~~30~~34

Chapter 2 – Proposed Action and Description of the Alternatives 2-1
2.1 NEPA Requirements 2-1
2.2 CEQA Requirements ..... 2-~~1~~2
2.3 Alternatives Development ..... 2-~~2~~3
2.4 Proposed Action and Alternatives ..... 2-~~7~~8
2.4.1 Facilities Common to All Alternatives ..... 2-~~7~~8
2.4.1.1 J.C. Boyle Dam and Powerhouse 2-9
2.4.1.2 Copco 1 Dam and Powerhouse 2-11
2.4.1.3 Copco 2 Dam and Powerhouse 2-12
2.4.1.4 Iron Gate Dam and Powerhouse 2-13
2.4.2 Alternative 1: No Action/No Project Alternative ..... 2-~~13~~14
2.4.3 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action) ..... ~~2-19~~
~~2.4.4 Alternative 3: Partial Facilities Removal of Four Dams 2-61~~
~~2.4.5 Alternative 4: Fish Passage at Four Dams ... 2-70~~
~~2.4.6 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate ..... 2-83~~
~~2.5 Preferred Alternative ..... 2-86~~
2~~.6 ..... References 2-87~~-21

~~Chapter 3 Affected Environment/Environmental Consequences ..... 3.1-1~~
~~3.1 Introduction ..... 3.1-1~~
~~3.1.1 Format of the Environmental Analysis ..... 3.1-2~~
~~3.2 Water Quality ..... 3.2-1~~
~~3.2.1 Area of Analysis ..... 3.2-1~~
~~3.2.2 Regulatory Framework ..... 3.2-4~~
~~3.2.3 Existing Conditions/Affected Environment 3.2-19~~
~~3.2.4 Environmental Consequences ..... 3.2-33~~
~~3.2.5 Mitigation Measures ..... 3.2-147~~
~~3.2.6 Summary of Short-term and Long-term Effects on Water Quality ..... 3.2-148~~
~~3.2.7 References ..... 3.2-162~~
~~3.3 Aquatic Resources ..... 3.3-1~~
~~3.3.1 Area of Analysis ..... 3.3-1~~
~~3.3.2 Regulatory Framework ..... 3.3-3~~
~~3.3.3 Existing Conditions/Affected Environment 3.3-3~~
~~3.3.4 Environmental Consequences ..... 3.3-47~~
~~3.3.5 References ..... 3.3-219~~
~~3.4 Algae ..... ~~

~~3.4.1 Area of Analysis ..... 3.4-1~~
~~3~~2.4.3.1 Deconstruction Actions..... 2-25
2.4.3.2 Schedule..... 2-33
2.4.3.3 Workforce 2-35
2.4.3.4 Environmental Measures 2-35
2.4.3.5 Reservoir Restoration..... 2-37
2.4.~~2 Regulatory Framework ..... 3.4-1~~
~~3.4.3 Existing Conditions/Affected Environment 3.4-2~~
~~3.4.4 Environmental Consequences..... 3.4-9~~
~~3.4.5 References..... 3.4-28~~
~~3.5 Terrestrial Resources ..... 3.5-1~~
~~3.5.1 Area of Analysis ..... 3.5-1~~
~~3.5.2 Regulatory Framework ..... 3.5-1~~
~~3.5.3 Existing Conditions/Affected Environment 3.5-3~~
~~3.5.4 Environmental Consequences..... 3.5-41~~
~~3.5.5 References..... 3.5-79~~
3.6 ~~Flood Hydrology ..... 3.6-1~~
~~3.6.1 Area of Analysis ..... 3.6-1~~
~~3.6.2 Regulatory Framework ..... 3.6-3~~
~~3.6.3 Existing Conditions/Affected Environment 3.6-4~~
~~3.6.4 Environmental Consequences..... 3.6-19~~
~~3.6.5 References..... 3.6-40~~
~~3.7 Groundwater ..... 3.7-1~~
~~3.7.1 Area of Analysis ..... 3.7-1~~
~~3.7.2 Regulatory Framework ..... 3.7-1~~
~~3.7.3 Existing Conditions/Affected Environment 3.7-1~~
~~3.7.4 Environmental Consequences..... 3.7-14~~
~~3.7.5 References..... 3.7-23~~
~~3.8 Water Supply/Water Rights ..... 3.8-1~~
~~3.8.1 Area of Analysis ..... 3.8-1~~
~~3.8.2 Regulatory Framework ..... 3.8-1~~
~~3.8.3 Existing Conditions/Affected Environment 3.8-4~~
~~3.8.4 Environmental Consequences..... 3.8-12~~
~~3.8.5 References..... 3.8-27~~
~~3.9 Air Quality ..... 3.9-1~~
~~3.9.1 Area of Analysis ..... 3.9-1~~
~~3.9.2 Regulatory Framework ..... 3.9-1~~
~~3.9.3 Existing Conditions/Affected Environment 3.9-3~~
~~3.9.4 Environmental Consequences..... 3.9-8~~
~~3.9.5 References..... 3.9-27~~
~~3.10 Greenhouse Gases/Global Climate Change ..... 3.10-1~~
~~3.10.1 Area of Analysis ..... 3.10-1~~
~~3.10.2 Regulatory Framework ..... 3.10-1~~
~~3.10.3 Existing Conditions/Affected Environment3.10-2~~
~~3.10.4 Environmental Consequences..... 3.10-12~~
~~3.10.5 References..... 3.10-47~~

~~3.11 Geology, Soils, and Geologic Hazards ..... 3.11-1~~
~~3.11.1 Area of Analysis ..... 3.11-1~~
~~3.11.2 Regulatory Framework ..... 3.11-1~~
~~3.11.3 Existing Conditions/Affected Environment3.11-1~~
~~3.11.4 Environmental Consequences ..... 3.11-17~~
~~3.11.5 References ..... 3.11-29~~
~~3.12 Tribal Trust ..... 3.12-1~~
~~3.12.1 Area of Analysis ..... 3.12-2~~
~~3.12.2 Regulatory Framework ..... 3.12-2~~
~~3.12.3 Existing Conditions/Affected Environment3.12-2~~
~~3.12.4 References ..... 3.12-47~~
~~3.13 Cultural and Historic Resources ..... 3.13-1~~
~~3.13.1 Area of Analysis ..... 3.13-1~~
~~3.13.2 Regulatory Framework ..... 3.13.1~~
~~3.13.3 Existing Conditions/Affected Environment3.13-8~~
~~3.13.4 Environmental Consequences ..... 3.13-26~~
~~3.13.5 References ..... 3.13-41~~
~~3.14 Land Use, Agricultural and Forest Resources ..... 3.14-1~~
~~3.14.1 Area of Analysis ..... 3.14-2~~
~~3.14.2 Regulatory Framework ..... 3.14-8~~
~~3.14.3 Existing Conditions/Affected Environment3.14-9~~
~~3.14.4 Environmental Consequences ..... 3.14-19~~
~~3.14.5 References ..... 3.14-31~~
~~3.15 Socioeconomics ..... 3.15-1~~
~~3.15.1 Area of Analysis ..... 3.15-1~~
~~3.15.2 Regulatory Framework ..... 3.15-1~~
~~3.15.3 Existing Conditions/Affected Environment3.15-3~~
~~3.15.3 Environmental Consequences ..... 3.15-25~~
~~3.15.4 References ..... 3.15-100~~
~~3.16 Environmental Justice ..... 3.16-1~~
~~3.16.1 Area of Analysis ..... 3.16-1~~
~~3.16.2 Regulatory Framework ..... 3.16-1~~
~~3.16.3 Existing Conditions/Affected Environment3.16-3~~
~~3.16.4 Environmental Consequences ..... 3.16-23~~
~~3.16.5 References ..... 3.16-37~~
~~3.17 Population and Housing ..... 3.17-1~~
~~3.17.1 Area of Analysis ..... 3.17-1~~
~~3.17.2 Regulatory Framework ..... 3.17-2~~
~~3.17.3 Existing Conditions/Affected Environment3.17-3~~
~~3.17.4 Environmental Consequences ..... 3.17-8~~
~~3.17.5 References ..... 3.17-16~~
~~3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power ..... 3.18-1~~
~~3.18.1 Area of Analysis ..... 3.18-1~~
~~3.18.2 Regulatory Framework ..... 3.18-3~~
~~3.18.3 Existing Conditions/Affected Environment3.18-4~~

3.18.4 Environmental Consequences 3.18-14
3.18.5 References 3.18-32
3.19 Scenic Quality 3.19-1
3.19.1 Area of Analysis 3.19-1
3.19.2 Regulatory Framework 3.19-1
3.19.3 Existing Conditions/Affected Environment 3.19-2
3.19.4 Environmental Consequences 3.19-11
3.19.5 References 3.19-37
3.20 Recreation ..... 3.20-1 Facilities 2-38
3.20.1 Area of Analysis 3.20-1
3.20.2 Regulatory Framework 3.20-2
3.20.3 Existing Conditions/Affected Environment 3.20-2
3.20.4 Environmental Consequences 3.20-34
3.20.5 References 3.20-66
3.21 Toxic/Hazardous Materials 3.21-1
3.21.1 Area of Analysis 3.21-1
3.21.2 Regulatory Framework 3.21-1
3.21.3 Existing Conditions/Affected Environment 3.21-2
3.21.4 Environmental Consequences/Environmental Impacts 3.21-5
3.21.5 References 3.21-18
3.22 Traffic and Transportation 3.22-1
3.22.1 Area of Analysis 3.22-1
3.22.2 Regulatory Framework 3.22-1
3.22.3 Existing Conditions/Affected Environment 3.22-4
3.22.4 Environmental Consequences 3.22-7
3.22.5 References 3.22-23
3.23 Noise and Vibration 3.23-1
3.23.1 Area of Analysis 3.23-1
3.23.2 Regulatory Framework 3.23-1
3.23.3 Existing Conditions/Affected Environment 3.23-3
3.23.4 Environmental Consequences 3.23-8
3.23.5 Mitigation Measures 3.23-22
3.23.6 References 3.23-26

Chapter 4 Cumulative Effects 4-1
4.1 Cumulative Effects Overview 4-1
4.1.1 Regulatory Requirements 4-1
4.2 Cumulative Effects Methods 4-3
4.2.1 Identifying Past, Present, and Future Actions Contributing to Cumulative Effects 4-3
4.2.2 Cumulative Effects Area of Analysis 4-5
4.2.3 Timeframe 4-8
4.2.4 Mitigation 4-8
4.3 Actions and Projects Considered in Cumulative Effects Analysis 4-9
4.3.1 Documents Reviewed 4-9
4.3.2 Cumulative Projects 4-21

~~4.4 Cumulative Effects Analysis ..... 4-27~~
~~4.4.1 Water Quality ..... 4-28~~
~~4.4.2 Aquatic Resources ..... 4-54~~
~~4.4.3 Algae ..... 4-89~~
~~4.4.4 Terrestrial Resources ..... 4-95~~
~~4.4.5 Flood Hydrology ..... 4-106~~
~~4.4.6 Groundwater ..... 4-111~~
~~4.4.7 Water Supply/Water Rights ..... 4-116~~
~~4.4.8 Air Quality ..... 4-124~~
~~4.4.9 Greenhouse Gases/Global Climate Change 4-131~~
~~4.4.10 Geology, Soils and Geologic Hazards ..... 4-137~~
~~4.4.11 Tribal Trust ..... 4-143~~
~~4.4.12 Cultural and Historic Resources ..... 4-145~~
~~4.4.13 Land Use, Agricultural and Forest Resources 4-151~~
~~4.4.14 Socioeconomics ..... 4-156~~
~~4.4.15 Environmental Justice ..... 4-160~~
~~4.4.16 Population and Housing ..... 4-164~~
~~4.4.17 Public Health and Safety, Utilities and Public Services, Solid Waste, and Power ..... 4-168~~
~~4.4.18 Scenic Quality ..... 4-176~~
~~4.4.19 Recreation ..... 4-183~~
~~4.4.20 Toxic/Hazardous Materials ..... 4-192~~
~~4.4.21 Traffic and Transportation ..... 4-195~~
~~4.4.22 Noise and Vibration ..... 4-202~~
~~4.5 References ..... 4-207~~

~~Chapter 5 Other Required Disclosures ..... 5-1~~
~~5.1 Irreversible and Irretrievable Commitment of Resources .. 5-1~~
~~5.2 Relationship Between Short-Term Uses and Long-Term Productivity 5-2~~
~~5.2.1 Klamath Hydroelectric Settlement Agreement 5-2~~
~~5.2.2 Klamath Basin Restoration Agreement ..... 5-4~~
~~5.2.3~~ Keno Transfer ..... ~~5-5~~ 2-38
~~5.~~2.4.3.8 East and ~~West Side~~Westside Facilities~~..... 5-6~~ –
~~5.3 Growth Inducing Impacts ..... 5-6~~
~~5.4 Summary of~~ ..... Programmatic Measure 2-40
2.4.3.9 City of Yreka Water Supply Pipeline Relocation – Programmatic Measure 2-40
2.4.3.10 KBRA – Programmatic Measures 2-41
2.4.4 Alternative 3: Partial Facilities Removal of Four Dams 2-67
2.4.4.1 Deconstruction Actions 2-68
2.4.4.2 Schedule 2-74
2.4.4.3 Workforce 2-74
2.4.4.4 Environmental ~~Impacts ..... 5-7~~Measures 2-75
~~5.5 Significant and Unavoidable Impacts ..... 5-99~~
2.4.4.5 Reservoir Restoration 2-75

2.4.4.6 Recreation Facilities..... 2-75
2.4.4.7 Keno Transfer 2-75
2.4.4.8 East and Westside Facilities – Programmatic Measure 2-75
2.4.4.9 City of Yreka Water Supply Pipeline Relocation – Programmatic Measure..... 2-76
2.4.4.10 KBRA – Programmatic Measures 2-76

Contents (continued)

Page

2.4.5 Alternative 4: Fish Passage at Four Dams 2-76
2.4.5.1 Construction Details..... 2-79
2.4.5.2 Schedule..... 2-89
2.4.5.3 Workforce 2-89
2.4.5.4 Environmental Measures 2-90
2.4.5.5 Trap and Haul around Keno Impoundment – Programmatic Measure..... 2-90
2.4.6 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate 2-90
2.4.6.1 Schedule..... 2-91
2.4.6.2 Workforce 2-92
2.4.6.3 Environmental Measures 2-92
2.4.6.4 Recreation Facilities..... 2-93
2.4.6.5 Trap and Haul around Keno Impoundment – Programmatic Measure..... 2-93
2.4.6.6 City of Yreka Water Supply Pipeline Relocation – Programmatic Measure..... 2-94
2.5 Preferred Alternative..... 2-94
2.6 References..... 2-95

Chapter 3 – Affected Environment/Environmental Consequences 3.1-1
3.1 Introduction..... 3.1-1
3.1.1 Format of the Environmental Analysis..... 3.1-2
3.1.1.1 Area of Analysis 3.1-2
3.1.1.2 Regulatory Framework 3.1-2
3.1.1.3 Wild and Scenic River Act Component Analysis..... 3.1-2
3.1.1.4 Coastal Zone Management Act Consistency Determination..... 3.1-2
3.1.1.5 Basis of Comparison for the Affected Environment/Environmental Setting 3.1-3
3.1.1.6 Environmental Consequences..... 3.1-3
3.1.2 References..... 3.1-10
3.2 Water Quality..... 3.2-1
3.2.1 Area of Analysis 3.2-1
3.2.2 Regulatory Framework 3.2-4
3.2.2.1 Designated Beneficial Uses of Water 3.2-4
3.2.2.2 Water Quality ~~5-99~~ Standards 3.2-6
3.2.2.3 Water Quality Impairments..... 3.2-13
3.2.2.4 Total Maximum Daily Loads..... 3.2-15

Contents (continued)

Page

3.2.3 Existing Conditions/Affected Environment 3.2-20
3.2.3.1 Overview of Water Quality Processes in the Klamath Basin 3.2-20
3.2.3.2 Water Temperature 3.2-22
3.2.3.3 Suspended Sediments 3.2-24
3.2.3.4 Nutrients 3.2-26
3.2.3.5 Dissolved Oxygen 3.2-28
3.2.3.6 pH 3.2-29
3.2.3.7 Chlorophyll-a and Algal Toxins 3.2-31
3.2.3.8 Inorganic and Organic Contaminants 3.2-32
3.2.4 Environmental Consequences 3.2-36
3.2.4.1 Environmental Effects Determination Methods 3.2-36
3.2.4.2 Significance Criteria 3.2-45
3.2.4.3 Effects Determinations 3.2-50
3.2.5 Mitigation Measures 3.2-160
3.2.5.1 Mitigation Measures Associated with Other Resource Areas 3.2-161
3.2.6 Summary of Short-term and Long-term Impacts on Water Quality 3.2-161
3.2.7 References 3.2-176
3.3 Aquatic Resources ..... ~~5-100~~ 3.3-1
~~5.5.3~~3.3.1 Areas of Analysis 3.3-1
3.3.2 Regulatory Framework 3.3-3
3.3.2.1 Federal Authorities and Regulations 3.3-3
3.3.2.2 State Authorities and Regulations 3.3-3
3.3.2.3 Local Authorities and Regulations 3.3-4
3.3.3 Existing Conditions/Affected Environment 3.3-4
3.3.3.1 Aquatic Species 3.3-4
3.3.3.2 Physical Habitat Descriptions 3.3-27
3.3.3.3 Habitat Attributes Expected to be Affected by the Project 3.3-31
3.3.4 Environmental Consequences 3.3-70
3.3.4.1 Environmental Effects Determination Methods 3.3-70
3.3.4.2 Significance Criteria 3.3-75
3.3.4.3 Effects Determinations 3.3-77
3.3.4.4 Mitigation Measures 3.3-241
3.3.5 References 3.3-265
3.4 Algae ~~5-100~~ 3.4-1
~~5.5~~3.4.1 Area of Analysis 3.4-1
3.4.2 Regulatory Framework 3.4-1
3.4.2.1 Federal Authorities and Regulations 3.4-2

Contents (continued)

Page

3.4.2.2 State Authorities and Regulations 3.4-2
3.4.2.3 Tribal Authorities and Regulations 3.4-2
3.4.3 Existing Conditions/Affected Environment 3.4-2
3.4.3.1 Phytoplankton 3.4-3
3.4.3.2 Periphyton 3.4-5
3.4.3.3 Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir 3.4-5
3.4.3.4 Hydroelectric Reach 3.4-7
3.4.3.5 Klamath River Downstream from Iron Gate Dam 3.4-10
3.4.3.6 Klamath Estuary 3.4-12
3.4.3.7 Marine Nearshore Environment 3.4-13
3.4.4 Environmental Consequences 3.4-13
3.4.4.1 Environmental Effects Determination Methods 3.4-13
3.4.4.2 Significance Criteria 3.4-14
3.4.4.3 Effects Determinations 3.4-15
3.4.4.4 Mitigation Measures 3.4-30
3.4.4.5 Summary of Impacts on Algae 3.4-31
3.4.5 References 3.4-37
3.5 Terrestrial Resources 3.5-1
3.5.1 Area of Analysis 3.5-1
3.5.2 Regulatory Framework 3.5-1
3.5.2.1 Federal Authorities and Regulations 3.5-1
3.5.2.2 State Authorities and Regulations 3.5-3
3.5.2.3 Local Authorities and Regulations 3.5-3
3.5.3 Existing Conditions/Affected Environment 3.5-3
3.5.3.1 Vegetation Communities and Habitat Types 3.5-3
3.5.3.2 Culturally Significant Species 3.5-23
3.5.3.3 Wildlife 3.5-24
3.5.3.4 Special-Status Species 3.5-28
3.5.3.5 Wildlife Corridors and Habitat Connectivity 3.5-49
3.5.4 Environmental Consequences 3.5-49
3.5.4.1 Environmental Effects Determination Methods 3.5-49
3.5.4.2 Significance Criteria 3.5-50
3.5.4.3 Effects Determinations 3.5-50
3.5.4.4 Mitigation Measures 3.5-92
3.5.5 References 3.5-101
3.6 Flood Hydrology 3.6-1
3.6.1 Area of Analysis 3.6-1
3.6.2 Regulatory Framework 3.6-3

Contents (continued)

Page

3.6.2.1 Federal Authorities and Regulations 3.6-3
3.6.2.2 Affected County Flood Codes and Ordinances 3.6-4
3.6.3 Existing Conditions/Affected Environment 3.6-4
3.6.3.1 Historical Hydrologic Conditions 3.6-5
3.6.3.2 Basin Hydrology 3.6-7
3.6.3.3 Historic Stream Flows 3.6-14
3.6.3.4 Flood Hydrology and River Flood Plain 3.6-19
3.6.3.5 Risks of Dam Failure 3.6-19
3.6.4 Environmental Consequences 3.6-20
3.6.4.1 Environmental Effects Determination Methods 3.6-20
3.6.4.2 Significance Criteria 3.6-21
3.6.4.3 Effects Determinations 3.6-21
3.6.4.4 Mitigation Measures 3.6-41
3.6.5 References 3.6-42
3.7 Groundwater 3.7-1
3.7.1 Area of Analysis 3.7-1
3.7.2 Regulatory Framework 3.7-1
3.7.2.1 State Authorities and Regulations 3.7-1
3.7.2.2 Local Authorities and Regulations 3.7-1
3.7.3 Existing Conditions/Affected Environment 3.7-1
3.7.3.1 Groundwater Basin Hydrology Description 3.7-1
3.7.4 Environmental Consequences 3.7-14
3.7.4.1 Environmental Effects Determination Methods 3.7-14
3.7.4.2 Significance Criteria 3.7-15
3.7.4.3 Effects Determinations 3.7-15
3.7.4.4 Mitigation Measures 3.7-22
3.7.5 References 3.7-24
3.8 Water Supply/Water Rights 3.8-1
3.8.1 Area of Analysis 3.8-1
3.8.2 Regulatory Framework 3.8-1
3.8.2.1 Federal Water Law 3.8-1
3.8.2.2 State Water Law 3.8-2
3.8.2.3 Interstate Water Allocation 3.8-4
3.8.3 Existing Conditions/Affected Environment 3.8-4
3.8.3.1 Upper Klamath Basin 3.8-5
3.8.3.2 Lower Klamath Basin 3.8-11
3.8.4 Environmental Consequences 3.8-13
3.8.4.1 Environmental Effects Determination Methods 3.8-13

Contents (continued)

Page

3.8.4.2 Significance Criteria 3.8-14
3.8.4.3 Effects Determinations..... 3.8-14
3.8.4.4 Mitigation Measures 3.8-32
3.8.5 References..... 3.8-33
3.9 Air Quality ..... ~~5-100~~ 3.9-1
~~5.5.5 Green House~~3.9.1..... Area of Analysis 3.9-1
3.9.2 Regulatory Framework 3.9-1
3.9.2.1 Federal Authorities and Regulations..... 3.9-2
3.9.2.2 State Authorities and Regulations..... 3.9-2
3.9.2.3 Local Authorities and Regulations..... 3.9-3
3.9.2.4 Tribal Air Quality Management..... 3.9-3
3.9.3 Existing Conditions/Affected Environment..... 3.9-3
3.9.3.1 Existing Air Quality Conditions 3.9-3
3.9.4 Environmental Consequences..... 3.9-8
3.9.4.1 Environmental Effects Determination Methods..... 3.9-8
3.9.4.2 Significance Criteria 3.9-8
3.9.4.3 Effects Determinations..... 3.9-10
3.9.4.4 Mitigation Measures 3.9-28
3.9.5 References..... 3.9-31
3.10 Greenhouse Gases/Global Climate Change ..... ~~5-~~ 3.10-1
3.10.1 Area of Analysis 3.10-1
3.10.2 Regulatory Framework 3.10-1
3.10.2.1 Federal Authorities and Regulations..... 3.10-1
3.10.2.2 State Authorities and Regulations..... 3.10-2
3.10.3 Existing Conditions/Affected Environment..... 3.10-11
3.10.4 Environmental Consequences..... 3.10-13
3.10.4.1 Environmental Effects Determination Methods..... 3.10-13
3.10.4.2 Significance Criteria 3.10-15
3.10.4.3 Effects Determinations..... 3.10-17
3.10.4.4 Interim Measures 3.10-32
3.10.4.5 Mitigation Measures 3.10-48
3.10.5 References..... 3.10-52
3.11 Geology, Soils, and Geologic Hazards 3.11-1
3.11.1 Area of Analysis 3.11-1
3.11.2 Regulatory Framework 3.11-1
3.11.2.1 State Authorities and Regulations..... 3.11-1
3.11.2.2 County Authorities and Regulations..... 3.11-1
3.11.3 Existing Conditions/Affected Environment..... 3.11-1
3.11.3.1 Regional Geology 3.11-2
3.11.3.2 Geomorphology 3.11-4

Contents (continued)

Page

3.11.3.3 Sediment Supply and Transport 3.11-9
3.11.3.4 Reservoir Substrate Composition 3.11-9
3.11.3.5 Slope Stability/Landslides 3.11-13
3.11.3.6 Faults and Seismicity 3.11-15
3.11.3.7 Volcanic Activity and Associated Strata 3.11-16
3.11.4 Environmental Consequences 3.11-17
3.11.4.1 Environmental Effects Determination Methods 3.11-17
3.11.4.2 Significance Criteria 3.11-17
3.11.4.3 Effects Determinations 3.11-17
3.11.4.4 Mitigation Measures 3.11-29
3.11.5 References 3.11-30
3.12 Tribal Trust 3.12-1
3.12.1 Area of Analysis 3.12-2
3.12.2 Regulatory Framework 3.12-3
3.12.2.1 Federal Authorities and Regulations 3.12-3
3.12.3 Existing Conditions/Affected Environment 3.12-3
3.12.3.1 The Klamath Tribes 3.12-3
3.12.3.2 Quartz Valley Community 3.12-16
3.12.3.3 Karuk Tribe 3.12-20
3.12.3.4 Hoopa Valley Indian Tribe 3.12-31
3.12.3.5 Yurok Tribe 3.12-39
3.12.3.6 Resighini Rancheria 3.12-47
3.12.4 References 3.12-53
3.13 Cultural and Historic Resources 3.13-1
3.13.1 Area of Analysis 3.13-1
3.13.2 Regulatory Framework 3.13-1
3.13.2.1 National Historic Preservation Act of 1966, as amended in 1992 ..... 3.13-3
3.13.2.2 Native American Graves Protection and Repatriation Act (NAGPRA) 3.13-6
3.13.2.3 Executive Order 13007 Indian Sacred Sites 3.13-6
3.13.2.4 Archaeological Resources Protection Act of 1979 ..... 3.13-7
3.13.2.5 California Environmental Quality Act 3.13-7
3.13.3 Existing Conditions/Affected Environment 3.13-11
3.13.3.1 Regional Prehistory and Ethnography 3.13-11
3.13.3.2 Historic Period 3.13-25
3.13.3.3 Known Cultural and Historic Resources in the APE 3.13-27
3.13.4 Environmental Consequences 3.13-30
3.13.4.1 Effects/Impacts Determination Methods 3.13-30

Contents (continued)

Page

3.13.4.2 Significance Criteria 3.13-32
3.13.4.3 Effects Determinations..... 3.13-33
3.13.4.4 Mitigation Measures 3.13-48
3.13.5 References..... 3.13-54
3.14 Land Use, Agricultural and Forest Resources 3.14-1
3.14.1 Area of Analysis 3.14-2
3.14.1.1 Klamath County, Oregon 3.14-2
3.14.1.2 Siskiyou County, California..... 3.14-4
3.14.1.3 Modoc County 3.14-4
3.14.1.4 Klamath Basin National Wildlife Refuge System 3.14-4
3.14.1.5 Land Ownership..... 3.14-5
3.14.2 Regulatory Framework 3.14-9
3.14.2.1 Federal Authorities and Regulations..... 3.14-9
3.14.2.2 State Authorities and Regulations..... 3.14-9
3.14.2.3 Local Authorities and Regulations..... 3.14-9
3.14.3 Existing Conditions/Affected Environment..... 3.14-10
3.14.3.1 Land Use 3.14-10
3.14.3.2 Existing Infrastructure 3.14-17
3.14.4 Environmental Consequences..... 3.14-17
3.14.4.1 Effects Determination Methods 3.14-17
3.14.4.2 Significance Criteria 3.14-18
3.14.4.3 Effects Determinations by Alternative..... 3.14-18
3.14.5 References..... 3.14-28
3.15 Socioeconomics 3.15-1
3.15.1 Area of Analysis 3.15-1
3.15.2 Regulatory Framework 3.15-1
3.15.2.1 Federal Authorities and Regulations..... 3.15-1
3.15.3 Existing Conditions/Affected Environment..... 3.15-3
3.15.3.1 Four Facilities 3.15-3
3.15.3.2 Commercial Fishing..... 3.15-4
3.15.3.3 Recreation 3.15-11
3.15.3.4 Indian Tribes 3.15-17
3.15.3.5 PacifiCorp Hydroelectric Service 3.15-19
3.15.3.6 Real Estate, Property Tax and Other County Revenues 3.15-20
3.15.3.7 Irrigated Agriculture 3.15-23
3.15.3.8 Refuge Recreation..... 3.15-25
3.15.4 Environmental Consequences..... 3.15-26
3.15.4.1 Effects Determination Methods 3.15-26
3.15.4.2 Effects Determinations..... 3.15-40
3.15.5 References..... 3.15-102

Contents (continued)

Page

3.16 Environmental Justice 3.16-1
3.16.1 Area of Analysis 3.16-1
3.16.2 Regulatory Framework 3.16-1
3.16.2.1 Federal Authorities and Regulations 3.16-2
3.16.2.2 State Authorities and Regulations 3.16-2
3.16.2.3 Local Authorities and Regulations 3.16-2
3.16.3 Existing Conditions/Affected Environment 3.16-2
3.16.3.1 Demographics, Income, and Employment 3.16-2
3.16.3.2 Tribal Environmental Justice Concerns 3.16-9
3.16.4 Environmental Consequences 3.16-24
3.16.4.1 Effects Determination Methods 3.16-24
3.16.4.2 Effects Determinations 3.16-26
3.16.4.3 Mitigation Measure Analysis 3.16-39
3.16.4.4 Mitigation Measures Associated with other Resources 3.16-39
3.16.4.5 Summary of Beneficial Effects 3.16-39
3.16.5 References 3.16-40
3.17 Population and Housing 3.17-1
3.17.1 Area of Analysis 3.17-1
3.17.2 Regulatory Framework 3.17-2
3.17.3 Existing Conditions/Affected Environment 3.17-3
3.17.3.1 Klamath County, Oregon 3.17-3
3.17.3.2 Jackson County, Oregon 3.17-4
3.17.3.3 Siskiyou County, California 3.17-5
3.17.3.4 Unincorporated Areas 3.17-6
3.17.4 Environmental Consequences 3.17-8
3.17.4.1 Effects Determination Methods 3.17-8
3.17.4.2 Significance Criteria 3.17-8
3.17.4.3 Effects Determinations 3.17-8
3.17.4.4 Mitigation Measures 3.17-16
3.17.5 References 3.17-17
3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power 3.18-1
3.18.1 Area of Analysis 3.18-1
3.18.1.1 Public Health and Safety Area of Analysis 3.18-1
3.18.1.2 Utilities and Public Services Area of Analysis 3.18-1
3.18.1.3 Solid Waste Area of Analysis 3.18-1
3.18.1.4 Power 3.18-3

Contents (continued)

Page

3.18.2 Regulatory Framework 3.18-3
3.18.2.1 Federal Laws, Authorities and Regulations 3.18-3
3.18.2.2 State Authorities and Regulations 3.18-3
3.18.2.3 Local Authorities and Regulations 3.18-4
3.18.3 Existing Conditions/Affected Environment 3.18-4
3.18.3.1 Public Health and Safety 3.18-4
3.18.3.2 Utilities and Public Services 3.18-8
3.18.3.3 Solid Waste 3.18-15
3.18.3.4 Power 3.18-16
3.18.4 Environmental Consequences 3.18-19
3.18.4.1 Environmental Effects Determination Methods 3.18-19
3.18.4.2 Significance Criteria 3.18-20
3.18.4.3 Effects Determinations 3.18-21
3.18.4.4 City of Yreka Water Supply Pipeline Relocation – Programmatic Measures 3.18-37
3.18.4.5 Mitigation Measures 3.18-38
3.18.5 References 3.18-39
3.19 Scenic Quality 3.19-1
3.19.1 Area of Analysis 3.19-1
3.19.2 Regulatory Framework 3.19-1
3.19.2.1 Federal Laws, Authorities and Regulations 3.19-1
3.19.2.2 State Laws, Authorities and Regulations 3.19-2
3.19.2.3 Local Authorities and Regulations 3.19-2
3.19.3 Existing Conditions/Affected Environment 3.19-2
3.19.3.1 Applicable Visual Resource Management Class Designations within the Area of Analysis 3.19-3
3.19.3.2 Klamath River 3.19-8
3.19.3.3 Four Facilities Setting 3.19-10
3.19.4 Environmental Consequences 3.19-11
3.19.4.1 Effects Determination Methods 3.19-11
3.19.4.2 Significance Criteria 3.19-12
3.19.4.3 Effect Determinations 3.19-13
3.19.4.4 Mitigation Measures 3.19-35
3.19.5 References 3.19-36
3.20 Recreation 3.20-1
3.20.1 Area of Analysis 3.20-1
3.20.2 Regulatory Framework 3.20-1
3.20.2.1 Federal Authorities and Regulations 3.20-2
3.20.2.2 State Authorities and Regulations 3.20-2

Contents (continued)

Page

3.20.2.3 Local Authorities and Regulations 3.20-2
3.20.3 Existing Conditions/Affected Environment 3.20-2
3.20.3.1 Regional Opportunities 3.20-2
3.20.3.2 Recreation Opportunities along the Klamath River Segment Upstream of J.C. Boyle Reservoir 3.20-10
3.20.3.3 Recreation Opportunities in the Klamath River Segment Between J.C. Boyle Reservoir and Iron Gate Dam 3.20-13
3.20.3.4 Recreation Opportunities along the Klamath River Segment Downstream from Iron Gate Reservoir 3.20-23
3.20.3.5 Wild and Scenic Rivers Conditions 3.20-27
3.20.4 Environmental Consequences 3.20-34
3.20.4.1 Effects Determination Methods 3.20-34
3.20.4.2 Recreation Significance Criteria 3.20-35
3.20.4.3 Effects Determinations 3.20-36
3.20.4.4 KBRA – Programmatic Measures 3.20-59
3.20.4.5 Mitigation Measures 3.20-64
3.20.5 References 3.20-65
3.21 Toxic/Hazardous Materials 3.21-1
3.21.1 Area of Analysis 3.21-1
3.21.2 Regulatory Framework 3.21-1
3.21.2.1 Federal Laws, Authorities and Regulations 3.21-1
3.21.2.2 State Laws, Authorities and Regulations 3.21-1
3.21.3 Affected Environment/Environmental Setting 3.21-2
3.21.3.1 Sites with Potential HTRW Concerns 3.21-2
3.21.3.2 HTRW at PacifiCorp Dams and Associated Facilities 3.21-3
3.21.3.3 School Sites in the Project Area 3.21-5
3.21.3.4 Hazardous Waste Disposal Facilities 3.21-5
3.21.4 Environmental Consequences 3.21-5
3.21.4.1 Effects Determination Methods 3.21-5
3.21.4.2 Significance Criteria 3.21-7
3.21.4.3 Effects Determinations 3.21-7
3.21.4.4 Mitigation Measures 3.21-18
3.21.5 References 3.21-19
3.22 Traffic and Transportation 3.22-1
3.22.1 Area of Analysis 3.22-1
3.22.2 Regulatory Framework 3.22-1
3.22.2.1 Significance Criteria 3.22-2
3.22.3 Existing Conditions/Affected Environment 3.22-4

Contents (continued)

Page

3.22.3.1 KHSA – River Reach Road Network 3.22-4
3.22.3.2 KBRA – Road Network 3.22-7
3.22.4 Environmental Consequences 3.22-7
3.22.4.1 Environmental Effects Determination Methods 3.22-7
3.22.4.2 Effects Determinations 3.22-9
3.22.4.3 Mitigation Measures 3.22-22
3.22.5 References 3.22-23
3.23 Noise and Vibration 3.23-1
3.23.1 Area of Analysis 3.23-1
3.23.2 Regulatory Framework 3.23-1
3.23.2.1 Local Authorities and Regulations 3.23-1
3.23.3 Existing Conditions/Affected Environment 3.23-3
3.23.3.1 Existing Noise Levels near Construction Sites 3.23-3
3.23.3.2 Existing Noise Levels along the Haul Routes 3.23-7
3.23.3.3 Environmental Consequences 3.23-8
3.23.3.4 Environmental Effects Determination Methods 3.23-8
3.23.3.5 Significance Criteria 3.23-11
3.23.3.6 Effects Determinations 3.23-11
3.23.3.7 Mitigation Measures 3.23-22
3.23.4 References 3.23-26

Chapter 4 – Cumulative Effects 4-1
4.1 Cumulative Effects Overview 4-1
4.1.1 Regulatory Requirements 4-1
4.1.1.1 National Environmental Policy Act 4-1
4.1.1.2 National Historic Preservation Act 4-2
4.1.1.3 California Environmental Quality Act 4-2
4.2 Cumulative Effects Methods 4-3
4.2.1 Identifying Past, Present, and Future Actions Contributing to Cumulative Effects 4-3
4.2.2 Cumulative Effects Area of Analysis 4-5
4.2.3 Timeframe 4-8
4.2.4 Mitigation 4-9
4.2.4.1 National Environmental Policy Act 4-9
4.2.4.2 National Historic Preservation Act 4-9
4.2.4.3 California Environmental Quality Act 4-9
4.3 Actions and Projects Considered in Cumulative Effects Analysis 4-9
4.3.1 Documents Reviewed 4-9

Contents (continued)

Page

4.3.2 Cumulative Projects 4-23
4.4 Cumulative Effects Analysis 4-23
4.4.1 Water Quality 4-29
4.4.1.1 Alternative 2: Full Facilities Removal of Four Dams 4-42
4.4.1.2 Alternatives 3, 4, and 5 4-57
4.4.1.3 Mitigation Measures 4-57
4.4.2 Aquatic Resources 4-58
4.4.2.1 Alternative 2: Full Facilities Removal of Four Dams 4-58
4.4.2.2 Alternatives 3, 4, and 5 4-95
4.4.2.3 Mitigation Measures 4-96
4.4.3 Algae 4-96
4.4.3.1 Alternative 2: Full Facilities Removal of Four Dams 4-100
4.4.3.2 Alternatives 3, 4, and 5 4-104
4.4.3.3 Mitigation Measures 4-104
4.4.4 Terrestrial Resources 4-104
4.4.4.1 Alternative 2: Full Facilities Removal of Four Dams 4-109
4.4.4.2 Alternatives 3, 4, and 5 4-116
4.4.4.3 Mitigation Measures 4-117
4.4.5 Flood Hydrology 4-117
4.4.5.1 Alternative 2: Full Facilities Removal of Four Dams 4-121
4.4.5.2 Alternatives 3, 4, and 5 4-123
4.4.5.3 Mitigation Measures 4-123
4.4.6 Groundwater 4-124
4.4.6.1 Alternative 2: Full Facilities Removal of Four Dams 4-126
4.4.6.2 Alternatives 3, 4, and 5 4-128
4.4.6.3 Mitigation Measures 4-128
4.4.7 Water Supply/Water Rights 4-128
4.4.7.1 Alternative 2: Full Facilities Removal of Four Dams 4-132
4.4.7.2 Alternatives 3, 4, and 5 4-137
4.4.7.3 Mitigation Measures 4-138
4.4.8 Air Quality 4-138
4.4.8.1 Alternative 2: Full Facilities Removal of Four Dams 4-141
4.4.8.2 Alternatives 3, 4, and 5 4-144
4.4.8.3 Mitigation Measures 4-144

Contents (continued)

Page

4.4.9 Greenhouse Gases/Global Climate Change 4-144
4.4.9.1 Alternative 2: Full Facilities Removal of Four Dams 4-147
4.4.9.2 Alternatives 3, 4, and 5 4-150
4.4.9.3 Mitigation Measures 4-151
4.4.10 Geology, Soils and Geologic Hazards 4-151
4.4.10.1 Alternative 2: Full Facilities Removal of Four Dams 4-154
4.4.10.2 Alternatives 3, 4, and 5 4-157
4.4.10.3 Mitigation Measures 4-158
4.4.11 Tribal Trust 4-158
4.4.11.1 Alternative 2: Full Facilities Removal of Four Dams 4-158
4.4.11.2 Alternatives 3, 4, and 5 4-159
4.4.11.3 Mitigation Measures 4-159
4.4.12 Cultural and Historic Resources ..... ~~5-101~~ 4-160
~~5.5.7~~4.4.12.1 ..... Alternative 2: Full Facilities Removal of Four Dams 4-163
4.4.12.2 Alternatives 3, 4, and 5 4-166
4.4.12.3 Mitigation Measures 4-166
4.4.13 Land Use, Agricultural and Forest Resources 4-166
4.4.13.1 Alternative 2: Full Facilities Removal of Four Dams 4-169
4.4.13.2 Alternatives 3, 4, and 5 4-170
4.4.13.3 Mitigation Measures 4-171
4.4.14 Socioeconomics ..... ~~5-102~~ 4-171
~~5.5.8~~4.4.14.1 ..... Alternative 2: Full Facilities Removal of Four Dams 4-173
4.4.14.2 Alternative 3: Partial Facilities Removal of Four Dams 4-176
4.4.14.3 Alternatives 4 and 5 4-177
4.4.15 Environmental Justice ..... ~~5-104~~ 4-178
~~5.5.9 Scenic Quality ..... 5-104~~
~~5.5.10 Recreation ..... 5-106~~
~~5.5.11~~4.4.15.1 ..... Alternative 2: Full Facilities Removal of Four Dams 4-178
4.4.15.2 Alternatives 3, 4, and 5 4-182
4.4.15.3 Mitigation Measures 4-182
4.4.16 Population and Housing 4-182
4.4.16.1 Alternative 2: Full Facilities Removal of Four Dams 4-184
4.4.16.2 Alternatives 3, 4, and 5 4-185
4.4.16.3 Mitigation Measures 4-185

4.4.17 Public Health and Safety, Utilities and Public Services, Solid Waste, and Power 4-185

Contents (continued)

Page

4.4.17.1 Alternative 2: Full Facilities Removal of Four Dams 4-189
4.4.17.2 Alternatives 3, 4, and 5 4-194
4.4.17.3 Mitigation Measures 4-194
4.4.18 Scenic Quality 4-194
4.4.18.1 Alternative 2: Full Facilities Removal of Four Dams 4-198
4.4.18.2 Alternatives 3, 4, and 5 4-202
4.4.18.3 Mitigation Measures 4-202
4.4.19 Recreation 4-202
4.4.19.1 Alternative 2: Full Facilities Removal of Four Dams 4-206
4.4.19.2 Alternatives 3, 4, and 5 4-211
4.4.19.3 Mitigation Measures 4-211
4.4.20 Toxic/Hazardous Materials 4-211
4.4.20.1 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action) 4-213
4.4.20.2 Alternatives 3, 4, and 5 4-215
4.4.20.3 Mitigation Measures 4-215
4.4.21 Traffic and Transportation 4-215
4.4.21.1 Alternative 2: Full Facilities Removal of Four Dams 4-219
4.4.21.2 Alternatives 3, 4, and 5 4-223
4.4.21.3 Mitigation Measures 4-223
4.4.22 Noise and Vibration 4-223
4.4.22.1 Alternative 2: Full Facilities Removal of Four Dams 4-225
4.4.22.2 Alternatives 3, 4, and 5 4-227
4.4.22.3 Mitigation Measures 4-227
4.5 References 4-228

Chapter 5 – Other Required Disclosures 5-1
5.1 Irreversible and Irretrievable Commitment of Resources 5-1
5.2 Relationship Between Short-term Uses and Long-term Productivity 5-2
5.2.1 Klamath Hydroelectric Settlement Agreement 5-2
5.2.2 Klamath Basin Restoration Agreement 5-4
5.2.3 Keno Transfer 5-5
5.2.4 East and Westside Facilities – Programmatic Measure 5-6
5.3 Growth Inducing Impacts 5-6

5.4 Summary of Environmental Impacts 5-7

Contents (continued)

Page

5.5 Significant and Unavoidable Impacts 5-97
5.5.1 Water Quality 5-97
5.5.2 Aquatic Resources 5-97
5.5.3 Algae 5-98
5.5.4 Air Quality 5-98
5.5.5 Greenhouse Gases/Global Climate Change 5-99
5.5.6 Cultural and Historic Resources 5-99
5.5.7 Scenic Quality 5-100
5.5.8 Recreation 5-102
5.5.9 Noise and Vibration ..... 5-~~106~~102
5.6 Adverse Environmental Effects After Mitigation Relative to NEPA 5-112
5.6.1 Socioeconomics 5-112
5.6.2 Environmental Justice 5-116
5.7 Synopsis of Major Impacts and Benefits of the Alternatives 5-117
5.7.1 Existing Conditions/Affected Environment 5-119
5.7.2 Alternative 1 (No Action/No Project Alternative) 5-119
5.7.3 Alternative 4 (Fish Passage at Four Dams Alternative) 5-120
5.7.4 Alternative 5 (Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate) 5-121
5.7.5 Alternatives 2 (Full Facilities Removal of Four Dams [Proposed Action]) and Alternative 3 (Partial Removal of Four Dams) 5-122
5.7.6 Comparing Alternatives 2 and 3 5-127
5.8 Environmentally Preferable and Preferred Alternative 5-130
5.8.1 NEPA Environmentally Preferable~~/Superior~~ Alternative ..... 5-~~106~~130
5.~~7~~8.2 Preferred Alternative 5-131
5.9 CEQA Environmentally Superior Alternative 5-131
5.10 Controversies and Issues Raised by Agencies and the Public ..... 5-~~108~~133
5.~~8~~11 References ..... 5-~~110~~135

Chapter 6 – Compliance with Applicable Laws, ~~Podicies~~Policies, and Plans 6-1
6.1 Related Laws, Rules, Regulations, Executive Orders, and Other Authorities 6-1
6.2 References ..... 6-~~10~~13

Chapter 7 – Consultation and Coordination, Document Availability, and Distribution List 7-1
7.1 Public Involvement 7-1
7.1.1 Public Scoping 7-1
7.1.2 Public Hearings 7-1

Contents (continued)

Page

7.2 Agency Coordination 7-12
7.2.1 Cooperating Agencies 7-23
7.2.2 Reviewing Agencies 7-56
7.3 Government-to-Government Consultation 7-56
7.4 Non-Government Organization Coordination 7-68
7.4.1 Stakeholder Briefings and Technical Workshops 7-68
7.4.2 Briefings on Request 7-79
7.5 Endangered Species Act Consultation 7-89
7.6 Consultation under the Magnuson-Stevens Act 7-810
7.7 Consultation Pursuant to Section 106 of the NHPA 7-910
7.8 Environmental Justice – E.O.xecutive Order 12898 7-1012
7.9 Document Availability 7-1112
7.9.1 -Libraries and Federal and State Agencies 7-1213
7.9.2 WebsiteWeb Site 7-1315
7.10 Distribution List 7-1315
7.10.1 -Elected Officials, Representatives and Government Agencies 7-1315
7.10.2 Businesses, Organizations, and Individual Members of the Public 7-15
of the Public 7-17
7.11 References 7-1617

Chapter 8 – List of Preparers and Contributors 8-1

Chapter 9 – Glossary 9-1

Tables

Table ES *Page*

1. Hydroelectric Dams (Four Facilities) on the Mainstem Klamath RiverES-14
Table ES-2. KBRA Program Summary ES-23
Table ES-3. Timetable for Fish Passage Improvements at each Dam from Date of FERC License Renewal ES-25
Table ES-4. Summary of Significant and Unavoidable Impacts ES-28
Table ES-5. Summary of Adverse Environmental Effects Related to NEPA ES-37
Table ES-6. Summary of Major Long-Term Benefits for Salmonid Restoration and Water Quality.....ES-44
Table ES-7. Summary of Controversies and Issues Raised by Agencies and the Public ES-47
Table -1-1. Linkage of KBRA Programs, Plans, Commitments to Dam Removal 1-2629
Table 1-2. Cooperating Agencies.....1-2932
Table 2-1. Location of CEQA Guidelines Section 15124 Project Description Components.....2-2-2
Table -2-2. ..... Initial Alternatives 2-5 2-4
Table 2-3. Alternatives Selected for Analysis in the EIS/EIR 2-78
Table 2-4. Dam and Powerhouse Components 2-78
Table 2-5. Power Generation Facilities.....2-89
Table 2-6. Interim Measures included in the No Action/No Project Alternative.....2-1517
Table 2-7. Status of TMDLs in the Klamath River Basin.....2-1820

Tables (continued)

Table ~~2-8. Sediment Stored In Reservoirs 2-20~~ *Page*

~~Table 2-9.~~ 2-8 ..... Stored Sediment in the Klamath Hydroelectric Project, Fall 2009 2-23
2-9 Estimated Amount of Sediment in the Reservoirs in 2020 and Erodible Sediment with Dam Removal 2-24
2-10 KHSA Interim Measures that would not produce ~~Environmental Effects 2-21~~
~~Table 2-10.~~ Environmental Effects 2-25
2-11 KHSA Interim Measures Analyzed in the Proposed Action ..... 2-~~22~~26
~~Table~~ 2-~~11.~~12 ..... Drawdown Plans for J.C. Boyle, Copco 1, and Iron

~~Table~~ 33
2-~~12.~~13 Workforce Projections for the Proposed Action ..... 2-~~32~~35
~~Table~~ 2-~~13.~~14 ..... Recreation Facilities under the Proposed Action 2-~~35~~39
~~Table~~ 2-~~14.~~15 Non-Federal Parties to the KBRA ..... ~~2-39~~
~~Table~~ 2-~~15.~~44
2-16 Summary of KBRA Programs ..... 2-~~40~~45
~~Table~~ 2-~~16.~~17 ..... KBRA Fisheries Restoration Projects 2-~~43~~48
~~Table~~ 2-~~17.~~18 KBRA Fisheries Reintroduction Projects ..... ~~2-45~~
~~Table~~ 2-~~18.~~51
2-19 KBRA Fisheries Monitoring Projects ..... 2-~~46~~52
~~Table~~ 2-~~19.~~20 ..... Reclamation's Klamath Project Diversion Limitations per KBRA Appendix E-1 ..... 2-~~50~~56
~~Table~~ 2-~~20.~~21 KBRA Environmental Water Management Projects ..... ~~2-59~~
~~Table~~ 2-~~21.~~64
2-22 Summary of Features to be Removed or Retained with Alternative 3 ..... 2-~~62~~68
~~Table~~ 2-~~22.~~23 ..... Estimated Construction Workforce for Partial Removal at each Facility ..... 2-~~69~~75
~~Table~~ 2-~~23.~~24 ..... Minimum Structure Footprint and Dimensions for Fish Ladders at Each Dam ..... 2-~~72~~78
~~Table~~ 2-~~24.~~25 ..... Fish Passage Improvements under the Fish Passage at Four Dams Alternative ..... 2-~~73~~79
~~Table~~ 2-~~25.~~26 ..... Estimated Minimum Amount of Reinforced Concrete Necessary for Fish Ladder at Each Dam ..... 2-~~74~~80
~~Table 2-26. Timetable for Fish Passage Improvements at each Dam from Date of FERC License Renewal ..... 2-82~~
~~Table~~ 2-27. ..... Timetable for Implementation of Fish Passage Improvements at each Dam from Date of FERC License Renewal 2-89
2-28 Estimated Average Construction Workforce for Fish ~~Passage at Four Dams 2-83~~
~~Table 2-28.~~ ..... Passage at Four Dams 2-90
2-29 Estimated Construction Workforce for Full Removal of Iron Gate and Copco 1 Dams with Fish Passage at Copco 2 and J.C. Boyle Dams ..... 2-~~85~~92

~~Table~~ 2-~~29.~~30Recreation ~~Facility Changes~~Facilities under the Fish Passage at J.C. Boyle and ~~Copco~~ Copco 2, Remove Copco 1 and Iron Gate Alternative . 2-~~86~~93
~~Table~~ 3.1-1~~.~~ ..... KBRA Plans and Programs Analyzed 3.1-4
3.2-1~~-5~~
~~Table 3.2-1.~~ Location of Klamath ~~River~~ Basin Features Relevant to the Water Quality Area of Analysis~~. .....~~ 3.2-2

Tables (continued)

Table *Page*

3.2-2
~~Table 3.2-2.~~ ..... Designated Beneficial Uses of Water in the Area of Analysis~~..... 3.2-4~~
~~Table~~ 3.2-4
3.~~-~~2-3 Oregon Surface-Water Quality Objectives Relevant to the Proposed Action ~~and~~ and Alternatives..... ~~3.2-7~~
~~Table~~ 3.2-7
3.2-4~~.~~ California Surface-Water Quality Objectives..... 3.2-9
~~Table~~ 3.2-5~~.~~ ..... Minimum DO Concentrations Based ~~-~~on Percent Saturation Criteria 3.2-11
~~Table~~ 3.2-6~~.~~ ..... Hoopa Valley Tribe Surface-Water Quality Objectives~~–~~ 3.2-12
~~Table~~ 3.2-7~~.~~ .....California Marine Water Quality Objectives Relevant to the Proposed ~~Action~~ Action and Alternatives..... 3.2-13
~~Table~~ 3.2-8~~.~~ .....Water Quality Impaired Water Bodies within the Area of Analysis 3.2-14
~~Table~~ 3.2-9~~.~~ .....Status of TMDLs in the Klamath Basin as of February 2012 3.2-15
~~Table~~ 3.2-10~~.~~Summary of Water ~~Quality~~Quality Guidance, Criteria, or Targets for Toxigenic Blue~~-~~-Green Algae and Algal Toxins in the Area of Analysis..... 3.2-~~45~~49
~~Table~~ 3.2-11~~.~~ ..... Summary of Model Predictions for SSCs in the Klamath River ~~Downstream of~~ Downstream from Iron Gate Dam for the Proposed Action..... 3.2-~~92~~98
~~Table~~ 3.2-12~~.~~ ..... Estimated Short-term Immediate Oxygen Demand (IOD) and Biochemical Oxygen Demand (BOD) by Month for Modeled Flow and SSCs ~~Immediately~~ Immediately Downstream ~~of~~ from Iron Gate Dam Under the Proposed Action~~.~~ .....3.2-~~107~~115
~~Table~~ 3.2-13~~.~~ .....Estimated Location of Minimum Dissolved Oxygen and Location at ~~which~~ which Dissolved Oxygen Would Return to 5 mg/L Downstream ~~of~~ from Iron Gate Dam Due to High Short-term SSCs Under the Proposed Action.....3.2-~~108~~116
~~Table~~ 3.2-14~~.~~ ....Summary of Short-~~Term~~ term (<2 years) and Long-~~Term~~term (2–50 years) Water ~~Quality~~ Quality Impacts 3.2-162
3.~~2-149~~
~~Table~~ 3~~.3~~-1~~.~~ ..... Declines in Klamath River Anadromous Fish 3.3~~-~~-5
3~~-5~~
~~Table~~ .3~~.3~~-2~~.~~ ..... Estimated Volume of Sediment Currently Stored within Hydroelectric Reach Reservoirs .....3.3~~.3-31~~-35
~~Table 3.3-3. .....C.~~3.3-3Ceratomyxa shasta ~~Genotypes~~
~~Table~~ 3.3-4~~. .....2010~~ Biological Opinion ~~Proposed~~
3.3-A Summary of the Iron Gate Dam long-term flow targets expected to be achieved by water year 2010 unless modified by study results 3.3-59
3.3-B Instream flow recommendations by annual exceedence

levels for net inflows to Upper Klamath Lake on a monthly basis below Iron Gate Dam 3.3-60

Tables (continued)

Table *Page*

3.3-~~-~~5~~.~~ Proposed Action, Most-Likely Scenario SSCs Compared~~ With~~ with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) ~~For~~for Fall-~~ Run~~run Chinook Salmon ..... 3.3-~~98~~135

~~Table~~ 3.3-~~-~~6~~.~~ .. Proposed Action, Most-Likely Scenario SSCs Compared~~ With~~ with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) ~~For~~ for Spring-~~ Run~~run Chinook Salmon..... 3.3-~~104~~142

~~Table~~ 3.3-~~-~~7~~.~~ .. Proposed Action, Most-Likely Scenario SSCs Compared~~ With~~ with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions~~ (10% Exceedance Probabilities) For Coho Salmon ..... 3.3-108~~

~~Table 3.3-8.~~ ..... (10% Exceedance Probabilities) for Coho Salmon 3.3-147

3.3-8 Proposed Action, Most-Likely Scenario SSCs Compared ~~With~~with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) ~~For~~ for Summer and Winter Steelhead..... 3.3-~~114~~154

~~Table~~ 3.3-9~~.~~ ... Proposed Action, Most-Likely Scenario SSCs Compared~~ With~~ with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) ~~For~~ for Pacific Lamprey ..... 3.3-~~122~~162

~~Table~~ 3.3-10 .... Proposed Action, Most-Likely Scenario SSCs Compared~~ With~~ with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions~~ (10% Exceedance Probabilities) For Green Sturgeon ..... 3.3-125~~

~~Table~~ (10% Exceedance Probabilities) for Green Sturgeon 3.3-165

3.3-11~~.~~ Comparison of Short-term ~~SCC~~SSC Effects from the Proposed Action with and without Mitigation Measures; ~~most~~Most-likely~~ scenario (i.e.~~ Scenario (i.e., 50% Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon ..... 3.3-~~203~~249

~~Table~~ 3.3-12~~.~~Comparison of Short-term ~~SCC Effects~~SSC effects from the Proposed Action with and without Mitigation Measures; ~~most~~Most-likely scenario (i.e~~.~~., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey ..... 3.3-~~206~~252

Tables (continued)

Table *Page*

3.3-13. Comparison of Short-term SCCSSC Effects from the Proposed Action with and without Mitigation Measures; most-likely scenario (i.e.Most-Likely Scenario (i.e., 50% Exceedance Probabilities) for Green Sturgeon and Suckers....3.3-209255
Table 3.3-14. Comparison of Short-term SCC EffectsSSC effects from the Proposed Action with and without Mitigation Measure AR-8 for Freshwater Mussels....3.3-210256
Table 3.3-15. Comparison of Short-term SCC EffectsSSC effects from the Proposed Action with and without Mitigation Measures; worst-case scenarioWorst-Case Scenario (10% Exceedance Probabilities) for Fall- and Spring-run Chinook Salmon....3.3-211257
Table 3.3-16. Comparison of Short-term SCC EffectsSSC effects from the Proposed Action with and without Mitigation Measures; worst-case scenarioWorst-Case Scenario (10% Exceedance Probabilities) for Coho Salmon and Steelhead....3.3-213259
Table 3.3-17. Comparison of Short-term SCC EffectsSSC effects from the Proposed Action with and without Mitigation Measures; worstWorst-case scenario Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers....3.3-215261
Table 3.3-18. Comparison of Short-term SCC EffectsSSC effects from the Proposed Action with and without Mitigation Measures; worst-case scenario (Worst-Case Scenario (i.e., 10% Exceedance Probabilities) for Freshwater Mussels....3.3-218264
Table 3.4-1. .... Summary of Algae Impacts.... 3.4-2432
Table 3.5-1. .... River Reaches in the PacifiCorp Study (2004a).... 3.5-4
Table 3.5-2. Distribution of Vegetation Cover Types Mapped in 2002 in the PacifiCorp Study 3.5-9
Table the PacifiCorp Study Area (2004a)....3.5-8
3.5-3 Sub-Classification of Vegetation Cover Types Mapped in 2002 in the PacifiCorp Study Area (2004a)....3.5-109
Table 3.5-4. ....Special-Status Species Known to Occur in the Project Area 3.5-23
Table Area....3.5-31
3.5-5 Estimates of Historic, Existing and Future Wetlands at the Reservoirs....3.5-70
3.5-6 No Surface-Disturbing Activity Spatial Buffers and Seasonal Timing Restriction Stipulations for Raptor Nests....3.5-7596
Table 3.6-1. ....Biological Opinion Requirements for Iron Gate Dam Releases (cfs)....3.6-910
Table 3.6-2. ....USGS Gages on the Klamath River 3.6-14

Table 3.6-3. ..... Historic Monthly Average Flows (cfs) in Wetter Years (10% Exceedance Level) during Water Years 1961-2009 on the Klamath River 3.6-15
Table on the Klamath River 3.6-16
3.6-4. Annual and Seasonal Daily Flows 3.6-1617

Tables (continued)

Table *Page*

3.6-5. Flood Frequency Analysis on Klamath River for 10-yr to 100-yr Floods based upon Full Period of Record of Each Gage 3.6-17 18
Table 3.6-6. .....Modeled Average Monthly Flows (cfs) in Wetter Years (10% Exceedance Level) on the Klamath River under the No Action/No Project Alternative 3.6-21 22
Table 3.6-7. .....No Action/No Project Alternative Resource Management Actions Affecting Flood Hydrology on the Klamath River. 3.6-22
Table River..... 3.6-23
3.6-8. Flood Flow Exceedance: Modeled Wet Water Year FlowsConditions on the Klamath River under the Proposed Action 3.6-27 28
Table 3.6-9. ..... Flood Attenuation of Iron Gate and Copco 1 Reservoirs 3.6-30 31
Table 3.7-1. .....Well Construction Information for Wells within 2.5 Miles of J.C. Boyle Reservoir 3.7-10
Table 3.8-1. ..... Upper Klamath Basin Hydrologic Sub-Basins 3.8-6
Table 3.8-2 Summary of Water Rights Listings From California's Electronic Water Rights Information Management System 3.8-11
3.8-3 Common Benefits to all Indian Tribes with Dam Removal and Implementation of the KBRA 3.8-29
3.9-1. Federal Attainment Status of the Study Area 3.9-4
Table 3.9-2. ..... California Air Quality Attainment Status for the Study Area..... 3.9-7
Table 3.9-3. .....Uncontrolled Emissions Inventories for the Proposed Action 3.9-12 13
Table 3.9-4. ..... Uncontrolled Emissions from Reservoir Restoration (Reseeding) 3.9-15
3.9-5 Uncontrolled Emissions from Relocation and Demolition of Recreation Facilities 3.9-16
3.9-6 Uncontrolled Emissions from Construction of Yreka Water Supply Pipeline 3.9-18
3.9-7 Uncontrolled Emissions Inventories for the Partial Facilities Removal Alternative 3.9-19 21
Table 3.9-5. 8 ..... Uncontrolled Emissions Inventories for the Fish Passage at Four Dams Alternative..... 3.9-21 24
Table 3.9-6. 9 ..... Uncontrolled Emissions Inventories for the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative 3.9-23 25
Table 3.9-7. 3.9-10..... Uncontrolled Emissions from Reservoir Restoration (Reseeding) 3.9-26
3.9-11 Uncontrolled Emissions from Relocation and Demolition of Recreation Facilities 3.9-27
3.9-12 Summary of Mitigated Emissions by Alternative..... 3.9-26 29
Table 3.10-1. Projected Changes in Air Temperature under Existing Conditions 3.10-4
Table Conditions 3.10-4
3.10-2. Projected Seasonal Changes in Precipitation 3.10-6

~~Table~~ 3.10-7

Tables (continued)

Table *Page*

3.-10-3 Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural and Forestry Practices 3.10-1719
Table 3.10-4. .....Uncontrolled Direct GHG Emissions Inventories for Proposed Action – Full Facilities Removal 3.10-22
Table 3.10-5. Electricity Generation GHG Emissions from Replacement Sources after Removal of Four Dams (Existing Resource Mix) 24
3.10-28
Table 3.10-6. Electricity Generation GHG Emissions from Replacement Sources after Removal of Four Dams (33 Percent RPS) 3.10-29
Table 3.10-7. Adjusted Power Replacement Emissions Without Methane Emissions from Reservoirs..... 3.10-30
Table 3.10-8. Uncontrolled Direct GHG Emissions Inventories for Partial Facilities Removal 3.10-33
Table 3.10-9. 5Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Four Dams 3.10-37
Table Reservoir Restoration (Reseeding) 3-.10-26
3.10.-6 Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (Current Resource Mix)..... 3-10-38
Table 3-10-11. ..... Sources after Removal of Four Dams (Existing Resource Mix)..... 3.10-30
3.10-7 Electricity Generation Indirect GHG Emissions from Replacement Sources after Fish Passage Construction (33 Percent RPS) 3-10-38
Table 3-10.12. ..... Sources after Removal of Four Dams (33 Percent RPS) 3.10-31
3.10-8 Adjusted Power Replacement Emissions WithWithout Methane Emissions from Reservoirs 3-.10-3932
Table 3-10-13.3.10-9Uncontrolled Direct GHG Emissions Inventories for Partial Facilities Removal 3.10-37
3.10-10 Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Two Dams, Remove Copco 1 and Iron Gate 3-10-41
Table 3.10-14.Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (Current Resource Mix) ..... Passage at Four Dams
3.10-42
Table 3.10-1511 ..... Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (Current Resource Mix)..... 3.10-41
3.10-12 Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (33 Percent RPS)..... 3.10-42
3.10-13 Adjusted Power Replacement Emissions With Methane Emissions from Reservoirs 3.10-42
3.10-14 Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Two Dams, Remove Copco 1 and Iron Gate..... 3.10-44
3.10-15 Uncontrolled Direct GHG Emissions Inventories for Reservoir Restoration (Reseeding) 3.10-45

3.10-16 Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (Current Resource Mix) 3.10-46
3.10-17 Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (33 Percent RPS) ..... 3.10-~~43~~47
~~Table~~ 3.10-~~16~~18 Adjusted Power Replacement Emissions With Methane ~~Emissions from Reservoirs ..... 3-10.43~~
~~Table~~ Emissions from Reservoirs ..... 3.10-~~17~~ 47
3.10-19 Impact Summary Table (Without Methane Generation ~~from Reservoirs) 3.10-45~~
~~Table~~ from Reservoirs) ..... 3.10-~~18~~50
3.10-20 Impact Summary Table (With Methane Generation from ~~Reservoirs) 3.10-45~~
~~Table~~ Reservoirs) 3.10-51
3.11-1~~.~~ Cumulative Annual Sediment Delivery to the Klamath ~~River 3.11-10~~
~~Table~~ River 3.11-10
3.11-2~~.~~ Physical Properties of Reservoir Sediment ..... ~~3.11-11~~
~~Table~~ 3.11-11

Tables (continued)

Table *Page*

3.-11-3 Estimated Future Sediment Volume in Reservoirs under the No Action/No Project Alternative 3.11-18
Table 3.11-4. ..... Estimated Particle Sizes that would be Suspended at Average and Maximum Daily Discharge Rates 3.11-21
Table 3.11-5. ..... Comparison of Wet and Dry Reservoir Samples 3.11-2324
Table 3.12-1. Effects of Current Dam Operations on Klamath Tribes Trust Resources and Rights 3.12-9
Table Trust Resources and Rights 3.12-10
3.12-2. Effects of Current Dam Operations on Resources Traditionally Used by the Quartz Valley Tribe 3.12-18
3.12-3 Effects of Current Dam Operations on Resources Traditionally Used by the Karuk Tribe 3.12-2024
Table 13.12-3.4 ..... Effects of Current Dam Operations on Hoopa Valley Indian Tribe Trust Resources and Rights 3.12-3034
Table 13.12-4.5Effects of Current Dam Operations on Yurok Tribe Trust Resources and Rights 3.12-40
Table Resources and Rights 3.12-5.44
3.12-6 Effects of Current Dam Operations on Trust Resources and Rights and Resources Traditionally Used by the Resighini Rancheria 3.12-4450
Table 3.13-1. ..... Klamath Hydroelectric Facilities Historic District National Register Eligibility Recommendation 3.13-2528
Table 3.14-1. ..... Kuchel Act Lands in Reclamation's Klamath Project, 2009 3.14-5
3.14-6
Table 3.14-2. ..... 2009 Irrigable Lands in Reclamation's Klamath Project by State 3.14-14-16
Table 3.14-3. Klamath County Agricultural Land 3.14-18
Table 3.14-4. Acres of Agricultural Land in Siskiyou and Modoc Counties 3-14-19
Table 3.15-1. ..... Summary of the 2009 Regional Economy for Klamath and Siskiyou Counties 3-15.4
3.15-4
Table 3.15-2. ..... Summary of the Regional Economy for the San Francisco Management Area (San Mateo, San Francisco, Marin, and Sonoma Counties, CA) 3.-15-.7
Table 3.15-3. ..... Summary of the Regional Economy for the Fort Bragg Management Area (Mendocino County, CA) 3.15-7
3.15-7
Table 3.15-4. ..... Summary of the 2009 Regional Economy for the KMZ-CA (Humboldt and Del Del Norte Counties, CA) 3.15-8
3.15-8
Table 3.15-5. ..... Summary of the 2009 Regional Economy for the KMZ-OR (Curry County, OR) 3.15-8
3.15-8

~~Table 3.15-~~6~~.~~ .....Summary of the Regional Economy for the Central Oregon
Management Area (Coos, Douglas, and Lane~~ Counties OR)3.15-9~~
~~Table~~ Counties, OR) 3.15-9
3.15-7~~.~~ Landings of Troll-Caught Chinook Salmon and Coho Salmon
(# fish), 1981-2010, by Management Area..... 3.15-9
3.15-~~9~~
~~Table 3.15-~~8~~.~~ ....Landings of Troll-Caught Chinook Salmon and Coho Salmon
(1000s of pounds dressed weight), 1981-2010, by~~ Management Area 3.15-10~~
Management Area 3.15-10

Tables (continued)

Table *Page*

3.15-9. Ex-vessel Value of Troll-Caught Chinook Salmon and Coho Salmon ($1000s, Base Year=2012), 1981-2010, by Management Area3.15-10
Table Management Area ..... 3.15-10.
3.15-10 Ocean Sport Salmon Effort (# angler days) during 1981-2010, by Management Area 3-15.13
3.15-13
Table 3.15-11. ..... Ocean Sport Chinook Salmon and Coho Salmon Landings (# fish) during 1981-2010, by Management Area 3-15.13
3.15-13
Table 3.15-12. ... Summary of the Regional Economy for Del Norte, Humboldt and Siskiyou Counties in California and Klamath County, OR 3.15-14
3.15-14
Table 3.15-13. .....Summary of the 2009 Regional Economy for Klamath, Jackson, Humboldt, and Siskiyou Counties.....3.15-15-15
Table 3.15-14. ..... Commercially Guided Whitewater Boating Trips on Upper Klamath River from 2001 to 2009 ..... 3.15-16
Table 3.15-15-15. ..Commercially Guided Whitewater Boating Trips on Lower Klamath River from 2000 to 2009 ..... 3.15-17
Table 3.15-16.
3.15-16 Whitewater Boating User Days on the Klamath River from 1994 to 2009 ..... 3.15-17
3.15-17
Table 3.15-17. .....Income, Poverty, and Unemployment for Affected Federally Recognized Tribes 3-15.18
3.15-18
Table 3.15-18. .....Yurok and Hoopa Valley Reservation Indian Tribes Gillnet Chinook Salmon Spring and Fall Run Harvest (# fish) from 1981 to 2010..... 3.15-19
Table 3.15-19. .....Siskiyou County Average Tax Revenues from 2000 to 2010 3.15-21
Table 2010..... 3.15-22
3.15-20. Siskiyou County Annual Tax Amount Received from PacifiCorp from 2000 to 2011 ..... 3.15-22
Table 3.15-21. .....Summary of the 2009 Regional Economy for Klamath, Modoc, and Siskiyou Counties 3.15-2324
Table 3.15-22. .....Crop Acreage Summary for Irrigated Agriculture in Reclamation's Klamath Project Lands..... (acres) 3.15-24
3.15-24
Table 3.15-23. ..... Representative Crop Prices from 2005 to 2009 3.15-25
Table 3.15-24. .....Average Gross Farm Revenue Generated on Reclamation's Klamath Project Lands from 2005 to 2009..... 3.15-25
Table 3.15-25. Expenditures per User Day for Whitewater Boating on the Klamath River3.15-36
Table Klamath River (2012 dollars) 3.15-36

3.15-26. Daily Expenditures per Person for Hunting and Wildlife Viewing3.15-40
Table Viewing (2012 dollars) 3.15-40
3.15-27. Regional Economic Effects from Annual O&M Expenditures for the No Action/No Project Alternative 3.15-40
Table for the No Action/No Project Alternative 3-15.40
3.15-28. Annual Ex-Vessel Revenue for Management Areas for the No Action/No Project Alternative 3.15-41
No Action/No Project Alternative 3.15-41

Tables (continued)

Table *Page*

3.15-29. Regional Economic Total Effects from Ocean Commercial Fishing under No Action/No Project Alternative 3-15.41

3.15-41

Table 3.15-30.Regional Economic Effects from Reservoir Recreation for the No Action/No Project Alternative 3.15-43

Table the No Action/No Project Alternative..... 3.15-42

3.15-31. Regional Economic Effects from In-river Salmon Fishing for the No Action/No Project Alternative 3.15-42

Table for the No Action/No Project Alternative..... 3.15-43

3.15-32. Regional Economic Effects from In-river Steelhead fishing for the No Action/No Project Alternative 3.15-43Fishing

Table for the No Action/No Project Alternative..... 3.15-43

3.15-33. Total Annual Recreational Salmon Effort, Nonresident Effort and Nonresident Expenditures for the No Action/No Project Alternative 3.15-44

Table 3.15-34.Regional Economic Effects from Ocean Sport Salmon Fishing for the No Action/ ..... No Project Alternative 3.15-44

Table 3.15-35. Regional Economic Effects from Whitewater Recreation for the No Action/No Project Alternative 3.15-45

Table 3.15-36. Total Economic Effects over a 15 year period of In-Region Spending for Ongoing Restoration Actions under the No Action/No Project Alternative..... 3.15-49

Table 3.15-37. Gross Farm Revenue for the No Action/No Project Alternative during Drought Years..... 3.15-50

Table 3.15-38. Regional Economic Effects from Irrigated Agriculture for the No Action/No Project Alternative during Drought Years3.15-51

Table 3.15-39. Regional Economic Effects from Refuge Hunting for the No Action/No Project Alternative 3.15-52

Table 3.15-40. Total Economic Effects over a 15 year period of In-Region Spending for Tribal Program under the No Action/No Project Alternative3.15-52

Table 3.15-41. Regional Economic Effects from Dam Decommissioning for Alternative 2, the Proposed Action..... 3.15-53

Table 3.15-42. Regional Economic Effects from O&M Expenditures between the No Action/No Project Alternative and Alternative 2, the Proposed Action..... 3.15-54

Table 3.15-43. Mitigation Costs by Facility and Year (2012 $) for Alternative 2, the Proposed Action..... 3.15-55

Table 3.15-44. Regional Economic Effects from Mitigation Expenditures for Alternative 2, the Proposed Action..... 3.15-55

Table 3.15-45. Annual Ex-vessel Revenue for Management Areas ... 3.15-56

Table 3.15-46. Regional Economic Effects from Ocean Commercial Fishing between the No Action Alternative and Alternative 2, the Proposed Action3.15-57

~~Table 3.15-47. Regional Economic Effects from Reservoir Recreation between the No Action/No Project Alternative and Alternative 2, the Proposed Action ..... 3.15-58~~
~~Table 3.15-48. Total Annual Recreational Salmon Effort, Nonresident Effort and Nonresident Expenditures by Fishing Mode and Management Area for Alternative 2, the Proposed Action ..... 3.15-58~~
~~Table 3.15-49.~~34Regional Economic Effects from Ocean Sport Salmon Fishing ~~between the No Action/No Project Alternative and Alternative 2, the Proposed Action3.15-59~~
~~Table 3.15-50.Regional Economic Effects from In-river Salmon Fishing between~~ for the No Action/No Pr
3.15-~~60~~
~~Table 3.15-51.~~35 .....Regional Economic Effects from Whitewater Recreation for the No Action/No Project Alternative 3.15-45
3.15-36 Total Economic Effects over a 15 year period of In-Region Spending for Ongoing Restoration Actions under the No Action/No Project Alternative 3.15-50
3.15-37 Gross Farm Revenue for the No Action/No Project Alternative during Drought Years 3.15-51
3.15-38 Regional Economic Effects from Irrigated Agriculture for the No Action/No Project Alternative during Drought Years 3.15-51
3.15-39 Regional Economic Effects from Refuge Hunting for the No Action/No Project Alternative 3.15-52
3.15-40 Total Economic Effects over a 15-year Period of In-Region Spending for Tribal Program Under the No Action/ No Project Alternative 3.15-53
3.15-41 Regional Economic Effects from Dam Decommissioning for Alternative 2, the Proposed Action 3.15-54
3.15-42 Change in Regional Economic Effects from O&M Expenditures between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-55
3.15-43 Mitigation Costs by Facility and Year (2012 $) for Alternative 2, the Proposed Action 3.15-55
3.15-44 Regional Economic Effects from Mitigation Expenditures for Alternative 2, the Proposed Action 3.15-56
3.15-45 Annual Ex-vessel Revenue by Management Area (2012 dollars) 3.15-57
3.15-46 Change in Regional Economic Effects from Ocean Commercial Fishing between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-57

Tables (continued)

Table *Page*

3.15-47 Change in Regional Economic Effects from Reservoir Recreation between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3-15.58
3.15-48 Total Annual Recreational Salmon Effort, Nonresident Effort and Nonresident Expenditures by Fishing Mode and Management Area for Alternative 2, the Proposed Action..... 3.15-59
3.15-49 Change in Regional Economic Effects from Ocean Sport Salmon Fishing between the No Action/No Project Alternative and Alternative 2, the Proposed Action ..... 3.15-~~61~~59
~~Table~~ 3.15-50 ..... Change in Regional Economic Effects from In-river Salmon Fishing between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-60
3.15-51 Change in Regional Economic Effects from Whitewater Recreation between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-62
3.15-52~~. Potentially Affected and Affected~~Evaluated Parcels by Land Use in Siskiyou County..... 3.15-~~64~~66
~~Table~~ 3.15-53~~.~~Regional Economic Effects of KBRA Fishery Program ~~Actions Relative to No Action/No Project Alternative over a 15-year period.. ..3.15-67~~
~~Table 3.15-54. Regional Economic Effects of KBRA Water Resources Program Actions Relative to No Action/No Project Alternative over a 15-year period ..... 3.15-70~~
~~Table 3.15-55. Gross Farm Revenue by IMPLAN crop sectors between the No Action/No Project Alternative and Alternative 2, the Proposed Action for Drought Years ..... 3.15-72~~
~~Table 3.15-56. Regional Economic Effects from Gross Farm Revenue between the No Action/No Project Alternative and Alternative 2, the Proposed Action..... 3.15-72~~
~~Table 3.15-57. Regional Economic Effects from Increased Pumping Costs between the No Action/No Project Alternative and Alternative 2, the Proposed Action..... 3.15-73~~
~~Table 3.15-58. Regional Economic Effects from Lost Agricultural Production for the WURP ..... 3.15-74~~
~~Table 3.15-59. Regional Economic Effects from Refuge Recreation between the No Action/No Project Alternative and Alternative 2, the Proposed Action..... 3.15-75~~
~~Table 3.15-60. .....Regional Economic Effects of KBRA Regulatory Assurance~~ __ Actions Relative to No Act
~~Table~~ over a 15-year period (2012 dollars)..... 3.15-~~61.~~71
3.15-54 Regional Economic Effects of KBRA ~~Tribal~~Water Resources Program Actions Relative to No Action/No Project ~~Alternative over a 15-year period ..... 3.15-79~~ Alternative over a 15-year period (2012 dollars)..... 3.15-73

3.15-55 Gross Farm Revenue by IMPLAN crop sectors between the No Action/No Project Alternative and Alternative 2, the Proposed Action for Drought Years (1,000 $) 3.15-75
3.15-56 Change in Regional Economic Effects from Gross Farm Revenue between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-75
3.15-57 Change in Regional Economic Effects from Increased Pumping Costs between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-76
3.15-58 Regional Economic Effects from Lost Agricultural Production for the WURP 3.15-77
3.15-59 Change in Regional Economic Effects from Refuge Recreation between the No Action/No Project Alternative and Alternative 2, the Proposed Action 3.15-78
3.15-60 Regional Economic Effects of KBRA Regulatory Assurance Actions Relative to No Action/No Project Alternative over a 15-year period (2012 dollars) 3.15-79
3.15-61 Regional Economic Effects of KBRA Tribal Program Actions Relative to No Action/No Project Alternative over a 15-year period (2012 dollars) 3.15-82

Tables (continued)

Table *Page*

3.15-62. Regional Economic Effects from Dam Decommissioning for Alternative 3 ..... 3. 15-8083
Table 3.15-63. Change in Regional Economic Expenditures between the No Action/No Project Alternative and Alternative 3 ..... 3.15-84
3.15-81
Table 3.15-64. ..... Mitigation Costs by Facility Year (2012 $) for Alternative 3 3.15-8184
Table 3.15-65. ... Summary of Regional Economic Effects for Each Alternative 3.-15-89.92
Table 3.15-66. Summary of Regional Economic Effects over 15 Years of Ongoing Restoration Activities and KBRA Implementation 3.15-96
Table 3.15-67. Positive Effects of the Proposed Action and Alternatives 3.15-99
Table 3.16-1. ..... Population, Race, and Ethnicity, 2005-2009 American Community Survey 3.16-3
Table 3.16-2. Tribal Enrollment within the Area of Analysis, 2005... 3.16-4
Table 3.16-4
3.-16-3 Income and Poverty, 1999 ..... 3.16-5
Table 3.16-4. Poverty in Siskiyou County 3.16-5
Table 3.16-5.
3.16-5 Income and Poverty in Tribes, 1999 ..... 3.16-6
3.16-6
Table 3.16-6. ..... Housing and Employment 3.16-6
Table 3.16-7. Housing, Labor, and Employment, 2005 ..... 3.16-7
Table 3.16-7
3.16-8. Employment and Labor Force, 2005-2009, American Community Survey 3.16-7
Table 3.16-9. Federal Funds Distribution for Social Programs, 2010 3.16-8
Table 3.16-8
3.16-10. Local Funds Distributed for Government Services, 2010 3.16-9
Table 3.16-9
3.16-11. Beneficial Effects of the Proposed Action and Alternatives 3.16-3740
Table 3.17-1. ..... Cities Included for Analysis 3.17-2
3.17-2
Table 3.17-2. ..... Klamath Falls and County Housing Estimates, 2010 3.17-4
3.17-4
Table 3.17-3. ..... Medford and Jackson County Housing Estimates, 2010 3.17
3.17-5
Table 3.17-4. ..... Siskiyou County Housing Estimates, 2010 3.17-6
Table 3.17-5. ..... Unincorporated Areas Housing Estimates, 2010 3.17-8
Table 3.17-6. ..... Approximate Commute Distances (miles) 3.17-9
Table 3.18-1. ..... Example Communities in the Utilities and Public Services ..... 3.18-3 Potentially Affected by Alternatives 3.18-3
Table 3.18-2. Fire Protection Agencies in the Project Area 3.18-8

3.18-3 Utilities and Public Services in the Study Area 3.18-9
~~Table~~ 3.18-~~3.~~4 ..... Regional Landfills and Recycling Centers and Type of Waste Accepted ..... 3.18-~~11~~16
~~Table~~ 3.18-~~4.~~5 ..... Klamath Hydroelectric Project Facilities 3.18-~~13~~18
~~Table~~ 3.18-~~5.~~6 ..... Summary of Solid Waste Generation for Each Action Alternative ..... 3.18-~~22~~27
~~Table~~ 3.19-1~~.~~ ..... Visual Resource Inventory Matrix 3.19-6
~~Table~~ 3.19-2~~.~~ ..... Summary of Features that Would Be Removed under the Proposed Action Alternative and that would be Retained under the Partial Facilities Removal Alternative ..... 3.19-~~28~~27
~~Table~~ 3.19-3~~.~~ ..... Minimum Structure Footprint for Fish Ladders under the Fishway Alternatives ..... 3.19-~~33~~32

Tables (continued)

Table *Page*

3.20-1. Public Lands Offering Recreational Opportunities in the Vicinity of the Klamath River ... 3.20-54
Table 3.20-2. Rivers Providing Recreational Fishing Opportunities in the Region ... 3.20-76
Table 3.20-3. Rivers with Whitewater Boating Opportunities in the Region ... 3.20-7
Table 3.20-4. Comparison of Subject Reservoirs with Lakes and Reservoirs in the Region ... 3.20-8
Table 3.20-5. Keno Impoundment/Lake Ewauna Developed Recreation Facilities 3.20-11
Table Facilities ... 3.20-11
3.20-6. Acceptable Flow Ranges for Various River-Based Activities for Reaches of the Klamath River ... 3.20-13
Table 3.20-7. J.C. Boyle Reservoir Developed Recreation Facilities 3.20-17
Table 3.20-8. Hell's Corner Reach Developed Recreation Facilities 3.20-18
Table 3.20-9. Copco 1 Reservoir Developed Recreation Facilities 3.20-1819
Table 3.20-10. Iron Gate Reservoir Developed Recreation Facilities ... 3.20-19
Table 3.20
3.20-11. River-Based Recreation Opportunities below Iron Gate Dam 3.20-23
Table Dam ... 3.20-23
3.20-12. Estimated Number of Recreational Salmon Angler Days and Chinook Salmon Harvest on the Klamath River (excluding the Trinity River), 2001-2010 ... 3.20-26
Table 3.20-13. Estimated Number of Recreational Steelhead Angler Days on the Klamath River (excluding the Trinity River) 3.20-26,
Table 2003-2008 ... 3.20-26
3.20-14. Comparison of 1981 Flows to the Acceptable Range for Whitewater Boating and Fishing ... 3.20-31
Table 3.20-31
3.20-15. Estimated Abundance of Fish Species at the 1981 WSR Designation ... 3.20-33
Table 3.20-33
3.20-16. Estimated Number of Days Meeting the Range of Acceptable Flows for Recreational Activities on the Klamath River ... 3.20-4142
Table 3.20-17. Beneficial Effects of the Proposed Action and Alternatives 3.20-63
Table 3.22-1. Local and Regional Access Roads Relative to KHSA 3.22-2
Table 3.22-2. Traffic Flow Projections 3.22-12
Table 3.23-1. Maximum Allowable Noise Levels from Construction Equipment in Siskiyou County, CA ... 3.23-2
Table 3.23-2. Existing Noise Levels at Residential Receptors Near near Construction Sites ... 3.23-7
Table 3.23-3. Existing Peak Hour L_{eq} Along Proposed Haul and Commute Routes ... 3.23-8

~~Table~~ 3.23-4~~.~~ ..... Construction Operations, Equipment Types, and Their Noise Levels 3.23-9
~~Table~~ 3.23-5~~-~~ ..... Vibration Levels for Construction Equipment 3.23-10

Tables (continued)

Table *Page*

3.23-6. Summary of Noise Levels from Deconstruction Activities for the Proposed Action 3.23-13
Table for the Proposed Action 3.23-13
3.23-7. Summary of Vibration from Construction Activities for the Proposed Action3.23-15
Table Proposed Action 3.23-15
3.23-8. Summary of Construction-Related Traffic Noise from Off-site Hauling and Construction Worker Commute for the Proposed Action3.23-15
Table Proposed Action 3.23-15
3.23-9. Summary of Noise Levels from Construction Activities for the Fish Passage at Four Dams Alternative 3.23-18
Table 3.23-10. .. Summary of Vibration Levels at Receptors from Construction Activities for the Fish Passage at Four Dams Alternative 3.23-19
Table 3.23-11. ..Summary of Construction-Related Traffic Noise from Off-site Hauling for the Fish Passage at Four Dams Alternative 3.23-20
Table 3.23-12. ..Summary of Construction-Related Traffic Noise from Off-site Hauling for the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative 3.23-22
Table 4-1. Method for Developing the Cumulative Condition 4-4
4
Table 4-2. Cumulative Effects Area of Analysis by Resource ..... 4-6 for
Table Removal of the Four Facilities (KHSA) 4-6
4-3. Plans, Programs, and Other Documents Considered in Cumulative Effects Analysis 4-10
4-10
Table 4-4. Projects Considered in Cumulative Effects Analysis 4-2224
Table 4-5. Summary of Water Quality Impacts from Chapter 3 4-30
4-29
Table 4-6. Summary of Aquatic Resources Impacts from Chapter 3 4-59
4-55
Table 4-7. Summary of Algae Impacts from Chapter 3 4-8996
Table 4-8. Summary of Terrestrial Resources Impacts from Chapter 3 4-96105
Table 4-9. Summary of Flood Hydrology Impacts from Chapter 3 4-117
4-106
Table 4-10. ..... Population Projections for the Eight Klamath Basin Counties 4-121
4-109
Table 4-11. ..... Summary of Groundwater Impacts from Chapter 3 4-112124
Table 4-12. .....Summary of Water Rights/Water Supply Impacts from Chapter 3 4-129
4-116
Table 4-13. ..... Summary of Air Quality Impacts from Chapter 3 4-138
4-125

~~Table 4-~~14~~.~~ ..... Summary of Greenhouse Gases/Global Climate Change Impacts from Chapter 3 ..... 4-~~132~~145
~~Table~~ 4-15~~.~~ ..... Summary of Geology, Soils and Geologic Hazards Impacts from Chapter 3 4-151
4-~~137~~
~~Table 4-~~16~~.~~ .....Summary of Cultural and Historic Resources Impacts from Chapter 3 ..... 4-~~145~~160
~~Table~~ 4-17~~.~~ Summary of Land Use, Agricultural and Forest Resources Impacts from Chapter 3 4-167

Tables (continued)

Table *Page*

4-~~152~~
~~Table 4-~~18~~.~~ .....Summary of Population and Housing Impacts from Chapter 3 ..... 4-~~165~~183
~~Table~~ 4-19~~.~~ .....Summary of Public Health and Safety, Utilities and Public Services, Solid Waste, and Power Impacts from Chapter 3 4-186
4-~~168~~
~~Table 4-~~20~~.~~ .....Summary of Scenic Quality Impacts from Chapter 3 4-195
4-~~177~~
~~Table 4-~~21~~.~~ ..... Summary of Recreation Impacts from Chapter 3 4-203
4-~~184~~
~~Table 4-~~22~~.~~ .....Summary of Toxic/Hazardous Materials Impacts from Chapter 3 4-212
4-~~192~~
~~Table 4-~~23~~.~~ .....Summary of Traffic and Transportation Impacts from Chapter 3 4-216
4-~~196~~
~~Table 4-~~24~~.~~ .....Summary of Noise and Vibration Impacts from Chapter 3 ..... 4-~~203~~223
~~Table~~ 5-1~~.~~ Summary of Environmental Impacts ~~..... 5-8~~Relative to NEPA
~~Table 5-2. Summary of Significant and Unavoidable Adverse Impacts .....~~ and CEQA 5-8
5-~~75~~
~~Table 5-3.~~2 Summary of Environmental Effects Relative to NEPA ..... 5-~~84~~85
~~Table 5-4. Wild and Scenic River Resource Effects ..... 5-94~~
~~Table 5-5.~~5-3 ..... Summary of Significant Environmental Effects that Cannot be Avoided Relative to CEQA and NEPA 5-103
5-4 Summary of Adverse Environmental Effects Relative to NEPA 5-113
5-5 Summary of Major Long-term Benefits for Salmonid Restoration and Water Quality 5-123
5-6 Detailed Comparison of Alternative 2 and Alternative 3 5-127
5-7 Summary of Controversies and Issues Raised by Agencies~~ and the Public 5-108~~
~~Table~~ and the Public 5-133
6-1~~.~~ Related Federal Laws, Rules, Regulations, Executive Orders, and Other Authorities 6-1
~~Table~~ 6-2~~.~~ California State Statutes and Regulations ..... 6-~~5~~6
~~Table~~ 6-3~~.~~ Oregon State Statutes and Regulations~~-~~ ..... 6-~~7~~9
~~Table~~ 6-4~~.~~ Local Plans and Policies ..... 6-~~8~~11
~~Table~~ 7-1~~.~~ EIS/EIR Participating ~~Agencies~~ Agencies[1] 7-2
~~Table~~ 7-2~~.~~ Cooperating Agencies~~-~~ 7-3
~~Table~~ 7-3~~.~~ Cooperating Agency Meeting Updates~~.....~~ 7-4
7-4
~~Table 7-4.~~ Meetings with Potential Cooperating Agencies or

Non-Government Groups-..... 7-~~4~~5
~~Table~~ 7-5~~.~~ Tribal Consultations..... 7-~~6~~7
~~Table~~ 7-6~~.~~ Stakeholder Briefings and Technical Workshops..... 7-8
7-7-~~7~~
~~Table 7-7.~~ Libraries with Draft EIS/EIR Available ..... 7-~~12~~14
~~Table~~ 7-8~~.~~ Federal and State Agencies with Draft EIS/EIR Available ..... 7-~~13~~14
~~Table~~ 7-9~~.~~ EIS/EIR Distribution List ..... 7-~~14~~15

8-1 Federal Agencies 8-1
8-2 California Department of Fish and Game 8-2

Tables (continued)

Table *Page*

8-3 CDM Smith 8-3
8-4 Cardno/ENTRIX 8-5
8-5 Stillwater Sciences 8-5
8-6 River Design Group 8-5

Figures

Figure ES *Page*

1-1 The Klamath Basin ES-6 1-5
Figure ES-2. 1-2a ..... Klamath Basin Timeline ES-8 Since 1905 1-14
Figure ES-3. J.C. Boyle Dam and Powerhouse ES-15
Figure ES-4. Copco 1 Dam and Powerhouse ES-15
Figure ES-5. Copco 2 Powerhouse and Dam ES-16
Figure ES-6. Iron Gate Dam, Reservoir, and Power Generating Facilities ES-16
Figure ES-7. Alternatives Development and Screening Process ES-30
Figure ES-8. Simulation of Iron Gate Dam Before and After Full Facilities Removal ES-23
Figure ES-9. Simulation of Partial Facilities Removal ES-24
Figure ES-10. Example of Cast-In-Place Pool and Weir Fish Ladder .. ES-25
Figure 1-1. Klamath Basin 1-3
Figure 1-2. -2b Klamath Basin Timeline Since 1905 1-11
Figure 1-3. ..... Klamath Basin Expenditures (Sheets 2011) 1-13 15
Figure 1-4. 3 ..... Reclamation's Klamath Project 1-14 17
Figure 2-1. Alternatives Development and Screening Process 2-3
Figure 2-. 2. ..... J.C. Boyle Dam and Powerhouse 2-9-3
Figure 2-2 J.C. Boyle Dam and Powerhouse. 2-10
2-3. Example Flows in Peaking Reach downstream from J.C. Boyle Powerplant 2-10
Figure J.C. Boyle Powerplant (United States Geological Survey [USGS] station 11510700). 2-11
2-4. Copco 1 Dam and Powerhouse 2-11 12
Figure 2-5. ..... Copco 2 Powerhouse (left photo) and Dam. 2-12 13
Figure 2-6. ..... Iron Gate Dam, Reservoir, and Power Generating Facilities 2-13 14
Figure 2-7. No Action/No Project Flows below Iron Gate Dam in Wet, Average, and Dry Years Conditions. 2-16 18
Figure 2-8. ..... Proposed Action Flows at the Iron Gate Gauge in Wet, Average, and Dry Years ..... 2-19 Conditions 2-21
Figure 2-9. ..... J.C. Boyle Haul Roads and Disposal Sites. 2-24 28
Figure 2-10. ..... Copco 1 and Copco 2 Haul Roads and Disposal Sites. 2-28 30
Figure 2-11. ..... Iron Gate Haul Roads and Disposal Sites. 2-30 34
Figure 2-12. ..... Anticipated Schedule for Full Facilities Removal. 2-31 35
Figure 2-13. ..... On-Project Area. 2-49 55
Figure 2-14. ..... Key Milestones before Diversion Limits are Implemented. 2-52 58

~~Figure~~ 2-15~~.~~ ..... Off Project Irrigation Area. 2-~~56~~61
~~Figure~~ 2-16~~.~~ ..... View of J.C. Boyle Dam showing portion of dam and fish ladder to be removed for the Partial Facilities ~~Removal Alternative 2-64~~
~~Figure~~ Removal Alternative. 2-70
2-17~~.~~ Copco 1 showing portion of dam to be removed for the ~~Partial Facilities Removal Alternative ..... 2-65~~
~~Figure~~ Partial Facilities Removal Alternative. 2-71
2-18~~.~~ Copco 2 dam showing portion of dam to be removed for ~~the Partial Facilities Removal Alternative ..... 2-66~~
~~Figure~~ the Partial Facilities Removal Alternative. 2-72
2-19~~.~~ Section view of Iron Gate Dam showing 100-foot-wide bottom notch with different potential side slopes~~–~~. ..... 2-~~67~~73
~~Figure~~ 2-20~~.~~ ..... Iron Gate dam showing portion of dam to be removed for the Partial Facilities Removal Alternative. ..... 2-~~68~~73

Figures (continued)

Figure *Page*

2-21. Anticipated Schedule for Partial Facilities Removal 2-69 74

Figure 2-22. .....Example of cast-in-place pool and weir fish ladder. 2-72 78

Figure 2-23. .....Conceptual Layout of J.C. Boyle Fish Passage Facilities. 2-75 81

Figure 2-24. Copco 1 Fish Ladder Configuration and Floating Surface Bypass Collector 2-77, Fish Screen, a

Figure 2-25. Example of Floating Surface Bypass Collector in Upper Baker Dam, Washington 2-78

Figure Collection Device 2-83

2-26. 25 Copco 2 Fish Ladder and V-screen Fish Screen, along the left side of the river, for power water diversion 2-79 85

Figure 2-27. 26 .....Modifications at the tailrace of the Copco 2 Powerplant would extend the bank and install a tailrace barrier screen 2-80

Figure screen (red dots) 2-87

2-28. 27 Conceptual fish passage facilities layout for Iron Gate Dam showing fish ladder, water intake screen, and spillway transition modifications 2-81 88

Figure 2-29. 28 ..... Anticipated schedule for Fish Passage at J.C. Boyle and Copco 2 Dams with Removal of Copco 1 and Iron Gate Dams. 2-85 92

Figure 3.2-1. .....Water Quality Area of Analysis 3.2-3

Figure 3.2-2. ..... Summary of Anticipated Effects of Inorganic and Organic Contaminants in Klamath Reservoir and Estuary Sediments Under the No Action/No Project Alternative and the Proposed Action. This does not include an evaluation of the physical effects (e.g., dissolved oxygen, suspended sediment). (1): Qualitative evaluation conducted for this exposure scenario 3.2-74

Figure and the Proposed Action, for Five Exposure Pathways 3.2-80

3.2-3. Predicted Water Temperature at the California-Oregon State Line line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario) 3.2-78

Figure 3.2-4. Estimated Changes in Daily Maximum Klamath River Water Temperatures at ≈RM 198 due to the Presence of Copco 1 and 2 Reservoirs for the 2000 Calendar Year. Positive Values Represent an Increase above Modeled Natural Conditions. 3.2-79

Figure 3.2-5. Simulated Hourly Water Temperature Downstream of Iron Gate Dam (RM 190.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. 3.2-81

Figure 3.2-6. Simulated Hourly Water Temperature Immediately Upstream of the Scott River Confluence (RM 143.9) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. 3.2-81

~~Figure 3.2-7. Simulated Hourly Water Temperature Downstream of the Salmon River Confluence (≈RM 66) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams ..... 3.2-82~~
~~Figure 3.2-8. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Dry Hydrology 3.2-85~~
~~Figure 3.2-9. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Median Hydrology3.2-85~~
~~Figure 3.2-10. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Wet Hydrology 3.2-86~~
~~Figure 3.2-11. SSCs Modeled Downstream of Iron Gate Dam Under the Proposed Action Assuming Typical Dry Hydrology..... 3.2-90~~
~~Figure 3.2-12. SSCs Modeled Downstream of Iron Gate Dam Under the Proposed Action Assuming Median Hydrology..... 3.2-91~~
~~Figure 3.2-13. SSCs Modeled Downstream of Iron Gate Dam Under the Proposed Action Assuming Typical Wet Hydrology ..... 3.2-91~~
~~Figure 3.2-14. Annual predicted sediment delivery to the Pacific Ocean under the Proposed Action and the No Action (background conditions) by Water Year. Note: model results are only valid for the year of dam removal. No significant increase in sediment loads is predicted in years following dam removal..... 3.2-95~~
~~Figure 3.2-15. Comparison of TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.8) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate using Percent Retention Rates Predicted by the Empirical Relationship between Reach Inflow Concentration and Retention..... 3.2-102~~
~~Figure 3.2-16. Predicted Dissolved Oxygen Downstream of J.C. Boyle Dam (RM 224.7 to 228.3) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario)..... 3.2-105~~
~~Figure 3.2-17. Predicted Dissolved Oxygen at the Oregon-California State Line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario)~~ and the No Action/No Project Alternative ~~(T4BSRN Scenario)..... 3.2-105~~
(T4BSRN Scenario)..... 3.2-84
3.2-4 Estimated Changes in Daily Maximum Klamath River Water Temperatures at ≈RM 198 due to the Presence of Copco 1 and 2 Reservoirs for the 2000 Calendar Year. 3.2-85
3.2-5 Simulated Hourly Water Temperature Downstream from Iron Gate Dam (RM 190.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams..... 3.2-87
3.2-6 Simulated Hourly Water Temperature Immediately Upstream

of the Scott River Confluence (RM 143.9) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. 3.2-88

Figures (continued)

Figure *Page*

3.2-~~18.~~7 Simulated Hourly Water Temperature Downstream from the Salmon River Confluence (≈RM 66) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams 3.2-88
3.2-8 Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Dry Hydrology (WY2001)..... 3.2-91
3.2-9 Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Median Hydrology (WY1976)..... 3.2-92
3.2-10 Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Wet Hydrology (WY1984)..... 3.2-92
3.2-11 SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Action Assuming Typical Dry Hydrology (WY2001)..... 3.2-97
3.2-12 SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Action Assuming Median Hydrology (WY1976)..... 3.2-97
3.2-13 SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Action Assuming Typical Wet Hydrology (WY1984)..... 3.2-98
3.2-14 Annual predicted sediment delivery to the Pacific Ocean under the Proposed Action and the No Action (background conditions) by Water Year..... 3.2-101
3.2-15 Comparison of TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.8) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate using Percent Retention Rates Predicted by the Empirical Relationship between Reach Inflow Concentration and Retention (Green Cross). 3.2-109
3.2-16 Predicted Dissolved Oxygen Downstream ~~of Iron Gate~~from J.C. Boyle Dam (RM ~~190.1~~224.7 to 228.3) for the Klamath TMDL Scenarios Similar to the Proposed Action (~~TCD2RN~~TOD2RN Scenario) and the No Action/No Project Alternative ~~(T4BSRN Scenario)3.2-110~~ (T4BSRN Scenario)..... 3.2-113
3.2-17 Predicted Dissolved Oxygen at the Oregon-California State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario)..... 3.2-113

Figures (continued)

Figure *Page*

3.2-19. 18 Predicted Dissolved Oxygen Downstream of the from Iron Gate Dam (RM 190.1) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario) 3.2-119

3.2-19 Predicted Dissolved Oxygen Downstream from the Mainstem Confluence with the Shasta River (RM 176.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/ No Project Alternative (T4BSRN Scenario).....3.2-111119

Figure 3.2-20. Predicted Dissolved Oxygen at Seiad Valley (RM 129.4) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario) 3.2-111

Figure 3.2-21. Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 42.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario)..... 3.2-112

Figure 3.2-22. Predicted pH Downstream of J.C. Boyle Reservoir (RM 224.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/ No Project Alternative (T4BSRN Scenario) 3.2-114120

Figure 3.2-23. Predicted pH at the Oregon-California State Line (RM 208.5) for the3.2-21 .....Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 42.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario)3.2-114

Figure 3.2-24. Predicted Klamath River pH Immediately Downstream of Iron Gate Dam for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/ No Project Alternative (T4BSRN Scenario)..... 3.2-120

3.2-22 Predicted pH Downstream from J.C. Boyle Reservoir (RM 224.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).....3.2-116122

Figure 3.2-23..... Predicted pH at the Oregon-California State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario)..... 3.2-122

3.2-24 Predicted Klamath River pH Immediately Downstream from Iron Gate Dam for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario) 3.2-125

3.2-.25. Predicted Klamath River pH upstream of the Scott River

(RM 143.0) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).....3.2-~~116~~125
~~Figure~~ 3.2-26~~-~~..... Simulated Hourly Water Temperature Downstream ~~of~~from Iron Gate Dam (RM 190.1) Based on Year 2004 for Current Conditions Compared to Hypothetical Conditions: (a) without Iron Gate (IG), Copco 1 and 2, and J.C. Boyle (JCB) Dams and (b~~)~~) without Iron Gate (IG) and Copco 1 and 2 Dams .....3.2-~~139~~153

Figures (continued)

Figure 3.3-1. Five Study Reaches within the Area of Analysis for the Aquatic Resources Analysis 3.3-2 Page

Figure 3.3-2. Normal conditions (50 Percent Exceedance Probability) SSCs for Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model 3.3-29

Figure 3.3-3. Extreme conditions (10 Percent Exceedance Probability) SSCs for Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model 3.3-29

Figure 3.3-4. Mobilization Flow and Return Period at which Sediment Mobilization Occurs (Reclamation 2011) 3.3-33

Figure 3.3-5. Comparison of SSCs under Proposed Action and Existing Conditions at Iron Gate Dam, as Predicted Using SRH-1D Model3.3-76

Figure 3.3-6. Comparison of SSCs under Proposed Action and Existing Conditions at Orleans, as Predicted Using SRH-1D Model..... 3.3-77

Figure 3.3-7. Comparison of SSCs under Proposed Action and Existing Conditions at Klamath Station, as Predicted Using SRH-1D Model3.3-78

Figure 3.3-8. Cumulative Sediment Erosion from Dams in the Hydroelectric Reach During 2020 Drawdown Beginning in January 3.3-79

Figure 3.3-9. Reach-Averaged Erosion in the Hydroelectric Reach during Wet Year (Reclamation 2011)..... 3.3-80

Figure 3.3-10. Reach-Averaged D16 and D50 in Copco 1 Reservoir Reach Following Dam Removal (Reclamation 2011) 3.3-81

Figure 3.3-11. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years after Dam Removal 3.3-82

Figure 3.3-12. Reach Averaged Bed Elevation during Two Successive Wet, Median, or Dry Water Years from Iron Gate Dam to Bogus Creek (Reclamation 2011) 3.3-83

Figure 3.3-13. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Dam Removal3.3-84

Figure 3.3-14. Simulated D50 (mm) from Iron Gate Dam to Bogus Creek during Successive Wet, Median, and Dry Water Years 3.3-85

Figure 3.3-1 ..... Five Study Reaches within the Area of Analysis for the Aquatic Resources Analysis. 3.3-2

3.3-2 Normal conditions (50 Percent Exceedance Probability) SSCs for Three Locations Downstream from Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model. 3.3-32

3.3-3 Extreme conditions (10 Percent Exceedance Probability) SSCs for Three Locations Downstream from Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model. 3.3-33

3.3-4 Mobilization Flow and Return Period at which Sediment Mobilization Occurs..... 3.3-36

3.3-5 Mean daily flows (cubic feet per second) for the Klamath River at the USGS Gage at Keno for three different water

years, generally representing drier (1908), more normal (1911) and wetter (1907) conditions. 3.3-51
3.3-6 Timeline Depicting the Timing of Salmon Lifecycles in the Mainstem of the Klamath River Coinciding with Dam Removal Plans. 3.3-53
3.3-7 Mean daily flows (cubic feet per second) for the Klamath River at the USGS Gage near Fall Creek (Gage #11512500) for three different water years, generally representing drier (1937), normal (1936) and wetter (1943) conditions. 3.3-55
3.3-8 Comparison of mean daily flows recorded at Keno (USGS Gage #11509500) historically (1905-1912) with more recent conditions (1961-2000). 3.3-56
3.3-9 Comparison of SSCs under Proposed Action and Existing Conditions at Iron Gate Dam, as Predicted Using SRH-1D Model. 3.3-103
3.3-10 Comparison of SSCs under Proposed Action and Existing Conditions at Orleans, as Predicted Using SRH-1D Model. 3.3-104
3.3-11 Comparison of SSCs under Proposed Action and Existing Conditions at Klamath Station, as Predicted Using SRH-1D Model. 3.3-105
3.3-12 Sediment Erosion from Dams in the Hydroelectric Reach During 2020 Drawdown Beginning in January 3.3-107
3.3-13 Reach-Averaged Erosion in the Hydroelectric Reach during Wet Year. 3.3-108

Figures (continued)

Figure *Page*

3.3-14 Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years during and after Drawdown (Based on simulation results provided by Reclamation, March 2012). 3.3-108
3.3-15 Reach Averaged Bed Elevation Change for Two Successive Wet, Median, or Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012). 3.3-110
3.3-16 Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012)..... 3.3-111
3.3-17 Simulated D50 (mm) from Iron Gate Dam to Bogus Creek during Successive Wet, Median, and Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012)..... 3.3-112
3.3-18 Time series of average daily mean water temperature (lower panel) forecasted at Iron Gate Dam (RM 190) for the Index Sequential climate scenario spanning years 2020 to 2061, for Proposed Action and Existing Conditions 3.3-116
3.3-19 PacifiCorp (2005) Simulated hourly water temperatures below Iron Gate Dam based on a dry water year (WY 2002) for existing conditions compared to the Proposed Action (without Project dams), and USEPA (2003) water temperature criteria for salmonid growth and migration. 3.3-117
3.4-1 Biovolume (in red) and percent biovolume (in blue) of Microcystis aeruginosa above, within, and downstream from Copco 1 and Iron Gate Reservoirs during 2005..... 3.4-9
3.5-1~~.~~ PacifiCorp Terrestrial Resources Study Area..... 3.5-2
~~Figure~~ 3.5-2~~.~~ ..... PacifiCorp Terrestrial Resources Study Area. 3.5-~~7~~5
~~Figure~~ 3.5-3..... J.C. Boyle Reservoir Historic Vegetation Types. 3.5-11
3.5-4 Copco Reservoir Historic Vegetation Types. 3.5-13
3.5-5 Iron Gate Reservoir Historic Vegetation Types..... 3.5-15
3.5-6 J.C. Boyle Reservoir Revegetation 3.5-71
3.5-7 Copco Reservoir Revegetation. 3.5-72
3.5-8 Iron Gate Reservoir Revegetation..... 3.5-73
3.6-1~~.~~ Flood Hydrology Affected Area. 3.6-2
~~Figure~~ 3.6-2~~.~~ ..... Historical Upper Klamath Basin Hydrology Before Dams, National Wildlife Refuges, and Reclamation's ~~Klamath Project3.6-6~~
~~Figure~~ Klamath Project. 3.6-6
3.~~-~~6-3 USGS Stream Gage Locations..... 3.6-~~14~~15

Figures (continued)

Figure *Page*

3.6-4. Daily Average Flows at Five USGS Stream Gages on Klamath River. 3.6-1516
Figure 3.6-5. ..... Stream Flows Downstream from Iron Gate Dam in Wet, Average, and Dry YearsConditions. 3.6-1617
Figure 3.6-6. .....Stream Flows Downstream from J.C. Boyle Dam in Wet, Average, and Dry YearsConditions. 3.6-1718
Figure 3.6-7. .....Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Near Keno Dam. 3.6-2829
Figure 3.6-8. .....Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Below J.C. Boyle Dam. 3.6-2829
Figure 3.6-9. .....Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Below Iron Gate Dam3.6-29
Figure Gate Dam. 3.6-30
3.6-10. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Near Seiad Valley3.6-29
Figure Valley. 3.6-30
3.6-11. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action at Orleans. 3.6-3031
Figure 3.7-1. ..... Generalized Groundwater Potentiometric Surface Contour Map and Groundwater Flow Directions in the Upper Klamath Basin 3.7-3
Figure Klamath Basin. 3.7-3
3.7-2. Enlarged Portion of the Generalized Groundwater Potentiometric Surface Contour Map and Flow Directions for the Areas Around around J.C. Boyle, Copco, and Iron Gate Reservoirs. 3.7-4
Figure 3.7-3. ..... Locatable Wells within 2.5 Miles of J.C. Boyle Reservoir and Cross-Section Locations. 3.7-9
Figure 3.7-4. .....J.C. Boyle Reservoir Cross-Sections J and K. 3.7-11
Figure 3.7-5. ..... J.C. Boyle Reservoir Cross-Section L. 3.7-12
Figure 3.8-1. ..... Area of Analysis. 3.8-5
Figure 3.8-2. ..... Schematic of Reclamation's Klamath Project. 3.8-89
Figure 3.8-3. ..... Flows for different year types under the Proposed Action and No Action Alternatives just downstream from Iron Gate Dam 3.8-15
Figure Iron Gate Dam. 3.8-16
3.8-4. 90% ExceedenceExceedance Flows Near Seiad Valley, Orleans, and Klamath for Dam Removal and No Action Alternatives 3.8-1516
Figure 3.8-5. .....Annual flows under the No Action/No Project Alternative and Proposed Action 3.8-1921
Figure 3.9-1. ..... Area of Analysis for both the Klamath Hydroelectric Settlement Agreement (KHSA) and the Klamath Basin Restoration Agreement (KBRA). 3.9-2

Figures (continued)

Figure *Page*

3.9-2 Particulate Matter (PM_{10} and $PM_{2.5}$) NAAQS and California Ambient Air Quality Standards (CAAQS) Designations 3.9-5
3.9-3 Particulate Matter (PM_{10} and $PM_{2.5}$) and Carbon Monoxide (CO) NAAQS Designations in Oregon 3.9-6
3.9-4 Ozone (O_3) NAAQS and CAAQS Designations 3.9-7
3.9-5 Federal Class I Areas 3.9-10
3.10-1 California GHG Emission Sources (as of 2008) 3.10-11
3.10-2 Oregon GHG Emission Sources (as of 2007) 3.10-12
3.10-3 Greenhouse Gas Emissions Comparison 3.10-12
3.10-4 PacifiCorp Power Control Area Generation Resource Mix (as of 2007) 3.10-27
3.11-1 Klamath Basin Physiographic Provinces 3.11-3
3.11-2 Existing Potential Landslide Areas 3.11-14
3.14-1 Reclamation's Klamath Project and National Wildlife Refuges in the Vicinity 3.14-3
3.14-2 Land Ownership Around the Klamath River in the Vicinity of the Hydroelectric Reach 3.14-6
3.14-3 Land Use at Keno and J.C. Boyle Dams 3.14-12
3.14-4 Land Use – Iron Gate and Copco Dams 3.14-13
3.14-5 Upper Klamath Basin Agricultural Resources 3.14-16
3.15-1 Socioeconomic Area of Analysis 3.15
3.15-2 Klamath Management Zone Boundary and Ports 3.15-6
3.16-1 Tribal Lands near Haul Routes 3.16-30
3.17-1 Population and Housing Area of Analysis 3.17
3.17-2 Census Block Groups 3.17-7
3.18-1 Klamath Ba
3.18-2 Hospitals and Fire Stations near the Project Area 3.18-5
3.18-3 Fire Hazard in the Area of Analysis 3.18-7
3.18-4 PacifiCorp Service Area 3.18-17
3.19-1 Project Area Land Ownership for BLM and USFS 3.19-4
3.19-2 Key Observation Points from PacifiCorp (2004) Report 3.19
3.19-8 Historic River Channel for J.C. Boyle Reservoir 3.19-15

Figure 3.19-4. ..... Historic River Channel at Copco I Reservoir 3.19-15
3.19-16
Figure 3.19-5. .....Historic River Channel at Iron Gate Reservoir . 3.19
3.19-16
Figure 3.19-6 .....Iron Gate Dam before removal (top) and a simulation of what the facility could look like after full removal ..... (bottom) except for Landform/Vegetation restoration details which cannot be fully depicted until completion of the Definite Plan. 3.19-17

Figures (continued)

Figure *Page*

3.19-~~18~~
~~Figure 3.19-~~7~~.~~ Copco 1 Dam before removal (top) and a simulation of what ~~the~~ The facility could look like after full removal~~.....~~ (bottom) except for Landform/Vegetation restoration details which cannot be fully depicted until completion of the Definite Plan 3.19-18

3.19-~~19~~
~~Figure 3.19-~~8~~.~~ ..... View of Copco 2 Powerhouse and Historic Structure 3.19-19

3.19-~~20~~
~~Figure 3.19-~~9~~.~~ ..... View of J.C. Boyle Powerhouse. 3.19-28

3.19-~~29~~
~~Figure 3.19-~~10~~.~~ .....Example of cast in place pool and weir fish ladder used for fish passage, similar to that proposed for upstream fish passage for all four dams under this alternative..... 3.19-~~34~~33

~~Figure~~ 3.19-11~~.~~ ..... Example of fish ladder built into steep bedrock similar to Copco 1 option..... 3.19-~~34~~33

~~Figure~~ 3.20-1~~.~~ ..... Regional Recreation Areas. 3.20-3

3.20-2a Iron Gate Recreation Areas..... 3.20-14

~~Figure~~ 3.20-~~2a. ..... Iron Gate~~ 2bCopco Recreation Areas.

~~Figure 3.20-2b. Copco Recreation Areas ..... 3.20-15~~

~~Figure~~ 3.20-2c~~.~~ ..... J.C. Boyle Recreation Areas. 3.20-16

~~Figure~~ 3.20-3~~.~~ .....Klamath Wild and Scenic River Corridor. 3.20-~~27~~28

~~Figure~~ 3.20-4~~.~~ ..... Comparison of Available Recreation Flows - Keno Reach. 3.20-~~42~~43

~~Figure~~ 3.20-5~~.~~ .....Comparison of Available Recreation Flows - JC Boyle Bypass Reach. 3.20-43

3.20-6 Comparison of Available Recreation Flows - ~~JC Boyle Bypass Reach3.20-42~~

~~Figure 3.20-6. Comparison of Available Recreation Flows - Hells~~Hell's Corner ~~Reach3.20-43~~

~~Figure~~ Reach..... 3.20-44

3.20-7~~.~~ Comparison of Available Recreation Flows - Copco 2 Bypass ~~Reach3.20-43~~

~~Figure~~ Reach..... 3.20-44

3.20-8~~.~~ Comparison of Available Recreation Flows - Iron Gate to Scott River Reach 3.20-45

3.20-9 Comparison of Available Recreation Flows - ~~Iron Gate to~~ Scott River ~~Reach3.20-44~~

~~Figure 3.20-9.~~ ..... to Salmon River Reach 3.20-45

3.20-10 Comparison of Available Recreation Flows ~~- Scott River to~~ – Salmon ~~River Reach ..... 3.20-44~~

~~Figure 3.20-10.~~ ..... River to Trinity River Reach 3.20-46

3.20-11 Comparison of Available Recreation Flows - ~~Salmon River to Trinity River Reach..... 3.20-45~~

~~Figure 3.20-11. .....Comparison of Available Recreation Flows -~~ Trinity River to Ocean Reach ..... 3.20-~~45~~46

~~Figure~~ 3.21-1~~.~~ .....School Sites in the Project Area~~.....~~. 3.21

3.21-~~6~~

~~Figure 3.21-~~2~~.~~ ..... HTRW Sites, Keno Dam and ~~Reservoir3.~~Keno Impoundment/ Lake Ewauna..... 3.21-8
3.21-~~7~~
~~Figure~~ 3~~.21-3.~~ ..... HTRW Sites, Iron Gate and Copco Dams and Reservoirs 3.21-9
3.21-~~8~~
~~Figure 3.21-~~4~~.~~ ..... HTRW Sites, J.C. Boyle Dam and Reservoir~~-~~ 3~~-~~.21-~~9~~10
~~Figure~~ 3.22-1~~.~~ ..... Regional Access Routes Relative to the KHSA. 3.22-2
3.22-2
~~Figure 3.22-2.~~ ..... Copco Road (north of river, facing west) 3.22-5
~~Figure~~ 3.22-3~~.~~ ..... Access Bridge at J.C. Boyle Dam 3.22-6
~~Figure~~ 3.22-4~~.~~ ..... Bridge Accessing Lakeview Road (looking south) 3.22-6
~~Figure~~ 3.23-1~~.~~ ..... Primary Haul Routes ~~From~~ from Dam Sites 3.23-2

Figures (continued)

Figure *Page*

3.23-2
~~Figure 3.23-2.~~ J.C. Boyle Noise Receptors (Closest Receptors to J.C. Boyle ~~Dam) 3.23-4~~
~~Figure~~ Dam) ..... 3~~-~~.23-4
3.~~-~~23-3 Copco 1 ~~&~~ and 2 Noise Receptor (Closest Receptor to Copco 1
and Copco 2 Dams)..... 3.23-5
~~Figure~~ 3.23-4~~.~~ Iron Gate Noise Receptors (Closest Receptor to Iron Gate Dam) 3.23-6
~~Figure~~ 3.23-5~~. Parcel Lots within One-Mile of Iron Gate Dam ..... 3.23-24~~
~~Figure 3.23-6.~~ .....Parcel Lots within One-Mile of Copco 1 and 2 Dam~~s~~ 3.23-~~25~~24

3.23-6 Parcel Lots within One-Mile of Iron Gate Dam 3.23-25

Volume II – Final EIS/EIR Appendices

		Page
A	Klamath Settlement Final Alternatives Report	i
B	Standard Operating Procedures and Best Management Practices Common to the Action Alternatives	B-1
C	Water Quality Supporting Technical Information	C-1
D	Water Quality Environmental Effects Determination Methodology Supplemental Information	D-1
E	An Analysis of Potential Suspended Sediment Effects on Anadromous Fish in the Klamath Basin	E-1
F	An Analysis of Potential Bedload Sediment Effects on Anadromous Fish in the Klamath Basin	F-1
G	Vegetation Communities and Habitat Types Mapped by PacifiCorp	G-1
H	Special-Status Species Surveys Conducted by PacifiCorp	H-1
I	Special-Status Species Table	I-1
J	Modeled Changes to the 100-year Floodplain-Year Flood Plain	J-1
K	Groundwater Well Data	K-1
L	Water Rights	L-1
M	**Air Quality Impacts**	M-1
N	Greenhouse Gas Emission Impacts	N-1
O	County Economic Descriptions	O-1
P	KBRA Regional Economic Effects IMPLAN Analysis	P-1
Q	Aesthetics/Visual Resources Technical Report	Q-1
R	Recreation Data Input	R-1
S	Transportation and Circulation Analysis Data	S-1
T	2020 Traffic Volume Projections	T-1
U	Noise and Vibration Impact Analysis	U-1

Volume III – Responses to Comments on Draft EIS/EIR

Page

Chapter 10 Final EIS/EIR 10-1
10.1 Contents of the Final EIS/EIR 10-2
10.2 Public Involvement for the Klamath Facilities Removal EIS/EIR 10-3
10.2.1 Scoping 10-3
10.2.2 Release of the Draft EIS/EIR 10-4
10.2.3 Release of the Final EIS/EIR 10-5
10.3 Executive Summary 10-5
10.4 Preferred Alternative 10-6
10.5 Consultation and Coordination 10-6
10.6 Document Availability and Distribution 10-6
10.6.1 Document Availability 10-7
10.6.2 Distribution List 10-9
10.7 Next Steps 10-11
10.7.1 NEPA and CEQA Next Steps 10-11
10.7.2 KHSA 10-11
10.7.3 KBRA 10-11

Chapter 11 Comments and Responses 11-1
11.1 Summary of Comments Received and Responses to General Comments 11-1
11.2 Master Responses 11-44

Appendix AA: Duplicate Comments on the Draft EIS/EIR

Appendix AB: Changes to the September 2011 Public Draft EIS/EIR Reflected in the December 2012 Final EIS/EIR

Tables for Volume III

Table *Page*
10-1 Libraries with Final EIS/EIR Available 10-7
10-2 Federal and State Agencies with Final EIS/EIR Available 10-8
10-3 Final EIS/EIR Distribution List 10-9
11-1 Comments on Draft EIS/EIR 11-2
11-2 Master Responses 11-44

Abbreviations and Acronyms

AADT	Annual Average Daily Traffic
AB	Assembly Bill
ACHP	Advisory Council on Historic Preservation
ACS	American Community Survey
AET	Apparent Effects Threshold
AF	Acre ~~Feet~~feet
AFA	Aphanizomenon flos-aquae
AGR	Agricultural Supply
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act
Alternative 1	No Action/No Project
Alternative 2	Full Facilities Removal of Four Dams Alternative (Proposed Action)
Alternative 3	Partial Facilities Removal of Four Dams Alternative
Alternative 4	Fish Passage at Four Dams Alternative
Alternative 5	Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative
APE	Area of Potential Effects
AQUA	Aquaculture, Mariculture
AQMA	Air Quality Maintenance Area
ARPA	Archaeological Resource Protection
ASDSO	Association of State Dam Safety Officials
ASR	Aquatic Scientific Resources
AUM	Annual Unit Month
AWS	Auxiliary Water Supply
B	Beneficial
BA	Biological Assessment
BB	Black Bullhead
BCoCs	bioaccumulative chemicals of concern
BEP	Business Emergency Plan
BGEPA	Bald and Golden Eagle Protection Act
BIA	Bureau of Indian Affairs
BIOL	Preservation and Enhancement of Designated Areas of Special Biological Significance
BLM	Bureau of Land Management

BLS	Bureau of Labor Statistics
BMIs	Benthic Macroinvertebrates
BMP	Best Management Practice
BO	Biological Opinion
BOD	Biological Oxygen Demand
BOE	Board of Equalization
BP	Before Present
BSLVs	Bioaccumulation screening level values
BTs	Bioaccumulation Triggers
CAA	Federal Clean Air Act
CAAQS	California Ambient Air Quality Standards
Caltrans	California Department of Transportation
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CAS	California Climate Adaption Strategy
CASGEM	California Statewide Groundwater Elevation Monitoring
CBOD	Carbonaceous biochemical oxygen demand
CCA	California Coastal Act
CCR	California Code of Regulations
CEC	California Energy Commission
CDC	California Department of Conservation
CDC	Centers for Disease Control
CDFG	California Department of Fish and Game
CDM	Camp Dresser & McKee
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CH_4	methane
CHHSLs	California Human Health Screening Levels
CNDDB	California Natural Diversity Database
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
COLD	Cold Freshwater Habitat
COMM	Commercial and Sport Fishing

COPCs	Chemicals of Potential Concern
COPCO	California Oregon Power Company
CPUC	California Public Utilities Commission
CRFD	Colestin Rural Fire Protection District
CRHR	California Register of Historical Resources
CRS	Congressional Research Service
CSSC	California Department of Fish and Game Species of Special Concern
CTR	California Toxics Rule
CUL	Native American Culture, Ceremonial and Cultural Water Use
CUPAs	Certified Unified Program Agencies
CWA	Clean Water Act
CWC	California Water Code
CWT	Coded Wire Tags
CZMA	Coastal Zone Management Act
dB	decibels
dBA	A-weighted decibels
DC	direct current
DPW	Department of Public Works
DDE	1,1-bis-(4-chlorophenyl)-2,2-dichloroethene
DDT	dichlorodiphenyltrichloroethane
DEA	David Evans and Associations
DEET	N,N-Diethyl-meta-Toluamide (insect repellant)
DEQ	Department of Environmental Quality
Detailed Plan	Detailed Plan for Facilities Removal
Determination	Preliminary Section 7(a) Determination
DHS	California Department of Health Services
DMA	Designated Management Agency
DMMP	Dredged Material Management Program
DO	dissolved oxygen
DOA	Department of Agriculture
DOC	US Department of Commerce
DOF	Department of Finance
DOI	United States Department of the Interior
DPS	Distinct Population Segment
DPW	Department of Public Works
DQA	Division of Quality Assurance

DRE	Dam Removal Entity
DSL	Oregon Department of State Lands
DTSC	California Department of Toxic Substance Control
DW	dry weight
DWR	California Department of Water Resources
EBF	Ecological Base Flow
ECST	Environmental Compliance Sub-Team of the Technical Management Team
EDD	Employment Development Department
EDR	Environmental Data Resources
EDRRA	Evaluation of Dam Removal and Restoration of Anadromy
EFDC	Environmental Fluid Dynamics Code
EFH	Essential Fish Habitat
EGC	Engineering, Geomorphology, and Construction Sub-Team
eGRID	Emissions & Generation Resource Integrated Database
EIS	Environmental Impact Statement
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
ENSO	El Niño Southern Oscillation
EO	Executive Order
EPA	Environmental Protection Agency
~~EO~~EPRI	Electric Power Research Institute
ES	Executive ~~Order~~Summary
ESA	Environmental Site Assessment
ESA	Federal Endangered Species Act
EST	Estuarine Habitat
ESU	Evolutionary Significant Unit
FACA	Federal Advisory Committee Act
FEIS	Federal Energy Regulatory Commission Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FGC	Fish and Game Code
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FLIR	Forward Looking Infrared Radiometry

FDOT	Florida Department of Transportation
FNU	Formazin nephelometric units
FOF	Findings of Facts
FPA	Federal Power Act
FRP	Fisheries Restoration Plan
FRSH	Freshwater Replenishment
FSBC	Floating Surface Bypass Collector
ft/day	foot per day
ft/s	feet per second
FTA	Federal Transit Administration
FTEs	Full Time Equivalents
FTR	Final Technical Report
FWCA	Fish and Wildlife Coordination Act
GCM	Global Circulation Model
GEC	Gatherd Engineering Consultants
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GWP	global warming potential
GWR	Groundwater Recharge
HABS/HAER	Historic Architectural Building Survey/Historic Architectural Engineering Report
HALS	Historic American Landscape Survey
HASP	Health and Safety Plan
HAZNET	California Facility and Manifest Database
HCM	Highway Capacity Manual
HCN or CN^-	Toxic free cyanide
HGMP	Hatchery and Genetics Management Plan
HMBP	Hazardous Materials Business Plan
HMMP	Hazardous Materials Management Plan
HPMP	Historic Properties Management Plan
HSC	Health and Safety Code
HTRW	Hazardous, toxic, and radiological waste
HVTEPA	Hoopa Valley Tribe Environmental Protection Agency
ICNU	Industrial Customers of Northwest Utilities
ICP	Interim Conservation Plan
IGD	Iron Gate Dam
IGH	Iron Gate Hatchery

IHA	Indicators of Hydrologic Alteration
IM	Interim Measure
IMPLAN	IMpact analysis for PLANning
IND	Industrial Service Supply
IOD	Immediate Oxygen Demand
IPCC	Intergovernmental Panel on Climate Change
KBAC	Klamath Basin Advisory Council
KBCC	Klamath Basin Coordinating Council
KBRA	Klamath Basin Restoration Agreement
KDD	Klamath Drain District
Keno Transfer	Proposed transfer of the Keno Facilities from PacifiCorp to Reclamation
KFHAT	Klamath Fish Health Assessment Team
KFMC	Klamath Fishery Management Control
KHHD	Klamath Hydroelectric Historic District
KHP	Klamath Hydroelectric Project
KHSA	Klamath Hydroelectric Settlement Agreement
KMZ	Klamath Management Zone
KOPs	Key Observation Points
KRBFTF	Klamath River Basin Fisheries Task Force
KRFC	Klamath River Fall Chinook
KRSIC	Klamath River Stock Identification Committee
KRSMG	Klamath River Salmon Management Group
KRWQM	Klamath River Water Quality Model
KWAPA	Klamath Water and Power Agency
lbs	pounds
lb/ft^3	pounds per cubic foot
Leq	Equivalent average noise level
LKNWR	Lower Klamath National Wildlife Refuge
Lmax	noise levels of equipment operating at full power measured from 50ft away
LMB	Largemouth Bass
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
LOS	level of service
LPAHEL	Low Probability of Adverse Health Effects
LRD	Lost River Diversion
LRMP	Land and Resource Management Plan

LRP	Long Range Plan
LTS	Less than Significant
LUST	leaking underground storage tank
LWD	large woody debris
Lv	vibration velocity level
m/sec	meters per second
MAA	Management Agency Agreement
MAR	Marine Habitat
MBTA	Migratory Bird Treaty Act
MCL	Maximum Contaminant Level
MCPA	2-methyl-4-chlorophenoxyacetic acid
MDL	Method Detection Limit
mgd	million gallons per day
MIGR	Migration of Aquatic Organisms, Fish Migration
MLs	Maximum Levels
MLPA	Marine Life Protection Act
mm	millimeters
$MMTCO_2e$	million metric tons carbon dioxide equivalent
mph	miles per hour
MPRSA	Marine Protection, Research, and Sanctuaries Act, or Ocean Dumping Act
mtons/year	metric tons per year
MSAE	*Microcystis aeruginosa*
MTs	Maximum Levels
$MTCO_2e$	metric tons carbon dioxide equivalent
MUTCD	Manual of Uniform Traffic Control Devices
MW	Megawatts
MWh	Megawatt hours
MWMT	Maximum Weekly Maximum Temperature
MUN	Municipal and Domestic Supply
MY	Model Year
N	Nitrogen
N/A	Not Applicable
N:P	nitrogen to phosphorus
N_20	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act

NAHC	Native American Heritage Commission
NAS	National Academy of Science
NAV	Navigation
NBOD	Nitrogenous Oxygen Demand
NCFEC	No Change From Existing Conditions
NCRWQCB	North Coast Regional Water Quality Control Board
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
N-fixation	Nitrogen fixation
NH_3	ammonia
NH_4^+	ammonia
NHMRC	Australian Government National Health and Medical Research Council
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NNE	Nutrient Numeric Endpoints
NO_2	Nitrogen dioxide
NO_3^-	nitrate
NOAA Fisheries Service	National Oceanic and Atmospheric Administration Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOP	Notice of Preparation
NOx	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NSO	Northern Spotted Owl
NSR	North State Resources
NTU	nephelometric turbidity unit
NVCP	Noise control and Vibration Plan
NWR	National Wildlife Refuge
NWSRS	National Wild and Scenic Rivers System
NWS	National Weather Service
O_3	Ozone
OARs	Oregon Administrative Rules
OCAR	Oregon Climate Assessment Report

OCCRI	Oregon Climate Change Research Institute
OCRM	Office of Ocean and Coastal Resource Management
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
ODOT	Oregon Department of Transportation
OEHHA	Office of Environmental Health and Hazard Assessment
OHV	Off Highway Vehicle
O&M	Operation and Maintenance
OMB	Office of Management Budget
ON	organic nitrogen
ONHP	Oregon Natural Heritage Database
OPWAS	Off-Project Water Settlement
ORBIC	Oregon Biodiversity Information Center
ORS	Oregon Revised Statute
OSU	Oregon State University
OSTP	Office of Science and Technology Policy
OWRD	Oregon Water Resources Department
~~OSU~~	~~Oregon State University~~
P	Phosphorus
PAHs	poly-aromatic hydrocarbons
Pb	lead
PBDEs	polybrominated diphenyl ethers
PCA	Power Control Area
PCBs	polychlorinated biphenyls
PCEs	Primary Constituent Elements
PCPI	Per Capita Personal Income
PDO	Pacific Decadal Oscillation
PDPO	Pollutant Discharge Prohibition Ordinance
PELs	probable effect levels
~~PG&E~~	~~Pacific Gas and Electric Company~~
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
PM_{10}	Particulate Matter <10 microns
$PM_{2.5}$	Particulate Matter <2.5 microns

Porter-Cologne	California Porter-Cologne Water Quality Act
POW	Hydropower Generation
PP	particulate phosphorus
ppt	parts per thousand
PPV	peak particle velocity
PRBO	Point Reyes Bird Observatory
PRC	Public Resources Code
PRGs	Preliminary Remediation Goals
PRMS	Precipitation Runoff Modeling System
PROC	Industrial Process Supply
Proposed Action	Full Facilities Removal of Four Dams Alternatives
PSD	Prevention of significant deterioration
PSDDA	Puget Sound Dredge Disposal Analysis
PSPLC	Pokegama Sugar Pine Lumber Company
PUCs	Public Utility Commission
PWA	Phillip William and Associates
RARE	Rare, Threatened, or Endangered Species
Reclamation	Bureau of Reclamation
RCA	Riparian Conservation Area
REC-1	Water Contact Recreation, Water Contact Recreation including Aesthetic Enjoyment
REC-2	Non-contact Water Recreation, Non-contact Water Recreation including Aesthetic Enjoyment
RED	Regional Economic Development
RES	Renewable Electricity Standard
RHJV	Riparian Habitat Joint Venture
RM	River Mile
RMA	Resource Management Associates
RMP	Resource Management Plan
ROD	Record of Decision
ROW	Right of Way
RPS	Renewable Portfolio Standard
RSET	Regional Sediment Evaluation Team
RSLs	Regional Screening Levels
RV	Recreational Vehicle
RWS	River Water Surface
S	Significant
SAL	Inland Saline Water Habitat

SAR	Sediment Accumulation Rates
SCAPCD	Siskiyou County Air Pollution Control District
SCAQMD	South Coast Air Quality Management District
SCF	Sectional Center Facility
SDOR	Secretarial Determination Overview Report
SDWA	Safe Drinking Water Act
SDU	Small Domestic Use Appropriation
Secretary	Secretary of the Interior
SEF	Sediment Evaluation Framework
SF_6	Sulfur hexaflouride
SHELL	Shellfish Harvesting
SHPO	State Historical Preservation Officer
SIP	State Implementation Plan
SLs	Screening Levels
SLVs	Screening Level Values
SMS	Scenery Management System
SO_2	Sulfur dioxide
SOD	Sediment Oxygen Demand
SONCC	Southern Oregon Northern California Coast
SOx	sulfur oxides
SPWN	Spawning, Reproduction, and/or Early Development, Fish Spawning
SQuiRTs	Screening Quick Reference Tables
SRH-1D	one dimensional sedimentation and river hydraulics model
SRP	soluble reactive phosphorus
SRRC	Salmon River Restoration Council
SSC	suspended sediment concentration
~~SSDI~~	~~suspended sediment concentration~~
SSDI	Suspended Sediment Dose Index
SSO	site-specific objective
SVOCs	semi-volatile organic compounds
SWAMP	California Surface Water Ambient Monitoring Program
SWE	Snow Water Equivalent
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	California State Water Resources Control Board
TAT	Technical Advisory Team

TCC	Technical Coordination Committee
TCP	Traditional Cultural Properties
TDI	Total Daily Intake
T&E	Preservation of Threatened and Endangered Species
TIPU	Transportation, Information, and Public Utilities
Term	Stands For
TEQ	toxicity equivalent quotient
THP	Timber Harvest Plan
THPOs	Tribal Historical Preservation Officers
TID	Tulelake Irrigation District
TIN	Total Inorganic Nitrogen
TIPs	Tribal Implementation Plans
TKN	total Kjeldahl nitrogen, ; a measure of organic nitrogen plus ammonia, nitrate (NO_3) and ammonia (NH_4^+)
TLNWR	Tule Lake National Wildlife Refuge
TMDL	Total Maximum Daily Load
TMT	technical management team
TN	total nitrogen
TNM2.5	Traffic Noise Model version 2.5
TP	Total Phosphorous
tpy	tons per year
TRRP	Trinity River Restoration Program
TRVs	Toxicity Reference Values
TSS	Total Suspended Solids
UFWS	U.S. Fish and Wildlife Service
µg/L	micrograms per liter
UGB	Urban Growth Boundary
UKL	Upper Klamath Lake
UKTR	Upper Klamath Trinity River
UKWUA	Upper Klamath Lake Water Users Association
URBEMIS	Urban Emissions Model
USACE	United States Army Corp of Engineers
USC	United States Code
USBR	United States Bureau of Reclamation
USDA	United Stated Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service

USFWS	United States Fish and Wildlife Service
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey
UST	underground storage tank
v/c	volume to capacity ratio
VdB	vibration decibels
VOCs	volatile organic compounds
VRI	Visual Resources Inventory
VRM	Visual Resource Management Methodology
WARM	Warm Freshwater Habitat
WECC	Western Electricity Coordinating Council
WHO	World Health Organization
WILD	Wildlife Habitat, Wildlife Habitat and Endangered Species
WQ	Water Quality
WQCP	Water Quality Control Plan
WQMP	Water Quality Management Plan
WRIMS	Water Resource Integrated Modeling System
WSR	Wild and Scenic Rivers
WSRA	Wild and Scenic Rivers Act
WUA	Weighted Usable Area
WURP	Water Use Retirement Program
WY	Water year
W&S	Wild and Scenic
yd^3	cubic yards
YTEP	Yurok Tribe Environmental Program

~~1 No Action/No~~

Glossary

abeyance	A state of temporary suspension.
abutment	Structural element that ties a dam into the existing ground.
acclimation (of fish)	The process of a fish adjusting to change in its environment, allowing it to survive changes in temperature, water and food availability, and other stresses.
acre-foot	The amount of water required to cover 1 acre to a depth of 1 foot. One acre-foot equals 326,851 gallons or 43,560 cubic feet. This volume measurement is used to describe a quantity of storage in a reservoir.
adfluvial	Fish who live in lakes and migrate into rivers or stream to spawn.
adjudication	The final judgment in a legal proceeding; the act of pronouncing judgment based on the evidence presented.
Affirmative Determination	A determination by the Secretary of the Interior under Section 3 of the Klamath Hydroelectric Settlement Agreement that facilities removal should proceed.
alluvial	Deposition of sediment over a long period of time by a river; an alluvial layer; pertaining to the soil deposited by a stream.
ammocoete	Juvenile lamprey.
anadromous	A type of fish that hatch in freshwater, migrate to the ocean, mature there, and return to freshwater to spawn. Salmon and steelhead are examples.
anoxic conditions	Conditions with a deficiency of oxygen.
anthropogenic	Made by people or resulting from human activities.

antidegradation policy	A policy designed to prevent deterioration of existing levels of good water quality.
appropriations	Funds set aside (as by a legislature) for a specific purpose.
attraction flows	Drawing fish to dam fishways or spillways through the use of water flows.
bedload sediment	Particles carried along the bottom of a river or stream, rather than in the current.
beneficial use	The uses of a water resource that are protected by state water quality standards. Beneficial uses include human consumption, aquatic life, recreation, and fish and wildlife habitat.
benthic	The ecological region at the lowest level of a body of water, including the sediment surface and some sub-surface layers. Organisms living in this zone are called benthos or benthic organisms.
berm	A mound or linear embankment of fill material, typically earth fill.
best management practices (BMPs)	Physical, structural or managerial practices that control soil loss and reduce water quality pollution caused by nutrients, animal wastes, toxics, and sediment.
bioaccumulation	The process by which substances accumulate in the tissues of living organisms.
biochemical oxygen demand (BOD)	The amount of oxygen needed by aerobic micro-organisms to decompose all the organic matter in a sample of water; it is used as a measure of pollution.
biological opinion	The product of Endangered Species Act consultation, a document stating the opinion of the United State Fish and Wildlife Service or National Marine Fisheries Service on whether or not a federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

blue-green algae	Algae that can cause problems in aquatic environments because some produce chemicals that are toxic to animals, including humans.
bulk bag	A container made from abrasion resistant fabric designed to contain loose material such as seeds, or in this case sand and gravel, and used for work area isolation.
camas	A type of lily used as a food source by Native Americans.
cession (of property)	The assignment of property to another entity.
chlorophyll-a	A photosynthetic pigment that serves as a surrogate measure for abundance of algae.
cofferdam	A temporary enclosure designed to be watertight or minimize water infiltration to isolate work areas for construction.
cohort	A group of fish spawned during a given period, usually within a year.
confluence	The meeting of two or more bodies of water, such as the point where a tributary joins the mainstem.
connected action	The National Environmental Policy Act defines a connected action as an action that (i) automatically triggers other actions that may require environmental impact statements (ii) cannot or will not proceed unless other actions are taken previously or simultaneously (iii) is an interdependent part of a larger action and depends on the larger action for its justification. Connected actions are closely related and therefore should be discussed in the same impact statement (40 CFR Part 1508.25 (a)1).
consolidation (of sediments)	The process by which sediments are compacted together.
contour line	A line connecting points of equal elevation.

Cooperating Agencies	Under the National Environmental Protection Act (NEPA), the agencies having responsibility to assist the Lead Agency by participating in the NEPA process. The role of the cooperating agencies may include conducting environmental analyses of resources which the cooperating agency has jurisdiction by law or special expertise.
critical habitat	Areas that are essential to the conservation of a species listed under the federal Endangered Species Act.
cyanobacteria	Photosynthetic bacteria, also known as blue-green algae. Cyanobacteria form extensive and highly visible blooms in the freshwater and marine environment.
Dam Removal Entity	The party with primary responsibility for carrying out the dam removal and other components of the Klamath Hydroelectric Settlement Agreement.
decommissioning	Taking out of use, such as dismantling a dam or destroying an unneeded road.
desiccation	Drying out.
diel	Pertaining to a 24-hour period; daily.
direct effects	Related to socioeconomics, they are one or a series of production changes or expenditures made by producers/consumers as a result of an activity or policy. These initial changes are determined by an analyst to be a result of this activity or policy. Applying these initial changes to the multipliers in an IMPLAN model will then display how the region will respond, economically to these initial changes.
dissolved oxygen	The amount of oxygen in the water available to aquatic organisms measured in mg/L or percent saturation.
diversion	The act of diverting water from the main river course down a water separate conveyance system.
drawdown	Lowering of the water level in a reservoir.

drop structure	A structure, often part of a dam's spillway, to pass water to a lower elevation while controlling the energy and velocity of the water as it passes over.
elutriate	Separation of fine particles into size fractions according to their rate of fall through an upward current of water.
embankment	Earth or stone fill designed to hold back water.
emergent vegetation	Aquatic plants rooted underwater that grow above (emerge from) the surface of the water (e.g., cattails).
employment (jobs)	Employment in IMPLAN is measured in number of jobs. A job is the annual average of monthly jobs in that industry (this is the same definition used by Quarterly Census of Employment Wages, Bureau of Labor Statistics, and Bureau of Economic Analysis nationally). Thus, 1 job lasting 12 months = 2 jobs lasting 6 months each = 3 jobs lasting 4 months each. A job can be either full-time or part-time.
endemic	Native to or confined to a certain region.
entrainment (of fish)	The loss of fish during water diversion due to their movement with the flow of water. Entrainment can result in mortality from direct contact with structures, from steep drops, or from stranding in areas where water does not persist, such as irrigation systems.
environmental water	The quantity and quality of instream water available to support fisheries and other aquatic resources.
epilimnion	The top-most layer in a lake stratified by temperature. It is warmer and typically has a higher pH and dissolved oxygen concentration than the lower layers (the hypolimnion).
erosion	The wearing away of the land surface by wind or water. Erosion occurs naturally from weather or runoff but is often intensified by land-clearing practices.

ESA consultation	In compliance with the Endangered Species Act, the process by which a federal agency presents information to the United States Fisheries and Wildlife Service or National Oceanic and Atmospheric Administration Fisheries Service regarding actions that may affect listed species or their designated habitat.
escapement (of fish)	That portion of an anadromous fish population that escapes the commercial and recreational fisheries and reaches the freshwater spawning grounds.
escapement floor	The lower bound of an escapement goal, which sets the number of salmonids that are not harvested and return to the river for spawning.
estuary	A partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea.
eutrophic	Waters rich in dissolved nutrients (especially nitrogen and phosphorus); leads to accelerated growth of algae and plants that depletes oxygen levels.
extirpation	Local extinction of a species over a portion of its total range.
ex-vessel value	Gross value of all fish caught within the area of analysis.
final demand	The value of goods & services produced and sold to final users (institutions) during the calendar year. This value is also equivalent to the Direct Effect of the impact.
fine sediment	Sediment with small particle size such as silts and clays.
fish ladder (fishway, fish passageway)	A structure on or around artificial barriers such as dams and locks to allow fish to move around the barrier during migration.
flume	Open-channel water conveyance system.
focal species	Species of ecological and/or human value that is of priority interest for study or management.

forebay	Water conveyance area between reservoir and power generation facilities.
fry	A juvenile salmon or steelhead.
genotype	The genetic identity of an individual.
geomorphic	Relating to surface features of a landscape.
gravel augmentation	The direct placement of spawning-size gravel into the stream channel to increase spawning habitat by increasing the amount of area with suitable substrate.
gravity arch dam	A dam that curves upstream in a narrowing curve that directs most of the water against the canyon rock walls, providing the force to compress the dam.
greenhouse gases	Gases including carbon dioxide, methane, and nitrous oxide, that prevent heat from escaping from the atmosphere, resulting in climate change (also known as global warming).
groundwater recharge	The natural or intentional infiltration of surface water for the replenishment of existing natural underground water supplies.
hatchery	A place where large numbers of fish eggs are artificially fertilized and fry are hatched in an enclosed environment.
headcut	An erosional feature in waterways where an abrupt vertical drop in the stream bed occurs.
herbaceous	Referring to a plant that has leaves and stems that die down at the end of the growing season to the soil level. They have no persistent woody stem above ground.
hibernacula	A place where a hibernating animal shelters for the winter.
humic	Having a high organic carbon content.

Hydroelectric Reach	The portion of the Klamath River that includes the four most downstream dams (J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams).
hydrophilic	Plants especially suited to thrive in soils that are always wet.
hydroseeding	A planting process which utilizes a slurry of seed and mulch. The slurry is transported in a tank, either truck- or trailer-mounted and sprayed over prepared ground in a uniform layer.
hypereutrophic	Very nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency.
hypolimnetic anoxia	The absence of oxygen in the lower layers of a lake or reservoir.
hyporheic	Beneath the bed of a stream, where there is mixing of shallow groundwater and surface water.
hypoxia	Oxygen deficiency.
IMPLAN®	IMpact Analysis for PLANning, a regional input-output model that evaluates regional economic effects.
incidental take	The "take" (adverse effect) of a listed species that results from, but is not the purpose of, an activity. Incidental take cannot result in jeopardy to the species and must be specifically authorized in the biological opinion.
indirect effects	Related to socioeconomics, they represent the impact of local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain until all money leaks from the local economy, either through imports or by payments to value added (employee).
induced effects	Related to socioeconomics, they represent the response by an economy to an initial change that occurs through re-spending of income received by a component of value added (employee). The labor income is recirculated through the household spending patterns causing further local economic activity.

in situ	In the original or natural place.
intake structure	Facility designed to divert water from the river or reservoir.
ipos	Roots of the plant Carum oregonum, important to some Native Americans tribes.
isobath	A type of contour line connecting points of equal water depth in a body of water.
J.C. Boyle Bypass Reach	The reach of the Klamath River between J.C. Boyle Dam and J.C. Boyle Powerhouse. A bypass reach is that section of a river from which water is removed to generate hydropower. Water is often diverted from the river at the dam, transported through channels or penstocks downstream, and released back in the river at the powerhouse.
J.C. Boyle Peaking Reach	The reach of the Klamath River between the J.C. Boyle Powerhouse and the mouth of Shovel Creek. A peaking reach is that section of a river that receives the water from the generation of hydroelectric power at the powerhouse.
Keno Impoundment	The water body created by Keno Dam.
Keno Transfer	The transfer ownership and operational responsibility of the Keno facility from PacifiCorp to the United States Department of the Interior as part of Klamath Hydroelectric Settlement Agreement implementation.
Klamath Allottee	A tribal member who owns a beneficial interest in a tract of land within the original (1864) boundaries of the Klamath Indian Reservation.
Klamath Basin	The portion of land drained by the Klamath River and its tributaries. The Klamath River Basin is divided into the Upper Klamath Basin and the Lower Klamath Basin.

Klamath Hydroelectric Project	A system of hydroelectric components that includes the dams, powerhouses, and other facilities for generation of hydroelectric power on the Klamath River and developed jointly by the Bureau of Reclamation (Reclamation) and the California-Oregon Power Company (COPCO, the predecessor to PacifiCorp).
2 Klamath River Basin Compact	Agreement between the State of California and the State of Oregon and consented by U.S. Congress in 1957 that established the Klamath River Compact Commission to promote comprehensive development, conservation, and control of the resources of the Klamath River and to foster interstate comity between California and Oregon.
Klamath Tribes	The Tribes of the Klamath Basin include the Karuk Tribe, Yurok Tribe, Klamath Tribes (made up of the Klamaths, the Modocs, and the Yahooskin), Resighini Rancheria, Hoopa Valley Tribe, and Quartz Valley Community.
Lake Ewauna	Also known as Keno Impoundment.
labile	Active, possessing rapid turnover rates.
labor income	All forms of employment income, including Employee Compensation (wages and benefits) and Proprietor Income.
lacustrine	Of or pertaining to lakes.
Lead Agencies	The agencies with the primarily responsibility under NEPA and equivalent state environmental policy acts (e.g., California Environmental Quality Act [CEQA]) for carrying out an evaluation of the environmental effects of their decision-making and for preparation of the appropriate environmental document. For the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report, the U.S. Department of the Interior is Lead Agency under NEPA and the California

	Department of Fish and Game is Lead Agency under CEQA.
lease lands	Land located near Tule Lake National Wildlife Refuge or the Lower Klamath National Wildlife Refuge, leased by Reclamation.
lentic	Of, relating to, or living in still waters (lakes, ponds, or swamps).
levee	A natural or artificial slope or wall to regulate water levels. It is usually earthen and often parallel to the course of a river or the coast.
liquid limit	The water content at which the behavior of the soil changes from a plastic to a semi-liquid state.
littoral	The zone between high tide and low tide waterlines of a lake or ocean.
lotic	Of, relating to or living in actively moving waters (streams and rivers).
Lower Klamath Basin	The portion of the Klamath River Basin downstream of Iron Gate Dam.
macroinvertebrate	Aquatic insects, worms, clams, snails, and other animals without backbones that can be seen without the aid of a microscope.
macrophyte	An aquatic plant that grows in or near water and is either emergent, submergent, or floating.
mainstem	The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.
microcystin	A toxin produced by the blue-green algal species Microcystis aeruginosa.
mitigation	The act of alleviating or lessening an adverse condition.
morphological	Related to the form of. Morphology is the study of the forms of things.

Negative Determination	A determination by the Secretary of the Interior under Section 3 of the Klamath Hydroelectric Settlement Agreement that facilities removal should not proceed.
nonpoint source pollution	A term in the Clean Water Act also called "polluted runoff," water pollution produced by diffuse land-use activities. Occurs when runoff carries fertilizer, animal wastes, and other pollution into rivers, streams, lakes, reservoirs, and other bodies of water.
noxious weed	A plant species that has been designated by state or national agricultural authorities as a plant that is injurious to native plants, agricultural and/or horticultural crops, and/or humans and livestock.
nutrient loading	Discharging of nutrients from the watershed (basin) into a receiving water body (lake, stream, wetland).
off-Project	Not associated with (not receiving water from, in the case of irrigators) Reclamation's Klamath Project.
ogee-type drop structure	A drop structure with a curved shape consisting of two arcs that curve in opposite directions so that their ends are parallel.
on-Project	Associated with (receiving water from, in the case of irrigators) Reclamation's Klamath Project.
output (sales)	Related to socioeconomics, output represents the value of industry production. In IMPLAN these are annual production estimates for the year of the data set and are in producer prices. For manufacturers this would be sales plus/minus change in inventory. For service sectors production = sales. For Retail and wholesale trade, output = gross margin and not gross sales.
PacifiCorp	An electric power company in the northwestern United States that owns and operates the Klamath River dams.
palustrine	Of or pertaining to wetlands or freshwater marsh.
Parties	Signatories to the Klamath Hydroelectric Settlement Agreement.

pelagic	Relating to or occurring, living in, or frequenting the open ocean.
penstock	A pipe or conduit that carries water to a power generation turbine.
periphyton	A complex mixture of algae, bacteria, their secretions, associated detritus, and various species of microinvertebrates attached to submerged surfaces in most aquatic ecosystems.
phytoplankton	Small, photosynthetic aquatic organisms, including diatoms, green algae, and cyanobacteria (blue-green algae).
plasticity	The ability of a soil to transform from a solid state to a liquid state by adding water.
point source pollution	Pollution into bodies of water from specific discharge points such as sewer outfalls or industrial-waste pipes.
polychaete	Aquatic annelid worms belonging to the Class Polychaeta, segmented and have bristles for movement or attachment.
powerhouse	Structure that contains the power generation equipment such as the turbine, may be an enclosed building or an open area with concrete slabs and equipment.
programmatic analysis	For purposes of CEQA, the Klamath Basin Restoration Agreement analysis is programmatic, as described in Section 15168 of the CEQA Guidelines. A program-level document is appropriate when a project consists of a series of smaller projects or phases that may be implemented separately. Under the programmatic Environmental Impact Report approach, future projects or phases may require additional, project-specific environmental analysis.
Project Team	The group of lead, cooperating, and responsible agencies responsible for evaluating the alternatives in the Environmental Impact Statement/Report.

Proposed Action	One of the alternatives evaluated in the Environmental Impact Statement/Report, the Proposed Action (also known as the Full Facilities Removal of Four Dams Alternative (Proposed Action)
3	Partial Facilities Removal of Four Dams Alternative
4	Fish Passage at Four) includes the removal of four PacifiCorp Dams Alternative(J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) during a 20-month period which includes an 8-month period of site preparation and partial drawdown at Copco 1 and a 12-month period for full drawdown and removal of facilities. This alternative would include the complete removal of power generation facilities, water intake structures, canals, pipelines, ancillary buildings, and dam foundations.
5	Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

~~This page intentionally left blank.~~

protocol-level surveys	Standardized methods approved by the U.S. Fish and Wildlife Service or other resource agency for establishing the presence or absence of special-status species.
radial gate	Tainter gate.
Reclamation's Klamath Project	The system of reservoirs, dams, canals, and pumps built to drain and reclaim lake bed lands of the Lower Klamath and Tule Lakes, to store water of the Klamath and Lost Rivers, to divert irrigation supplies, and to control flooding of the reclaimed lands.
redd	A depression in streambed gravel dug by a female fish for depositing eggs during spawning.
regalia	Especially fine or decorative clothing.
relicensing	The administrative proceeding in which Federal Energy Regulatory Commission (FERC), in consultation with other federal and state agencies, decides whether and on what terms to issue a new license for an existing hydroelectric project at the expiration of the original license.
remediation	To address a problem. Often refers to the removal of pollution or contaminants from environmental media such as soil, groundwater, sediment, or surface water for the general protection of human health and the environment.
riffle	A shallow section of river characterized by numerous small waves on the surface often caused by gravel bars.
Resource Agencies	Government entities that have jurisdictional authority over various natural resources.

Responsible Agencies	Under CEQA, the agencies with discretionary approval authority over a portion of a CEQA project such as required permits.
restoration	The return of a landscape, ecosystem, or other system to a predefined historical state.
riparian	The area adjacent to a river or stream (and sometimes along shorelines of lakes or reservoirs).
riprap	Broken stone, cut stone blocks, or rubble that is placed on slopes to protect them from erosion.
river left and right	The designated side of the river when looking downstream in the direction of flow.
river mile	Measure of distance in miles along a river from its mouth. River mile numbers begin at zero and increase further upstream.
river mouth	The place where a river ends by flowing into another body of water such as a lake, ocean, or another river.
riverine	Of or pertaining to rivers.
run (of salmonids)	A group of fish that is migrating from the ocean to spawn in the rivers or streams where they were born.
salmonid	Of, belonging to, or characteristic of the family Salmonidae, which includes salmon, trout, and whitefish.
scour	The hole left behind when sediment is washed away from the bottom of a river. Although scour may occur at any time, scour action is especially strong during floods. Swiftly flowing water has more energy than calm water to lift and carry sediment down river.

secondary effects	Related to socioeconomics, they are indirect effects plus induced effects.
Secretarial Determination	Decision by the Secretary of the Interior based on a thorough scientific review of existing science, data and other information whether removal of the dams: (1) will advance restoration of the salmonid fisheries of the Klamath Basin; and 2) is in the public interest.
sedimentation	Settling of particulate matter in water related to particle size, water velocity, and water flow.
senescence	In plants, death triggered by an increase in the enzymes that promote the breakdown of plant cells.
smolt	A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.
soil moisture content	The weight of water contained in a sample of soil, typically expressed as a percentage of the dry weight of the soil.
spawning	The process by which fish release eggs and sperm and deposit them on the stream substrate.
special-status species	Plant and wildlife species listed as threatened or endangered under the federal or state endangered species acts. Also included are federal candidate species, federal species of concern, state sensitive species, state species of concern, and those given special status by the Bureau of Land Management, the U.S Forest Service, or Indian Tribes.
spillway	Open-channel used to convey water over a dam, typically constructed of concrete to resist scour and erosion.
stormwater	Water that is not absorbed into soil and rapidly flows downstream, increasing the level of waterways.

stratification (in lakes)	The formation of layers based on temperature, oxygen levels, salinity, and density that act as barriers to water mixing.
subsistence	The way by which a culture obtains its food.
supersaturation	When oxygen (or other substance) is more highly concentrated in water (or other substance) than is normally possible under normal temperature and pressure.
suspended sediment	Particles that settle slowly enough to be carried in flowing water.
switchyard	The enclosed areas at power stations containing switching facilities and equipment for the purpose of connecting to the transmission network.
tailrace	Open-channel area downstream of power generation turbine for return water to flow back to the river.
Tainter gate	A radial arm water control structure used to control flow into a spillway or overflow area.
talus	A deposit of broken, coarse rock found at the base of a cliff or mountain.
thalweg	The deepest part of a stream or river channel.
thermal refugia	Cool, well-oxygenated areas of rivers utilized by salmon and other species to avoid thermal stress.
thermocline	A layer within a body of water or air where the temperature changes rapidly with depth.
Tidal prism	The volume of water in an estuary or inlet between mean high tide and mean low tide, or the volume of water leaving an estuary at ebb tide.
topographical	Of or relating to the arrangement or accurate representation of the physical features of an area.
total effects	Related to socioeconomics, they are direct effects plus indirect effects plus induced effects.
total Kjeldahl nitrogen	A measure of organic nitrogen plus ammonia.

total maximum daily load (TMDL)	A regulatory term in the Clean Water Act that describes the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.
toxigenic	Producing or containing toxins.
transformer bushings	A transformer is a device that transfers electrical energy from one circuit to another; a bushing provides insulation for the transformer.
transhumance	The seasonal movement of people with their livestock over relatively short distances, typically to higher pastures in summer and to lower valleys in winter.
tributary	A stream or river that flows into a mainstem river and contributes water to it.
turbidity	A measure of the extent to which light passing through water is reduced owing to suspended materials.
Upper Klamath Basin	The portion of the Klamath River Basin located upstream of Iron Gate Dam. The Upper Klamath Basin is divided into two sub-basins: the Klamath Hydropower Reach from Iron Gate Dam to J.C. Boyle Dam and the basin upstream of J.C. Boyle Dam.
V-screen	A V-shaped screen over the water intake to prevent fish from swimming through.
volitional fish passage	The movement of migratory fish around a dam via an upstream fish ladder or downstream bypass system as opposed to being trapped and hauled around the dam or attempting to move through hydropower turbines where many would be killed. Volitional fishways allow anadromous fish to migrate when they are physiologically ready.
watershed	All the land drained by a given river and its tributaries. An entire drainage basin including all living and nonliving components of the system.

weir	A low structure built across a stream to raise the upstream water level while allowing water to flow over the top of the structure.
wocas	The nutritious seeds of the yellow pond lily, important to some Indian Tribes.

Chapter 1
Introduction

~~This~~ On September 22, 2011, the U.S. Department of the Interior (DOI), acting as the National Environmental Policy Act (NEPA) Lead Agency and the California Department of Fish and Game (CDFG), acting as the California Environmental Quality Act (CEQA) Lead Agency, released the Klamath Facilities Removal Draft Environmental Impact Statement/Environmental Impact Report (Draft EIS/EIR) for public review and comment.

In compliance with NEPA, a Notice of Availability (NOA) was published by DOI's Office of Environmental Policy and Compliance in the Federal Register (Federal Register Vol. 76, No. 184, 58833) on Thursday September 22, 2011, and an associated NOA was published by the U.S. Environmental Protection Agency (USEPA) in the Federal Register (Federal Register Vol. 76, No. 190, 60822) on Friday September 30, 2011. A Notice of Completion (NOC) was also published in the State Clearinghouse (State Clearinghouse # 2010062060) on the same date, in accordance with CEQA.

The Lead Agencies conducted public involvement activities on the EIS/EIR during scoping and upon release of the Draft EIS/EIR. The scoping comment period and scoping meetings were held in June and July of 2010. Additionally the Lead Agencies held six public hearings during the comment period on the Draft EIS/EIR at the following locations in California and Oregon:

- Klamath County Fairgrounds, Klamath Falls, Oregon, October, 18, 2011;
- Chiloquin Community Center, Chiloquin, Oregon, October 19, 2011;
- Yreka Community Center, Yreka, California, October 20, 2011;
- Karuk Community Room, Orleans, California, October 25, 2011;
- Arcata Community Center, Arcata, California, October 26, 2011; and
- Yurok Tribal Administration Office, Klamath, California, October 27, 2011.

Written and verbal comments were accepted at meetings and written comments were accepted throughout the comment period. The comment period on the Draft EIS/EIR closed on December 30, 2011.

Since receipt of public comments revision of the Draft EIS/EIR has been underway to produce this Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report (Final EIS/EIR). This Final EIS/EIR consists of three volumes: the revised Volume I, revised Volume II, and new Volume III. Volumes I and II of the Final EIS/EIR have been revised in response to the comments.

Volume III of the Final EIS/EIR contains responses to all comments received during the comment period (see Chapter 10, Chapter 11, and Chapter 12), as well as all changes made to the public Draft EIS/EIR (see Appendix AB in Volume III).

During the process of addressing public comments, some notable content changes were made in the Final EIS/EIR from the prior Draft EIS/EIR. In this Final EIS/EIR, the Lead Agencies:

- Disclosed the Preferred Alternative as Alternative 2, Full Facilities Removal of Four Dams (Proposed Action) (see Executive Summary, ES.7.4 and Chapter 5, Section 5.9);
- Refined and more clearly articulated how stored sediment and suspended sediment volumes were calculated (see Section 2.4.3 "Sediment Weight and Volume in the Four Facilities and Erosion with Dam Removal");
- More clearly identified the Yreka pipeline relocation discussion as being a programmatic level of analysis (see Section 2.4.3.9);
- Added a determination on critical habitat for eulachon with information from the recent listing (see Section 3.3.4.3);
- Expanded and refined the discussion in the Algae Section (see Section 3.4.4.3);
- Expanded the discussion on wetlands, riparian communities, and mitigation for possible effects to these resources (see Section 3.5.4.3);
- Expanded the discussion and added a determination on amphibians and reptiles (see Section 3.5.4.3);
- Expanded and refined the discussion on effects on groundwater from the On-Project plan (see Section 3.7.4.3);
- Expanded discussion and added a determination on water rights assurances related to tribal water rights (see Section 3.8.4.3);
- Expanded discussion of the Tribal Trust for several of the federally recognized tribes (see Section 3.12);
- Expanded the Cultural Resources sections to more comprehensively address National Historic Preservation Act (NHPA) compliance and more clearly articulated the mitigation measures for Cultural Resources (see Section 3.13.4.1);
- Refined the discussion on real estate effects (see Section 3.15.3.6); and
- Added a Scenic Quality mitigation measure SQ-1: Measures to Minimize Scenery Disturbances (See Section 3.19.4.4).

1.1 Purpose and Approach of this Document

This EIS/EIR evaluates the potential impacts of the removal of the four PacifiCorp[1] dams on the Klamath River as contemplated in the Klamath Hydroelectric Settlement Agreement (KHSA [2010]). The Klamath Basin Restoration Agreement (KBRA [2010]), as well as the transfer of Keno Dam~~, will be~~ are treated and analyzed as ~~a~~ connected

[1] PacifiCorp refers to the current utility and all previous owners/names.

action[2]~~.~~s.[3] The KBRA includes programs that will undergo detailed development and analysis in the future. Therefore, it is anticipated that additional ~~National Environmental Policy Act (~~NEPA~~)~~ and ~~California Environmental Quality Act (~~CEQA~~)~~ analyses for the suite of actions contained in KBRA will be tiered as appropriate to this EIS/EIR. ~~It is anticipated~~CDFG recognizes that additional ~~CEQA analysis will be necessary prior to dam removal as contemplated in the KHSA. The~~ environmental analysis may be required by any California public entity with an approval or permitting obligation if required by CEQA.

The EIS/EIR is being prepared in compliance with NEPA and CEQA and will inform a determination by the Secretary of the Interior (Secretary) (i.e., Secretarial Determination) on whether dam removal will advance salmonid restoration and is in the public interest, including but not limited to, consideration of potential impacts on affected local communities and ~~tribes~~Indian Tribes.

The KHSA establishes a process for the Secretarial Determination[4]~~.~~.[5] This process includes additional studies, environmental review, and the decision by the Secretary. This process also includes decisions by the States of Oregon and California as to whether they concur with the Secretarial Determination.

The J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams and appurtenant facilities (herein referenced as the Four Facilities) are being evaluated for removal, and Keno Dam is being evaluated for transfer (not the removal of) from PacifiCorp to ~~the Department of the Interior (~~DOI~~)~~ as a connected action. These dams are affecting salmonid fisheries by blocking ~~up to 420~~ hundreds of miles of potential river habitat, by affecting downstream water quality (specifically, dissolved oxygen, water temperature, and algal toxins), and altering flows in sections of the mainstem of the river (Hamilton et~~.~~ al. 2011). ~~-~~If authorized through legislation, the Secretary will use the impacts analysis presented in this EIS/EIR to help determine whether and to what extent facilities removal should

---

~~[2] NEPA defines a connected action as an action that (i) automatically triggers other actions that may require environmental impact statements (ii) cannot or will not proceed unless other actions are taken previously or simultaneously (iii) is an interdependent part of a larger action and depends on the larger action for its justification. Connected actions are closely related and therefore should be discussed in the same impact statement (40 CFR Part 1508.25 (a)1).~~

[3] NEPA defines a connected action as an action that (i) automatically triggers other actions that may require environmental impact statements (ii) cannot or will not proceed unless other actions are taken previously or simultaneously (iii) is an interdependent part of a larger action and depends on the larger action for its justification. Connected actions are closely related and therefore should be discussed in the same impact statement (40 CFR Part 1508.25 (a)1).

~~[4] Secretarial Determination: Decision by the Secretary of the Interior based on a thorough scientific review of existing science, data and other information whether removal of the dams: (1) will advance restoration of the salmonid fisheries of the Klamath Basin; and (2) is in the public interest.~~

[5] Secretarial Determination: Decision by the Secretary of the Interior based on a thorough scientific review of existing science, data and other information whether removal of the dams: (1) will advance restoration of the salmonid fisheries of the Klamath Basin; and (2) is in the public interest.

occur. ~~Under the KHSA, the Secretary will use best efforts to complete this determination by March 31, 2012.~~

Conflicts over water and other natural resources in the Klamath Basin between conservationists, tribes, farmers, fishermen, and State and Federal agencies have existed for decades. In particular, several developments affecting the Klamath Basin have occurred in recent years:

- In 2001, water deliveries to irrigation contractors in Reclamation's Klamath Project (described below) were substantially reduced.
- In 2002, returning adult salmon suffered a major die-off.
- In 2006, the commercial salmon fishing season was closed along 700 miles of the West Coast to protect weak Klamath River and other major river salmon stocks.
- In 2010, due to drought conditions,[6] Reclamation's Klamath Project had a reduction in water deliveries resulting in short-term idling of farmland and increased groundwater pumping.

Historical conflicts over the Klamath Basin's limited water resources stem in part from concerns over fish populations. The fish populations native to the Klamath River have decreased over time due to human activities in the basin. The Lost River and shortnose suckers have been affected by degradation and loss of habitat as a result of human activities in the Upper Klamath Basin over the last century (United States Fish and Wildlife Service [USFWS] 2008). Water resource development on the Klamath River and its tributaries (including the Shasta, Scott, and Trinity Rivers) has contributed to declines in salmonid fish populations that have harmed both in-river and coastal fishing for subsistence, commercial, and recreational fishing (Congressional Research Service 2005).

1.2 Physical and Biological Setting

The Klamath Basin geography, topography, hydrology, and biology are unique from other watersheds in the Pacific Northwest. Water in the Klamath River, unlike other watersheds in the Pacific Northwest, originates in relatively flat, open valleys before crossing the Trinity and Coast Ranges in a steep river canyon and intercepting cold water inputs from the ~~Shasta,~~ Scott, Salmon, and Trinity Rivers. The flat topography, along with lower average precipitation in the Upper Klamath Basin[7] ~~when compared to~~ than the Lower Klamath Basin, influences water flow and temperature in the river. Figure 1-1 illustrates many of the features of the Klamath Basin described in this section.

1.2.1 Geography and Topography

The Klamath River originates just downstream ~~of~~ from Upper Klamath Lake in southern Oregon and flows 253 miles southwest through northern California to the Pacific Ocean.

[6] As declared by the Governor of Oregon (State of Oregon 2010).
[7] ~~The Upper and Lower Klamath River basins are divided at Iron Gate Dam.~~

Along this course, the Klamath River crosses the Cascade Mountains; the Klamath is one of the only rivers to do so. The Upper Klamath Basin has five main lakes: Crater Lake, Upper Klamath Lake, Lower Klamath Lake, Clear Lake, and Tule Lake. The Lower Klamath Basin, with its border beginning at Iron Gate Dam, is almost 200 miles long and contains the four major Klamath River tributaries: the Shasta, Scott, Salmon, and Trinity Rivers. The basin is generally rural, with a total population of approximately 120,000. Its largest communities are Klamath Falls, Oregon and Yreka, California.

The Upper Klamath Basin has broad, extending valleys shaped by volcanoes and active faulting. The fault-bounded valleys contain all of the large, natural lakes and large wetlands of the Klamath Basin, with the exception of Crater Lake.

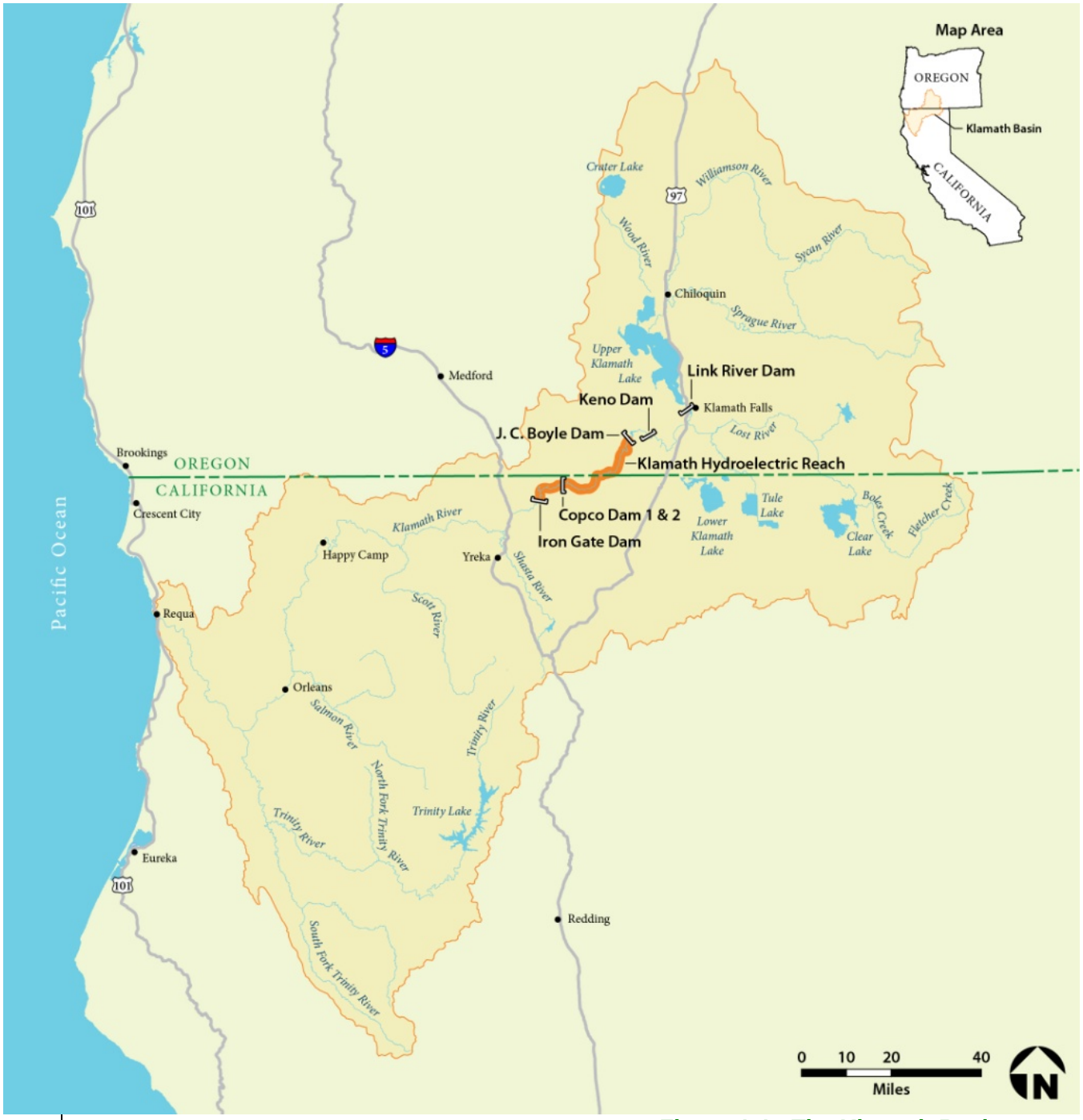


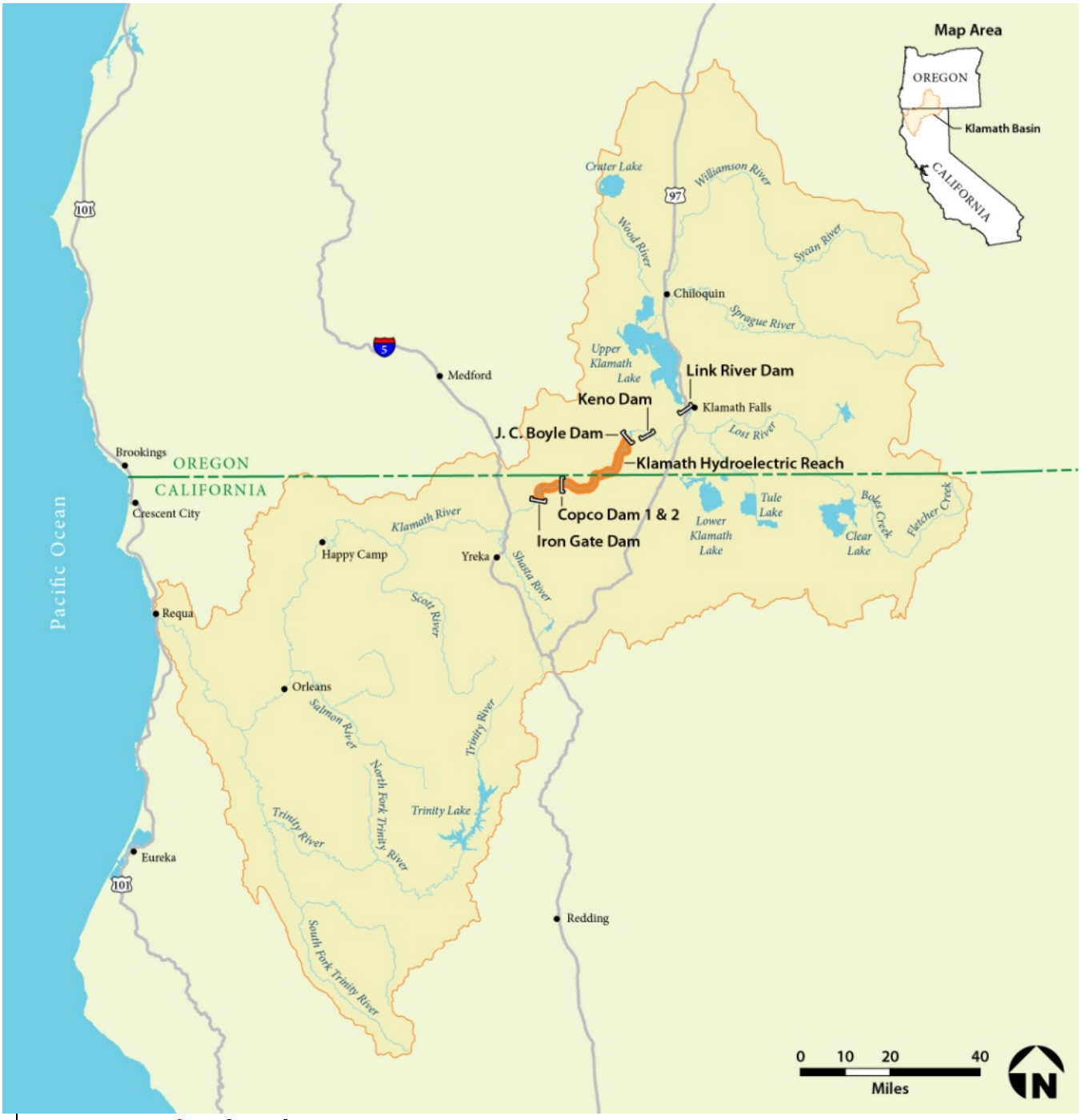
Figure 1-1. The Klamath Basin

As described above, the Klamath River is unlike most river systems, in that the river is warmer and flatter in its headwaters, while downstream portions, beginning near the dams, tend to be colder and steeper. The Klamath River flows through mountainous terrain from the Oregon-California ~~state~~State line to the reaches downstream ~~of~~from Iron Gate Dam. Downstream ~~of~~from Iron Gate Dam, and for most of the river's length to the

Pacific Ocean, the river maintains a relatively steep, high-energy channel. Here, the Klamath River forms a deep canyon surrounded by mountains of the Trinity and Coast Ranges. Lower Klamath Basin valleys include those of the Shasta and Scott Rivers (National Research Council [NRC] 2004).

1.2.2 Climate and Hydrology

The basin receives widely varying precipitation. The climate in the Upper Klamath Basin is dry, with an annual precipitation of approximately 13 inches at the river's origin near Klamath Falls, Oregon. In contrast, the Lower Klamath Basin is wet, with an annual precipitation of approximately 80 inches near the river's mouth at Requa, California. At its higher elevations (above 5,000 feet), the Upper Klamath Basin receives rain and snow during the late fall, winter and spring. Peak stream flows generally occur during snowmelt runoff in late spring/early summer. After the runoff period, flows drop in the late summer/early fall. Fall storms may increase flows compared with the lower summer flows in the Lower ~~Basin.~~



~~Figure 1-1. The~~ Klamath Basin.

Land- and Water-Use Changes in the Klamath Basin

When settlers of European descent first arrived in the Klamath Basin in the 1800s, there was a vast complex of 350,000 acres of lakes and wetlands, interconnected by sloughs and river channels. Many of these wetlands were attractive for farming if drained and a reliable source of irrigation could be developed. Construction of Reclamation's Klamath Project began in the early 1900s to facilitate farming. The Klamath Project, the largest water delivery system in the basin, now includes 7 dams, 18 canals, 45 pumping facilities, and over 500 miles of ditches to supply irrigation water to over 235,000 acres. Upper Klamath Lake's outlet was modified with the construction of Link River Dam (completed in 1921) to allow more active storage of irrigation water for the Klamath Project.

Farms and ranches above Upper Klamath Lake, and on tributaries in the lower Klamath River (e.g. Scott, Shasta, and Trinity Rivers) use surface water supplies that are not part of the Klamath Project. In total, about 62 percent of the wetlands in the Klamath Basin were converted to farming and ranching activities. However, some of these wetlands were retained, like the Lower Klamath National Wildlife Refuge, by President Roosevelt in 1908, creating the first waterfowl refuge in the United States and providing critical habitat along the Pacific Flyway.

Economic development of natural resources changed conditions in the Klamath Basin over the past 100 years, including extensive basin-wide logging, gold mining in the lower river basin, and construction of a railroad causeway in the early 1900s that isolated and dried Lower Klamath Lake. Construction of four main-stem hydroelectric facilities on the middle part of the Klamath Basin between 1918 (Copco 1 Dam) and 1962 (Iron Gate Dam) blocked the passage of migrating salmon and steelhead to the Upper Basin and represents that last major hydrologic modification in the basin.

The combination of these changes have contributed to significant loss of fish habitat, degradation of water quality, and declining fish populations -- especially for salmon and two endangered sucker species (shortnose and Lost River suckers). Hydrologic alterations, including water diversions, wetland losses, declining water quality, and dam construction are among the most significant land- and water-use changes in the Klamath Basin.

Land use patterns in the Klamath Basin will continue to reflect the value of natural resources in providing economic gain for local communities and the Nation. Returning to conditions seen in the 1800's is unrealistic; however, there are numerous opportunities to substantially improve fisheries, wildlife habitat, and water quality conditions in the Klamath Basin and reverse the pattern of environmental problems in the Klamath Basin.

1.2.3 Biology

The Klamath Basin has some of the richest biological and ecological habitats in the United States. The Klamath Basin is within the Klamath Bioregion (California) and the East and West Slope Cascades (Oregon) eco-regions. Below are overviews of the biological resources within this unique and biologically important basin and effects of natural resource development on these resources in the Upper and Lower Klamath Basins. Chapter 3 and the appendices of this document describe these resources in detail.

1.~~1~~2.3.1 Vegetation

Vegetation communities in these eco-regions include drier pine and fir forests in the mountain ranges of Siskiyou County and wetter forests near the coast. Recognized for their biological diversity, the Klamath-Siskiyou mountain ranges contain more than 3,000 known plant species, including 30 temperate conifer tree species, more than any other ecosystem in the world (~~California Department of Fish and Game [~~CDFG~~]~~ 2006). Land cover in the basin consists of a combination of upland ~~tree~~ forest habitat, aquatic habitat, and wetland habitat. Sagebrush and interior valley vegetation communities also exist within lower elevation areas.

The Klamath River Canyon itself is a mosaic of mixed conifer forest communities and riparian habitats (Federal Energy Regulatory Commission [FERC] 2007).

In addition to their ecological significance, many plants, especially wetland plants, in the Klamath Basin are culturally important to Indian Tribes in the Klamath River region for food, basketry, regalia, and medicine, and some have importance for ceremonial use as well (Larson and Brush 2010; FERC 2007).

1.~~1~~2.3.2 Wildlife

The Klamath Basin is home to a large number of wildlife species, with great diversity. Surveys have identified more than 200 vertebrate species, including amphibians, reptiles, birds, and mammals (PacifiCorp 2004a).

- ~~Five amphibian species are known to occur in the Klamath River area: long-toed salamander, Pacific chorus frog, western toad, and Pacific giant salamander. In addition, western toad and yellow-legged frog were reported in some of the tributaries of the lower Klamath subbasin during trapping studies conducted in 1991 (U.S. Fish and Wildlife Service [USFWS] 1992).~~
- ~~Reptile species diversity and relative abundance is considered high (PacifiCorp 2004a). The western fence lizard is a highly abundant reptile species and is found in a variety of habitats in the basin area. Other reptile species include gopher snake, northern sagebrush lizard, western rattlesnake, southern alligator lizard, yellow-bellied racer, common garter snake, western terrestrial garter snake, western pond turtle, common kingsnake, striped whipsnake, sharptail snake, ringneck snake, western skink, rubber boa, and California mountain kingsnake (PacifiCorp 2004a).~~

Effects of Natural Resource Development

In the Upper Klamath Basin

- Logging, road-building, farming, and ranching above Upper Klamath Lake have removed riparian vegetation, warmed streams, and increased the loads of nutrients and sediment entering the rivers and Upper Klamath Lake, contributing to water-quality problems.
- Draining tens of thousands of acres of wetlands around Upper Klamath Lake for agriculture land increased nutrient loads to the lake and eliminated near-shore habitat for aquatic biota.
- Link River Dam operations to meet irrigation water demand cause wider water-level fluctuation in Upper Klamath Lake.
- Upper Klamath Lake has become more enriched with nutrients, leading to nuisance blooms of blue-green algae that produce toxins (primarily microcystin) and creating pH and dissolved oxygen problems that are stressful to aquatic biota.
- Shortnose and Lost River suckers went from a dominant species in Upper Klamath Lake, and a food source for tribal members, to an endangered species in 1988, a closed fishery, and a fish population that continues to decline.
- The 20-mile Keno Reach of the Klamath River receives large loads of decaying organic matter (blue-green algae) from Upper Klamath Lake, producing extremely low dissolved-oxygen levels that persist in the summer and fall.
- Draining and farming hundreds of thousands of acres of wetlands below Upper Klamath Lake (and the Lost River Valley) has decreased habitat for waterfowl on the Pacific Flyway and affects the amount and timing of water released downstream for fish.
- Klamath River is blocked at Iron Gate Dam for passage of fall and spring run Chinook salmon, coho salmon, and steelhead, limiting fish production in the basin and access to salmon by tribes in the Upper Basin.

Sources:
Bortleson and Fretwell, 1993; CDFG 2004; Chesney and Yokel, 2003; National Academies Press, 2003; NOAA 2009; Risley and Laenen, 1998; Snyder and Morace, 1997; Sullivan et al, 2008; USFWS 1993; USFWS 2009; Wood, 2009.

The Upper Klamath Basin is along the Pacific Flyway, and it supports the largest concentration of migratory waterfowl in North America, with up to 2 million migratory birds during fall migration and about half that number in spring (Jarvis 2002). Large numbers of water-related birds also use the Upper Klamath Basin for breeding (Shuford et al. 2004). In addition, the Upper Klamath Basin supports the largest wintering population of bald eagles in the coterminous United States (Shuford et al. 2004).

- ~~In addition, many common mammals are found throughout the area including: black-tailed jackrabbit, mule deer, and California ground squirrel. Small mammals in the area include deer mouse, bushy-tailed woodrat, least chipmunk, and montane vole. Medium-sized mammals detected in the area include bobcat, striped skink, gray fox, yellow-bellied marmot, and coyote. Large mammals such as deer, elk, mountain lion, and black bear are also present. Five aquatic and/or riparian-associated fur-bearing mammals are present, including raccoon, beaver, muskrat, mink, and river otter (PacifiCorp 2004a).~~

1.~~1~~2.3.3 National Wildlife Refuges

The Klamath Basin National Wildlife Refuge (NWR) System comprises six refuges (Bear Valley, Clear Lake, Klamath Marsh, Lower Klamath, Tule Lake, and Upper Klamath). The refuges maintain critical wetland habitat in the river basin and provide a stopover point for three-quarters of the migratory waterfowl on the

Effects of Natural Resource Development

In the Lower Klamath Basin

- The four dams create water temperature in the river that are too warm in the fall for fish migration, and they affect the natural flow variability in the lower river and cause crowding of salmon below Iron Gate Dam, both of which contribute to fish disease.
- Severe water quality problems in these four reservoirs, including blue-green algal toxins (that can affect humans and fish), low dissolved oxygen, high temperatures, and high pH, create stressful biological conditions.
- Use of water in major Klamath River tributaries (e.g. Scott and Shasta Rivers) for farming and ranching has decreased critical habitat for coho salmon, which was federally listed in 1997.
- High nutrient concentrations leaving the Upper Basin result in the excessive growth of attached algae (periphyton) in the lower main-stem river, which causes stressful swings in pH and DO for aquatic biota.
- Reduced flows during extreme droughts have been identified as a factor in large fish die-offs, as occurred in the fall of 2002 when tens of thousands of pre-spawned salmon and steelhead died in the lower river.
- Weak Klamath salmon stocks in the ocean periodically require closure of fisheries and commercial and recreational fishing along 700 miles of the Oregon and California coasts, as occurred in 2006.

Sources:
Bortleson and Fretwell, 1993; CDFG 2004; Chesney and Yokel, 2003; National Academies Press, 2003; NOAA Fisheries 2009; Risley and Laenen, 1998; Snyder and Morace, 1997; Sullivan et al, 2008; USFWS

Pacific Flyway (USFWS 2010). The refuges provide vital feeding, nesting, and resting habitat for one to two million birds during the spring and fall migrations, all of which are highly dependent on the water resources of the area.

1.~~1~~2.3.4~~–~~ Fish

The Klamath Basin is home to 19 native fish species. The Klamath Basin once produced large runs of steelhead, Chinook salmon, coho salmon, green sturgeon, eulachon, coastal cutthroat trout, and Pacific lamprey. Runs of these anadromous fish (fish that migrate from salt water to spawn in fresh water) contributed substantially to tribal, commercial, and recreational fisheries (USFWS 1986; DOI Klamath Basin Task Force 1991; Gresh et al. 2000).

Some of these fish species are listed under the Federal Endangered Species Act (ESA) and California Endangered Species Act (CESA). Federally listed species include coho salmon, bull trout, Lost River sucker, shortnose sucker, southern distinct population segment green sturgeon, and southern distinct population segment eulachon. California listed species include coho salmon, Lost River sucker, shortnose sucker and longfin smelt. In addition, both the Lost River sucker and the shortnose sucker are fully protected under the California Fish and Game Code Section 5515(a)(3)(b)(4) and (6), respectively.

Upper Klamath Lake and other waterways in the upper watershed provide habitat for the Lost River and shortnose suckers. Suckers are an important part of tribal culture and were an important part of tribal diet. The Lost River and shortnose sucker spawning runs still constitute ceremonial events for the Klamath Tribes. In 1988, these fish were listed as endangered under the ESA (USFWS 1988) and ~~California Endangered Species Act~~CESA, eliminating the ability to fish for suckers and thus eliminating them from tribal diet and traditional cultural practices.

Copco 1 Dam, completed in 1918, was the first mainstem dam to block fish passage to the majority of the Upper Klamath Basin. Iron Gate Dam, completed in 1962, is the downstream-most dam that blocks upstream fish passage. Flow releases from Iron Gate Dam, and the quality of the water being released, affect the quantity and quality of fish habitat for listed and non-listed species in the mainstem downstream ~~of~~from Iron Gate Dam (FERC 2007). The other hydroelectric dams, with the exception of J.C. Boyle Dam, which is equipped with a ladder that does not meet current standards (Administrative Law Judge 2006), also block upstream fish passage and isolate fish populations between these dams. The dams have eliminated access for anadromous fish, including salmon and steelhead, to ~~approximately 420~~ hundreds of miles of potential habitat in at least 49 tributaries upstream of Iron Gate Dam.

The text boxes below describes the development and use of natural resources in the basin and some of the corresponding effects on water supplies and water quality as well as vegetation and wildlife communities in the Upper and Lower Klamath Basin.

Effects of Natural Resource Development

In the Upper Klamath Basin

- Logging, road-building, farming, and ranching above Upper Klamath Lake have removed riparian vegetation, warmed streams, and increased the loads of nutrients and sediment entering the rivers and Upper Klamath Lake, contributing to water-quality problems.
- Draining tens of thousands of acres of wetlands around Upper Klamath Lake for agriculture land increased nutrient loads to the lake and eliminated near-shore habitat for aquatic biota.
- Link River Dam operations to meet irrigation water demand cause wider water-level fluctuation in Upper Klamath Lake.
- Upper Klamath Lake has become more enriched with nutrients, leading to pH and dissolved oxygen problems that are stressful to aquatic biota and nuisance blooms of blue-green algae that produce toxins (primarily microcystin) .
- Shortnose and Lost River suckers went from a dominant species in Upper Klamath Lake, and a food source for tribal members, to an endangered species in 1988, a closed fishery, and a fish population that continues to decline.
- The Keno Reach and Keno Impoundment/Lake Ewauna receives large loads of decaying organic matter (blue-green algae) from Upper Klamath Lake, producing extremely low dissolved-oxygen levels that persist in the summer and fall.

Sources:
Bortleson and Fretwell, 1993; CDFG 2004; Chesney and Yokel, 2003; National Academies Press, 2003; NOAA Fisheries 2009; Risley and Laenen, 1998;

Effects of Natural Resource Development

In the Upper Klamath Basin

- Draining and farming hundreds of thousands of acres of wetlands below Upper Klamath Lake (and the Lost River Valley) has decreased habitat for waterfowl on the Pacific Flyway and affects the amount and timing of water released downstream for fish.

- Klamath River is blocked at Iron Gate Dam for passage of fall and spring run Chinook salmon, coho salmon, and steelhead, limiting fish production in the basin and access to salmon by tribes in the Upper Klamath Basin.

In the Lower Klamath Basin

- The four dams create a "thermal lag" in both the spring and the fall. This means that the river warms more slowly in the spring and cools more slowly in the fall than it would without the dams. The result of these thermal effects is a delay in timing of runs for the migration of fall Chinook salmon.

- Severe water quality problems in the two larger reservoirs, Copco 1 and Iron Gate, including blue-green algal toxins (that can affect humans and fish), low dissolved oxygen, high temperatures, and high pH, create stressful biological conditions.

- Use of water in major Klamath River tributaries (e.g.,Scott and Shasta Rivers) for farming and ranching has decreased habitat for coho salmon, which was federally listed in 1997.

- High nutrient concentrations leaving the Upper Klamath Basin result in the excessive growth of attached algae (periphyton) in the lower mainstem river, which causes stressful swings in pH and DO for aquatic biota.

- Reduced flows during extreme droughts have been identified as a factor in large fish die-offs, as occurred in the fall of 2002 when tens of thousands of pre-spawned salmon and steelhead died in the lower river.

- Weak Klamath salmon stocks in the ocean has required closure of fisheries and commercial and recreational fishing along 700 miles of the Oregon and California coasts, as occurred in 2006.

Sources:
Bortleson and Fretwell, 1993; CDFG 2004; Chesney and Yokel, 2003; National Academies Press, 2003; NOAA 2009; Risley and Laenen, 1998; Snyder and Moraga, 1997; Sullivan et al. 2008; USFWS 1992; USFWS 2000; Wood, 2000

1.~~2~~ 3 People and Historic Setting

1.3.1 Tribes

Six federally recognized ~~tribes~~ Indian Tribes live, work, hunt, and fish within the basin, including the Klamath Tribes, Quartz Valley ~~Tribe~~Indian Community, Karuk Tribe, Hoopa Valley Tribe, Yurok Tribe, and Resighini Rancheria. ~~The total tribal population in the basin is approximately 16,000.~~ Historically, the tribes depended on the fish populations of the Klamath Basin for food as well as ceremonial traditions. Prior to European settlement, generations of ~~Indian Tribes~~ Indians resided along the Klamath, , Shasta, Scott, and Trinity Rivers ~~and~~ , as well as in the Upper Klamath Basin, and depended on the fisheries for cultural, ceremonial, subsistence, and commercial purposes.

The decline in the fisheries has caused economic hardship for all the tribes. The Klamath Tribes, in the Upper Klamath Basin, have not had salmon harvest opportunities since 1918, when Copco 1 Dam was built. By contrast, the salmon harvest continues to provide revenue for the Yurok and Hoopa Valley Tribes (who reside in the Lower Klamath Basin).

~~1.2.1.~~1 .3.1.1 The Klamath Tribes

The Klamath Tribes, headquartered in Chiloquin, Oregon, in the Upper Klamath Basin near Upper Klamath Lake, are composed of three historically separate tribes: the Klamath Tribe, the Modoc Tribe, and the Yahooskin band of Snake Indians. The Klamath Tribes' ancestral territory covers approximately 580,000 acres. The current membership is about 3,400 and the current total land base is approximately 600 acres.

1.~~2~~3.1.2 Quartz Valley ~~Tribe~~

Indian Community

The Quartz Valley Indian ~~Reservation~~Community is a federally recognized ~~tribe~~Indian Tribe representing people of ~~upper Klamath~~Upper Klamath Basin (Karuk) and Shasta Indian ancestry. The Quartz Valley ~~Indian reservation is~~ Reservation is in Siskiyou County near the community of Fort Jones. The population is around 126, with a tribal enrollment of about 150. Total reservation size is 174 acres.

1.~~2~~3.1.3 Karuk Tribe

The Karuk Tribe has been federally recognized since 1979 and occupies territory along the middle section of the Klamath River. The 2000 U.S. Census reported tribal membership to be 2,702 individuals. In 2004, the California Department of Housing and Community Development reported tribal membership to be 3,164 individuals. Currently, the Karuk have one of the largest ~~tribes~~Indian Tribes in California with approximately 4,800 members.

1.~~2~~3.1.4 Hoopa Valley Tribe

The Hoopa Valley Indian Reservation is in the northeastern corner of Humboldt County in northern California, approximately 50 miles inland from the Pacific Ocean, and encompasses roughly 20 percent of Hupa aboriginal territory. The reservation has nearly 92,160 acres, and is the largest reservation in California. The northern portion of the reservation is in Yurok

ancestral territory. The Trinity River bisects the reservation, and a small length of the northern border of the reservation includes about a quarter mile reach of the Klamath River. The 2000 U.S. Census counted 2,633 people on the reservation, and the tribe listed an enrollment of 2,130 in 2004.

1.~~2~~3.1.5~~-~~ Yurok Tribe

With more than 5,000 members, the Yurok Tribe is the largest ~~tribe~~Indian Tribe in California. The tribe's ancestral territory covers approximately 350,000 acres and includes approximately 50 miles of Pacific coastline. Today, the tribe's reservation in Del Norte and Humboldt Counties in California encompasses approximately 57,000 acres, bordered on the west by the Pacific Ocean, and consists of a strip of land extending a mile along each side of the Klamath River from just upstream of the confluence of the Klamath and Trinity Rivers about 50 miles inland.

1.~~2~~3.1.6~~-~~ Resighini Rancheria

The Resighini Rancheria is in Del Norte County, California, and encompasses 239 acres. The Resighini Rancheria is several miles inland from the mouth of the Klamath River and rests on the southern banks of the river, completely surrounded by the Yurok Reservation. It is primarily settled by Yurok Indians affiliated with the Yurok Coast Indian Community. A population of 36 was reported on Rancheria lands in the ~~2000~~ 2000 U.S~~.~~. Census.

1.3.2 Early Euroamerican Settlement and Hydroelectric History

Before the influx of Euroamericans that began in the 1840s, the basin was settled by American Indians. Euroamerican exploration of the Klamath Basin began in the early 19th Century. The discovery of gold in California in 1848 prompted a dramatic influx of European immigrants to California and other areas, including the Klamath Basin. Euroamerican settlement in the Klamath River watershed continued throughout the 19th Century. Sustained logging enterprises appeared in the 1880s, and the first hydroelectric development in the Klamath Basin was established in 1891 in the Shasta River Canyon below Yreka Creek.

Envisioned in 1911, the Klamath Hydroelectric Project was built in phases, beginning with Copco 1 (1918), followed by Copco 2 (1925), J.C. Boyle (1958) and the Iron Gate facilities in 1962. The development of the Klamath Hydroelectric Project played a significant role in the area's economic development, both as part of a regionally significant, locally owned and operated private utility and through the role that increased electrical capacity played in the expansion of the timber, agriculture, and recreation industries during the 20th century.

~~1.2.1 Water Use and Management~~

~~*1.2.3.1 Water Management Conflicts*~~

~~Figure 1-2 presents a timeline for activities within the Klamath Basin that have resulted in current conditions. Conflicts over water and other natural resources in the Klamath Basin between conservationists, tribes, farmers, fishermen, and state and federal agencies have existed for decades. In particular, several developments affecting the Klamath Basin have occurred in recent years:~~

- ~~In 2001, water deliveries to irrigation contractors in Reclamation's Klamath Project (described below) were substantially reduced.~~
- ~~In 2002, returning adult salmon suffered a major die-off.~~
- ~~In 2006, the commercial salmon fishing season was closed along 700 miles of the West Coast to protect weak Klamath River and other major river salmon stocks.~~
- ~~In 2010, due to drought conditions[8], Reclamation's Klamath Project had a reduction in water deliveries resulting in short-term idling of farmland and increased groundwater pumping.~~

[8] ~~As declared by the Governor of Oregon (State of Oregon 2010)~~

Indian Tribe use of Klamath Basin since time immemorial

1855 Klamath River Reservation established (Yurok)

1864 Land for Hoopa Valley Indian Reservation set aside by Congress.

1864 Klamath Indian Reservation established (The Klamath Tribes)

1876 Boundaries of the Hoopa Valley Indian Reservation established by Executive Order

1905 Reclamation's Klamath Project Authorized by the Secretary of the Interior (May 15)

1906 Work on Reclamation's Klamath Project begins

1907 A-Canal completed

1908 President Theodore Roosevelt forms Lower Klamath Lake National Wildlife Refuge, the first in the nation

1910 Clear Lake Dam completed

1911 Clear Lake National Wildlife Refuge established

1912 Lost River Diversion Channel completed

1912 Wilson Diversion Channel completed

1917 Connection of Lower Klamath Lake to Klamath River blocked

1918 Copco 1 Dam completed; passage of salmon and steelhead to the Upper Basin blocked; harvest opportunities for Klamath tribes ends

1921 Anderson-Rose Dam on Lost River completed

1921 Link River Dam completed

1922 Copco 2 construction begins in order to meet additional electricity demand of timber industry and reregulate flows from Copco 1

1923 Malone Diversion Dam on Lost River completed

1924 Miller Diversion Dam on Miller Creek completed

1925 Copco 2 completed

1925 Gerber Dam completed

1928 Tule Lake (39,116 acres) and Upper Klamath Lake (15,000 acres) National Wildlife Refuges established

1930 Lost River Diversion Channel enlarged

1931 Keno Regulating Dam completed

1938 Land purchased for Resighini Rancheria

1939 Quartz Valley Indian Reservation established

1941 D-Pumping Plant completed

1950 Lost River Diversion Channel enlarged

1954 Klamath Tribes' (Modoc, Klamath, and Yahooskins) federal recognition terminated

1956 FERC Relicensing for PacifiCorp or predecessor

1957 Klamath River Basin Compact ratified by California and Oregon "to facilitate …the orderly …development, use, conservation, and control" of Basin water for domestic and agricultural uses, protection and enhancement of wildlife, fish, and recreational resources. To ensure equitable distribution and use of water between the two states and the Federal Government

1958 J.C. Boyle Dam completed, providing peaking power

1962 Iron Gate Dam completed

1966 Keno Dam replaced

1967 Lost River sucker listed as "Rare" by State of CA

1971 Shortnose sucker listed as "Rare" by State of CA

1971 Lost River and shortnose sucker identified as species of concern under the CESA

1975 Klamath Basin adjudication proceedings for State of Oregon begin

1979 Karuk Tribe becomes federally recognized

Figure 1-2a. Klamath Basin Timeline Since 1905

1981 Portion of the Lower Klamath River designated as a "Wild and Scenic" river

1984 Trinity River Restoration Program initiated

1986 Klamath Tribes reinstated as federally recognized tribes and close their sucker fisheries for conservation purposes. Hundreds of adult suckers are observed in a summer-time die-off in Upper Klamath Lake

1986 20 Year "Klamath River Basin Fishery Resources Restoration Act" - Public Law 99-552 (100 Stat. 3081, October 27, 1986), as amended by P.L. 100-580. Task Force Formed

1988 Lost River and shortnose sucker listed as endangered under ESA

1988 Hoopa-Yurok Act establishes an independent Yurok Reservation and Tribal government

1991 Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program completed by U.S. Fish and Wildlife Service

1993 Federal Government sets the Klamath tribal Fishing to 50% of total available harvest for Fall Chinook

1994 Klamath River from J.C. Boyle Powerhouse to the California-Oregon state line designated "Wild and Scenic" river

1995 Adoption of the Klamath, Six Rivers, and Shasta-Trinity National Land and Resource Management Plans that included findings from the 1993 Forest Ecosystem Management Team and 1994 Record of Decision for the Northwest Forest Plan for the Aquatic Conservation Strategy that mandated watershed restoration, identified key watersheds as strongholds for salmon recovery, and standards and guidelines to protect and restore watershed conditions

1995-1997 Many thousands of adult suckers observed in summer-time die-off in Upper Klamath Lake

1997 Coho salmon listed under ESA

2000 PacifiCorp begins re-licensing proceedings for the Klamath Hydroelectric Project

2001 Water deliveries to Reclamation's Klamath project are curtailed to protect ESA listed species due to drought

2002 At least 33,000 returning adult salmon, primarily fall-run Chinook, die in the mainstem of the Klamath

2003 Construction of new A-Canal headgates and fish screen

2004 PacifiCorp initiates dam relicensing application with FERC

2004 Construction of Lost River and shortnose sucker friendly fish ladder at Link River Dam

2004 PacifiCorp files Final License Application with FERC to re-license Klamath Hydroelectric Project

2005 Coho salmon listed under the CESA

2005 KBRA/KHSA talks begin

2005 Commercial salmon ocean harvest restricted on California and Oregon Coast due to weak Klamath stocks

2005 Water quality studies show that Copco and Iron Gate Reservoirs have regular, prolonged blooms of toxic algae in the summertime. Warnings against human contact with the reservoir water begin to be routinely posted

2006 Federal Agencies release drafts of mandatory prescriptions for a new Klamath Hydroelectric Project license, which if finalized will require fishways, flow management changes, and other changes

2006 PacifiCorp challenges scientific foundations of Federal prescriptions in a trial-type hearing under the Energy Policy Act of 2005. Judge's rulings support scientific foundations of most Federal prescriptions

2006 KBRA/KHSA talks intensify

2006 PacifiCorp's license to operate the Klamath Hydroelectric Project expires. The relicensing process continues and the Project continues operation under annual license

2006 Agriculture's contracts for low power rates expire

2006 700 miles of Oregon and California coast closed to commercial salmon fishing due to weak Klamath stocks

2007 Federal agencies finalize mandatory prescriptions for a new Klamath Hydroelectric Project license, requiring fishways and flow management changes, among other things

2007 FERC issues a Final Environmental Impact Statement for the Klamath Hydroelectric Project

2007 Commercial salmon ocean harvest restricted on California and Oregon coasts due to weak Sacramento River salmon stocks

2008 California commercial ocean harvest closed due to weak Sacramento River salmon stocks

2008 Removal of Chiloquin Dam opens Lost River and shortnose sucker habitat

2009 Oregon legislature passes Senate Bill 76, which provides for $180 million in PacifiCorp rate-payer contributions to the cost of removing the lower four dams in the Klamath Hydroelectric Project

2009 California commercial ocean salmon harvest closed

2010 Oregon Public Utilities Commission approves Oregon rate-payer contributions of $180 million to dam removal fund

2010 Reclamation significantly decreased water deliveries from Upper Klamath Lake to its Klamath Project to reserve water in Upper Klamath Lake for ESA-listed suckers and provide flow augmentation for ESA-listed coho downstream of Iron Gate Dam to comply with USFWS and NOAA Fisheries Biological Opinions

2010 KHSA and KBRA signed

2011 California Public Utilities Commission approves California rate-payer contributions of $13.76 million to dam removal fund

Figure 1-2b. Klamath Basin Timeline Since 1905

~~Historical conflicts over the Klamath Basin's limited water resources stem in part from concerns over fish populations. The fish populations native to the Klamath River have decreased over time due to human activities in the basin. The Lost River and shortnose suckers have been affected by degradation and loss of habitat as a result of human activities in the Upper Basin over the last century (USFWS 2008). Water resource development on the Klamath River and its tributaries (including the Shasta, Scott, and Trinity Rivers) has contributed to declines in salmonid fish populations that have harmed both in-river and coastal fishing for subsistence, commercial, and recreational fishing (Congressional Research Service 2005). These conflicts have cost the United States an average of $100 million per year over the past ten years (Sheets 2011). The KBRA was designed to reduce these expenditures, as shown in Figure 1-3.~~

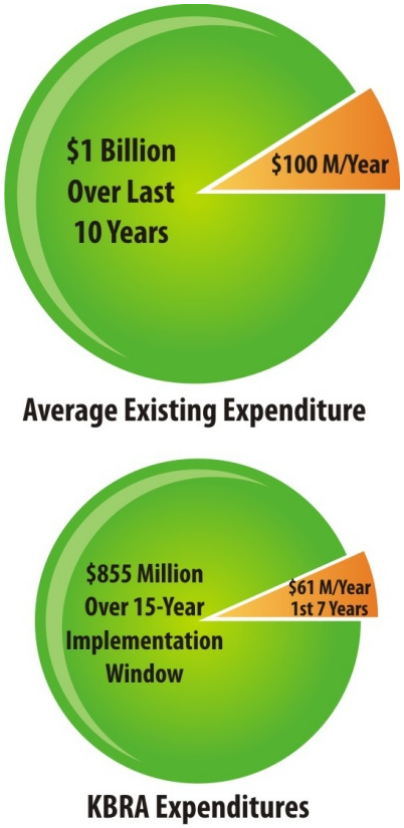


Figure 1-3. Klamath Basin Expenditures (Sheets 2011)

~~1.2.2 Reclamation's Klamath Project~~

~~In addition to the Klamath Basin's distinctive setting, biological resources, and cultural history, the basin is also the site of one of the first developments authorized under the 1902 Reclamation Act (P.L. 57-161, 32 Stat. 388). Development and construction of Reclamation's Klamath Project took place between 1905 and 1966, with major features of the project completed by the early 1940s. As the largest water management effort in the Upper Klamath Basin, Reclamation's Klamath Project features include a system of reservoirs, dams, canals, and pumps (Figure 1-4), and use of Gerber Reservoir and Clear Lake to reduce flooding of lands in the Tule Lake area. The authorization for Reclamation's Klamath Project stated its purpose:~~

Other historical developments have also influenced human uses of Klamath Basin resources. In 1906 the Bureau of Reclamation began constructing the Klamath Project, which converted wetlands to agricultural development and encouraged settlement of farmers in the Klamath Basin. Farmers in the Basin include off-project as well as project irrigators. In 1908 President Theodore Roosevelt established the Klamath Lake Reservation, the nation's first waterfowl refuge. The refuge, which was later renamed the Lower Klamath National Wildlife Refuge, is now part of a complex of refuges that attracts wildlife viewers and waterfowl hunters. The commercial salmon fishery, which originated with gillnetters on California rivers in the early 1850s, was superseded by ocean trollers when the river fisheries were closed (in 1933 for the Klamath River). The ocean salmon fishery, which originated with a few fishermen operating from sailboats in Monterey Bay in the 1880s, expanded to northern California ports by 1916 due to changes such as the replacement of sails with gasoline engines. Ocean recreational fishing became popular with the development of the commercial passenger fishing vessel industry after

World War II. The redband trout fishery in the Klamath Basin had become a renowned trophy fishery by 1920, and steelhead fishing on the Klamath River dates back to the early 1930s.

Multiple generations of farmers, fishermen and recreationalists have been a part of Klamath Basin and nearby coastal communities over the past century.

The text box below (p. 1-13) summarizes more detail of early settlement in the Klamath Basin and some of the effects of historic and current land and water use in the basin.

1.3.3 Water Use and Management

1.3.3.1 Water Management

Figure 1-2 presents a timeline for activities within the Klamath Basin that have resulted in current conditions. The timeline follows the development of several major institutions, Reclamation's Klamath Project, Oregon's Klamath Basin Adjudication, and PacifiCorp's Klamath Basin Hydroelectric Project and relicensing. Today these institutions influence the major water management decisions in the Klamath Basin and played a key role in the negotiations that eventually became the KHSA and KBRA.

History of Land- and Water-Use Changes in the Klamath Basin

When settlers of European descent first arrived in the Klamath Basin in the 1800s, there was a vast complex of 350,000 acres of lakes and wetlands, interconnected by sloughs and river channels. Many of these wetlands were attractive for farming if drained and a reliable source of irrigation could be developed. Construction of Reclamation's Klamath Project began in the early 1900s to facilitate farming. The Klamath Project, the largest water delivery system in the basin, now includes 7 dams, 18 canals, 45 pumping facilities, and over 500 miles of ditches to supply irrigation water to over 224,000 acres of agricultural lands (DOI 2010b). Upper Klamath Lake's outlet was modified with the construction of Link River Dam (completed in 1921) to allow more active storage of irrigation water for the Klamath Project.

Farms and ranches above Upper Klamath Lake, and on tributaries in the lower Klamath River (e.g., Scott, Shasta, and Trinity Rivers) use surface water supplies that are not part of the Klamath Project. In total, about 80 percent of the wetlands in the Klamath Basin were converted to farming and ranching activities (Atkins 1970, Natural Resources Conservation Service 2007 as referenced in Larson and Brush 2010). However, some of these wetlands were retained, like the Lower Klamath National Wildlife Refuge, by President Roosevelt in 1908, creating the first waterfowl refuge in the United States and providing critical habitat along the Pacific Flyway.

Economic development of natural resources changed conditions in the Klamath Basin over the past 100 years, including extensive basin-wide logging, gold mining in the lower river basin, and construction of a railroad causeway in the early 1900s that isolated and dried Lower Klamath Lake. Construction of four main-stem hydroelectric facilities on the middle part of the Klamath Basin between 1918 (Copco 1 Dam) and 1962 (Iron Gate Dam) blocked the passage of migrating salmon and steelhead to the Upper Basin and represents that last major hydrologic modification in the basin.

The combination of these changes have contributed to significant loss of fish habitat, degradation of water quality, and declining fish populations -- especially for salmon and two endangered sucker species (shortnose and Lost River suckers). Hydrologic alterations, including water diversions, wetland losses, declining water quality, and dam construction are among the most significant land- and water-use changes in the Klamath Basin.

Land use patterns in the Klamath Basin will continue to reflect the value of natural resources in providing economic gain for local communities and the Nation. Returning to conditions seen in the 1800's is unrealistic; however, there are numerous opportunities to substantially improve fisheries, wildlife habitat, and water quality conditions in the Klamath Basin and reverse the pattern of environmental problems in the Klamath Basin.

Indian Tribe use of Klamath Basin since time immemorial

1855 Klamath River Reservation established (Yurok)

1864 Land for Hoopa Valley Indian Reservation set aside by Congress.

1864 Klamath Indian Reservation established (The Klamath Tribes)

1876 Boundaries of the Hoopa Valley Indian Reservation established by Executive Order

1905 Reclamation's Klamath Project Authorized by the Secretary of the Interior (May 15)

1906 Work on Reclamation's Klamath Project begins

1907 A-Canal completed

1908 President Theodore Roosevelt forms Lower Klamath Lake National Wildlife Refuge, the first in the nation

1910 Clear Lake Dam completed

1911 Clear Lake National Wildlife Refuge established

1912 Lost River Diversion Channel completed

1912 Wilson Diversion Channel completed

1917 Connection of Lower Klamath Lake to Klamath River blocked by a railroad embankment

1918 Copco 1 Dam completed; passage of salmon and steelhead to the Upper Basin blocked; harvest opportunities for Klamath tribes ends

1921 Anderson-Rose Dam on Lost River completed

1921 Link River Dam completed

1922 Copco 2 construction begins in order to meet additional electricity demand of timber industry and reregulate flows from Copco 1

1923 Malone Diversion Dam on Lost River completed

1924 Miller Diversion Dam on Miller Creek completed

1925 Copco 2 completed

1925 Gerber Dam completed

1928 Tule Lake (39,116 acres) and Upper Klamath Lake (15,000 acres) National Wildlife Refuges established

1930 Lost River Diversion Channel enlarged

1931 Keno Regulating Dam completed

1938 Land purchased for Resighini Rancheria

1939 Quartz Valley Indian Reservation established

1941 D-Pumping Plant completed

1941 Construction of Klamath Straits Drain which provided hydrologic connection between Lost River basin and Klamath River

1950 Lost River Diversion Channel enlarged

1954 Klamath Tribes' (Modoc, Klamath, and Yahooskins) federal recognition terminated

1956 FERC Relicensing for PacifiCorp or predecessor

1957 Klamath River Basin Compact ratified by California and Oregon "to facilitate …the orderly …development, use, conservation, and control" of Basin water for domestic and agricultural uses, as well as protection and enhancement of wildlife, fish, and recreational resources. To ensure equitable distribution and use of water between the two states and the Federal Government

1958 J.C. Boyle Dam completed, providing peaking power

1962 Iron Gate Dam completed

1966 Keno Dam replaced

1967 Lost River sucker listed as "Rare" by State of CA

1971 Shortnose sucker listed as "Rare" by State of CA

1971 Lost River and shortnose sucker identified as species of concern under the CESA

1975 Klamath Basin adjudication proceedings for State of Oregon begin

1975 North Coast Regional Water Quality Control Board adopts basin plan for the Klamath River Basin, including designation beneficial uses for the river

1979 Karuk Tribe becomes federally recognized

1981 Portion of the Lower Klamath River designated as a "Wild and Scenic" river

1984 Trinity River Restoration Program initiated

1986 Klamath Tribes reinstated as federally recognized tribes and close their sucker fisheries for conservation purposes. Hundreds of adult suckers are observed in a summer-time die-off in Upper Klamath Lake

1986 20 Year "Klamath River Basin Fishery Resources Restoration Act" - Public Law 99-552 (100 Stat. 3081, October 27, 1986), as amended by P.L. 100-580. Task Force Formed

1988 Lost River and shortnose sucker listed as endangered under ESA

1988 Hoopa-Yurok Act establishes an independent Yurok Reservation and Tribal government

1990 State of Oregon refuses to issue a permit for the federally-licensed Salt Caves Hydroelectric Project

1991 Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program completed by U.S. Fish and Wildlife Service

1993 Federal Government sets the Klamath tribal fishing to 50% of total available harvest for Fall Chinook

1994 Klamath River from J.C. Boyle Powerhouse to the California-Oregon state line designated "Wild and Scenic" river

1995 Adoption of the Klamath, Six Rivers, and Shasta-Trinity National Land and Resource Management Plans that included findings from the 1993 Forest Ecosystem Management Team and 1994 Record of Decision for the Northwest Forest Plan for the Aquatic Conservation Strategy that mandated watershed restoration, identified key watersheds as strongholds for salmon recovery, and standards and guidelines to protect and restore watershed conditions

Figure 1-2a. Klamath Basin Timeline Since 1905.

1995-1997 Many thousands of adult suckers observed in summer-time die-off in Upper Klamath Lake

1997 Coho salmon listed as Federally threatened by National Oceanic and Atmospheric Administration (NOAA) Fisheries Service under the ESA

1998 South Fork Trinity River sediment TMDL completed

2000 PacifiCorp begins re-licensing proceedings for the Klamath Hydroelectric Project

2001 NOAA Fisheries issues Biological Opinion specifying minimum Iron Gate Dam flow and ramping rates for the protection of SONCC coho salmon for April – September 2001

2001 Water deliveries to Reclamation's Klamath project are curtailed to protect ESA listed species due to drought

2001 Reclamation's Klamath project water delivery curtailments reversed

2001 Trinity River sediment TMDL completed

2002 NOAA Fisheries issues Biological Opinion on Reclamation's proposed operations of the Klamath Project from April 1, 2002 – March 31, 2012

2002 At least 33,000 returning adult salmon, primarily fall-run Chinook, die in the mainstem of the Klamath

2002 Upper Klamath Lake Drainage temperature, dissolved oxygen, and pH TMDLs completed

2002 Coho salmon listed as threatened under the CESA

2003 Construction of new A-Canal headgates and fish screen

2003 North Coast Regional Water Quality Control Board adopts Native American cultural use as a beneficial use of the Klamath River from the Seiad Valley Hydrologic Subarea downstream to the Klamath Glen Hydrologic Subarea

2004 PacifiCorp initiates dam relicensing application with FERC

2004 Construction of Lost River and shortnose sucker friendly fish ladder at Link River Dam

2004 PacifiCorp files Final License Application with FERC to re-license Klamath Hydroelectric Project

2005 KBRA/KHSA talks begin

2005 Commercial salmon ocean harvest restricted on California and Oregon Coast due to weak Klamath stocks

2005 Water quality studies show that Copco and Iron Gate Reservoirs have regular, prolonged blooms of toxic algae in the summertime. Warnings against human contact with the reservoir water begin to be routinely posted

2005 Salmon River temperature TMDL completed

2006 Federal Agencies release drafts of mandatory prescriptions for a new Klamath Hydroelectric Project license, which if finalized will require fishways, flow management changes, and other changes

2006 PacifiCorp challenges scientific foundations of Federal prescriptions in a trial-type hearing under the Energy Policy Act of 2005. Judge's rulings support scientific foundations of most Federal prescriptions

2006 KBRA/KHSA talks intensify

2006 PacifiCorp's license to operate the Klamath Hydroelectric Project expires. The relicensing process continues and the Project continues operation under annual license

2006 Agriculture's contracts for low power rates expire

2006 700 miles of Oregon and California coast closed to commercial salmon fishing due to weak Klamath stocks

2006 Scott River temperature and sediment TMDLs completed

2007 Federal agencies finalize mandatory prescriptions for a new Klamath Hydroelectric Project license, requiring fishways and flow management changes, among other things

2007 FERC issues a Final Environmental Impact Statement for the Klamath Hydroelectric Project

2007 Commercial salmon ocean harvest restricted on California and Oregon coasts due to weak Sacramento River salmon stocks

2007 Shasta River temperature and dissolved oxygen TMDLs completed

2008 California commercial ocean harvest closed due to weak Sacramento River salmon stocks

2008 Removal of Chiloquin Dam opens Lost River and shortnose sucker habitat

2008 Lower Sprague River pH and nutrients TMDLs completed

2008 Removal of Chiloquin Dam opens Sprague River and shortnose sucker habitat

2008 Klamath Hydroelectric Settlement Agreement in Principle Released

2009 Oregon legislature passes Senate Bill 76, which provides for $180 million in PacifiCorp rate-payer contributions to the cost of removing the lower four dams in the Klamath Hydroelectric Project

2009 California commercial ocean salmon harvest closed

2010 Oregon Public Utilities Commission approves Oregon rate-payer contributions of $180 million to dam removal fund

2010 Reclamation significantly decreases water deliveries from Upper Klamath Lake to its Klamath Project to reserve water in Upper Klamath Lake for ESA-listed suckers and provide flow augmentation for ESA-listed coho downstream of Iron Gate Dam to comply with USFWS and NOAA Fisheries Biological Opinions

2010 Public review draft of KBRA released

2010 KHSA and KBRA signed

2010 Klamath River temperature, organic enrichment/low dissolved oxygen, nutrient, and microcystin TMDLs completed

2011 California Public Utilities Commission approves California rate-payer contributions of $13.76 million to dam removal fund

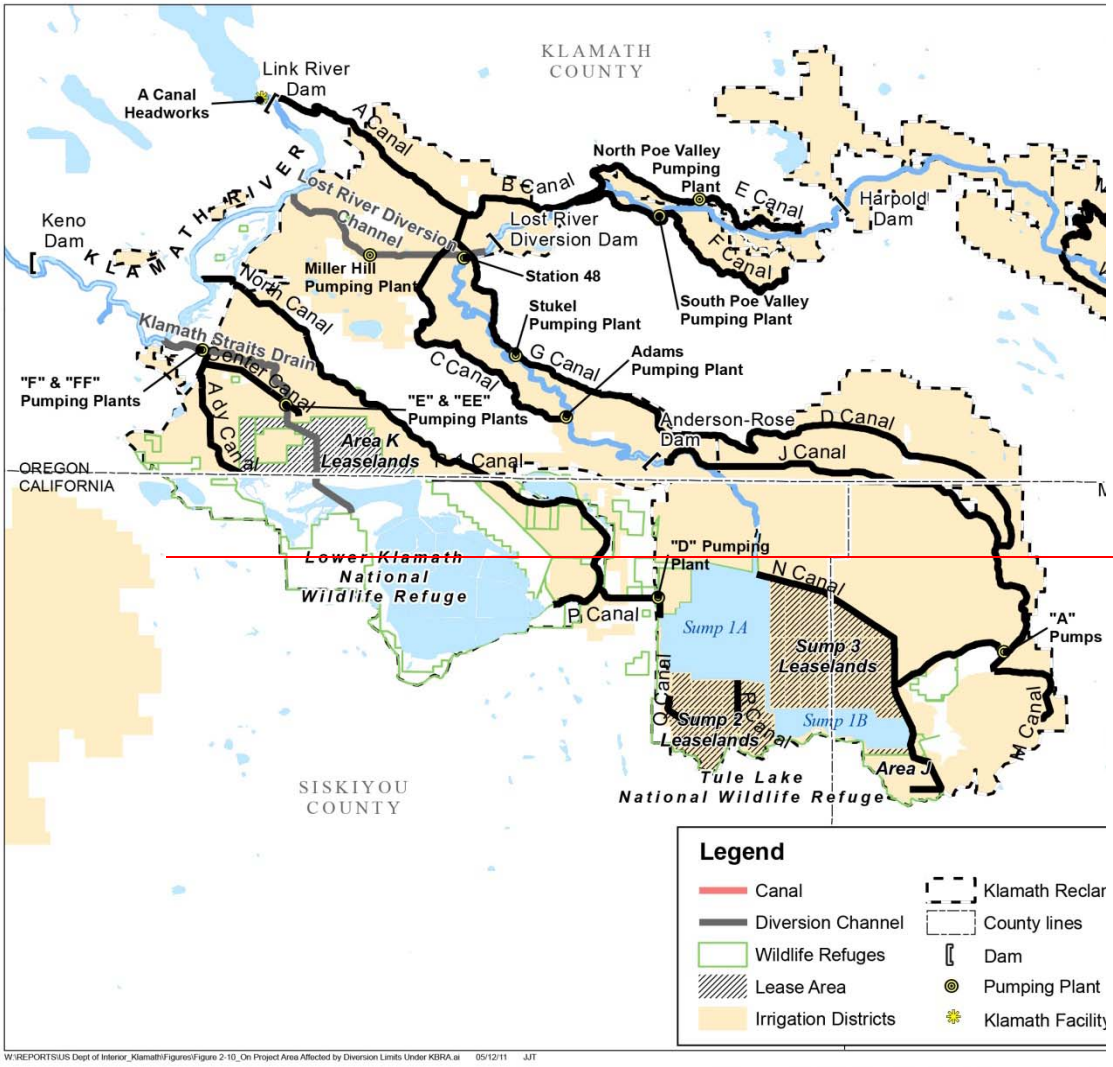
2011 Upper Klamath River and Lost River temperature, dissolved oxygen, pH, ammonia toxicity, and chlorophyll-a TMDLs completed

Figure 1-2b. Klamath Basin Timeline Since 1905.

1.3.4 Reclamation's Klamath Project

In addition to the Klamath Basin's distinctive setting, biological resources, and cultural history, the basin is also the site of one of the first developments authorized under the 1902 Reclamation Act (Public Law 57-161, 32 Stat. 388). Development and construction of Reclamation's Klamath Project took place between 1905 and 1966, with major features of the project completed by the early 1940s. As the largest water management effort in the Upper Klamath Basin, Reclamation's Klamath Project features include a system of reservoirs, dams, canals, and pumps (Figure 1-3), and use of Gerber Reservoir and Clear Lake to reduce flooding of lands in the Tule Lake area. The authorization for Reclamation's Klamath Project stated its purpose:

> *For project works to drain and reclaim lake bed lands of the Lower Klamath and Tule Lakes, to store water of the Klamath and Lost Rivers, including storage of water in Lower Klamath and Tule Lakes, to divert irrigation supplies, and to control flooding of the reclaimed lands.*



~~Figure 1-4. Reclamation's Klamath Project~~

Reclamation's Klamath Project was originally authorized at a time when an increasing number of farmers were drawn to the fertile land in northern California and southern Oregon. Development of Reclamation's Klamath Project converted much of the Tule Lake and Lower Klamath Lake wetland complexes into farmland.

The first dams constructed for Reclamation's Klamath Project included Clear Lake Dam (1910), Lost River Diversion Dam (1912), and Lower Lost River Diversion Dam (1921). Also in 1921, the completion of Link River Dam, executed through a contract between PacifiCorp and the United States, allowed for additional water management in the Upper Klamath Basin. This included greater storage in Upper Klamath Lake, water releases reflecting natural conditions, and controlled releases from the lake to provide a source of irrigation water. The agreement between the power company and the government allowed for PacifiCorp to operate the dam for hydropower production, and in return, the company was to supply low-cost electricity to Reclamation and farmers in the region.

Today, Reclamation's Klamath Project irrigates up to ~~235~~224,000 acres of land on which farmers grow wheat, malt barley, potatoes, onions, alfalfa, and other crops (~~Congressional Research Service 2005~~DOI 2010b). Reclamation's Klamath Project ~~features~~ also ~~provide~~provides recreational opportunities for boating, water skiing, hunting, fishing, camping, and picnicking. In addition, the Klamath Basin National Wildlife Refuge System usually receives water from the operation of Reclamation's Klamath Project for the benefit of waterfowl and other species.

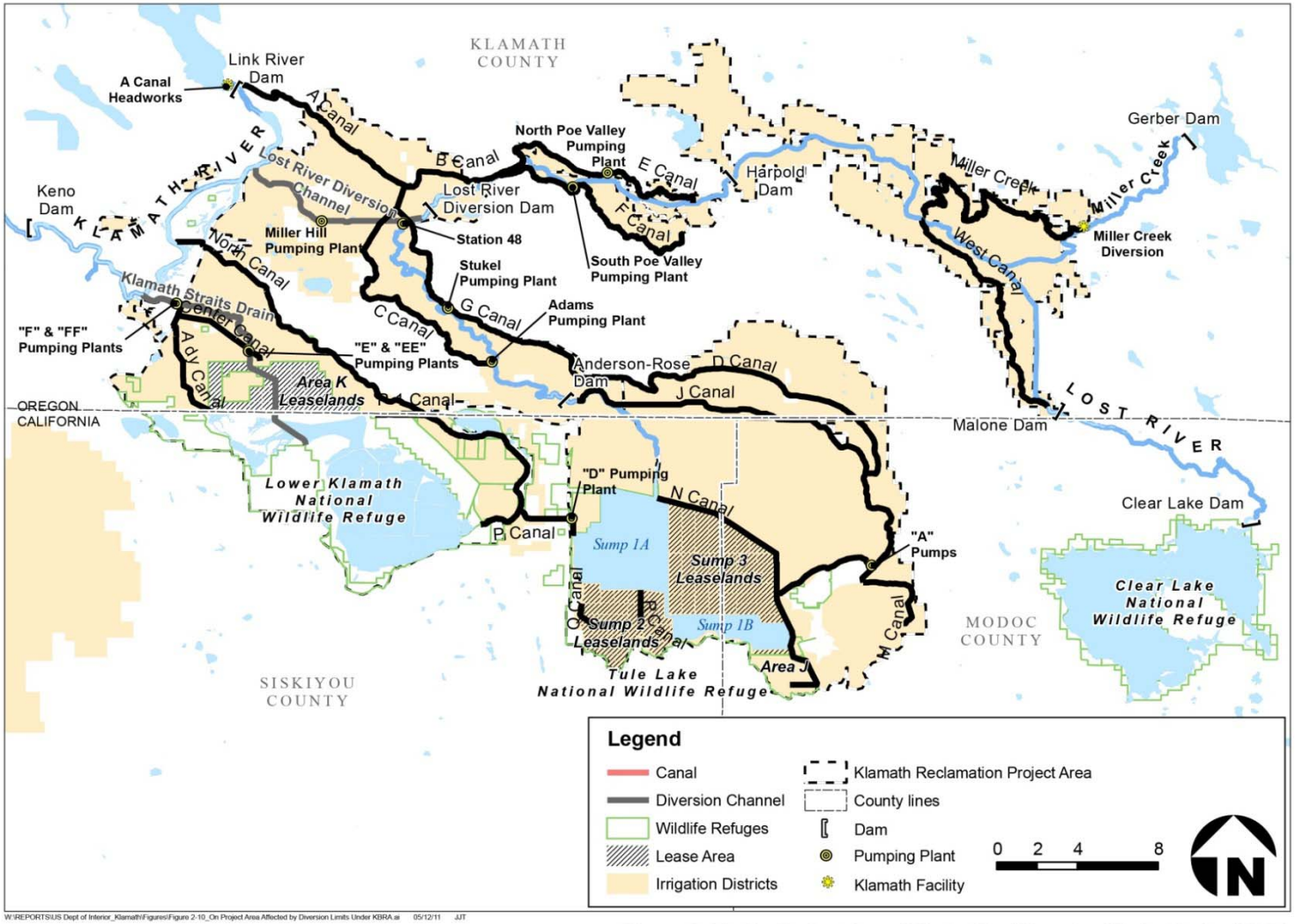


Figure 1-3. Reclamation's Klamath Project.

Reclamation's Klamath Project, with the exception of Clear Lake, does not include multi-year water storage facilities. Upper Klamath Lake represents most of its storage, but the lake is shallow, with an average depth of approximately 9 feet when full (Wood et al. 2006). Upper Klamath Lake can only provide small opportunities for carryover storage between years; therefore, Reclamation's Klamath Project operations are dependent on the amount of annual precipitation. During wet years, Reclamation's Klamath Project irrigators typically receive full contract deliveries of water. In the past few decades, however, Klamath Project irrigators and refuge managers have not always had their requests for water met during drought years because of the need to conserve water for fish in the Klamath River downstream ~~of~~from Iron Gate Dam and in Upper Klamath Lake.

Keno Dam (constructed in 1966 by PacifiCorp) also plays an important role in regulating water elevations in Keno Impoundment/Lake Ewauna for the gravity operation of irrigation canals. Keno Dam is owned by PacifiCorp and is not part of Reclamation's Klamath Project.

1.3.5 Oregon Water Rights Adjudication

If an appropriation of water was initiated prior to the enactment of the Oregon Water Rights Adjudication1909 water code and has not been forfeited or abandoned since then, a water user may have a "vested" water right. Federal reserved water rights vest no later than the date of the reservation, and as early as "time immemorial," regardless of whether they have been used. A claim to a vested water right is quantified and made a matter of record through an adjudication proceeding. The Oregon Water Resources Department (OWRD) is responsible for gathering information about the use of water and presenting its findings to the County Circuit Court. This circuit court is responsible for resolution and issues a decree that states who has the right to use water, the amount and location of water use, and the priority date. A water right certificate is issued for each decreed right (State of Oregon 2009).

The Klamath Basin Adjudication is the adjudication process for pre-1909 and ~~federal~~ Federal reserved water right claims for the use of surface water within the Klamath Basin. The Klamath Basin proceeding began in 1975. Claims of water use have been gathered and contests have been filed on most of those claims. Administrative law judges have been holding hearings and issuing proposed orders determining the claims and contests. The OWRD will review those proposed orders, and any proposed settlements of contests, and submit its Findings and Order of Determination to the Circuit Court in December 2012. Water right claims have been filed by private water users, The Klamath Tribes, Klamath allottees, and the United States (the Klamath Project and for Indian and other ~~federal~~Federal reservations of land). Once OWRD's findings are submitted to court there will be an opportunity for parties to file exceptions to those findings. The Klamath Circuit Court will resolve the exceptions and issue a decree. As of July 2010, 97 percent of contests and 92 percent of the claims in the Klamath have

reached a proposed resolution, either by issuance of an administrative law judge's proposed order or by a proposed settlement of contests (State of Oregon 2010).

1.3.6 Klamath Hydroelectric Project and Relicensing

1.~~2~~3.6.1 Klamath Hydroelectric Project

Constructed between 1911 and 1962, the Klamath Hydroelectric Project includes eight facilities: Iron Gate, Copco 1, Copco 2, J.C. Boyle, Fall Creek, and Keno Dams, and the East and ~~West Side~~Westside developments. The portion of the Klamath River that includes the four most downstream dams is referred to as the Klamath Hydroelectric Reach. Keno Dam was originally constructed to produce power, but hydropower facilities were never developed (PacifiCorp 2004b) and it currently has no generating facilities. Its primary purpose is to maintain water levels in Keno Impoundment/Lake Ewauna for gravity delivery of water into irrigation canals. Link River Dam was constructed for Reclamation's Klamath Project. Link River Dam is operated under Reclamation direction for regulating flows, storing water in Upper Klamath Lake, and hydropower production through the PacifiCorp's East and ~~West Side~~Westside powerhouses.

The purpose of the PacifiCorp Klamath Hydroelectric Project is power generation. In addition, the Four Facilities provide mid to late summer whitewater boating on the Hells Corner Reach as a result of hydropower peaking operations and other recreation opportunities at the existing reservoirs and associated facilities. PacifiCorp's total annual generation from the Klamath Hydroelectric Project is 716,800 megawatt-hours of electricity (FERC 2007). These dams were not designed to provide downstream flood protection or to provide water storage for drought relief (FERC 2007). The J.C. Boyle, Copco 1, and Copco 2 facilities are hydro peaking[9] operations and Iron Gate Dam is operated as a re-regulating facility, so that on a daily basis roughly as much water enters the Hydroelectric Reach as leaves the Hydroelectric Reach. Chapter 2 presents additional information about the physical characteristics of the Four Facilities.

1.~~2~~3.6.2 Federal Energy Regulatory Commission Relicensing

The Klamath Hydroelectric Project is regulated by FERC. The original 1956 license for these dams expired in 2006. The dams have been operating under annual licenses since the original license expired. The annual license specifies the same conditions as the original license. The 1956 PacifiCorp license pre-dated environmental laws, and did not include prescriptions (Section 18 of the Federal Power Act [16 USC 811]) for fish passage over or around the dams; only J.C. Boyle Dam has fish passage facilities, but these fishways do not meet current criteria (Administrative Law Judge 2006).

On February 24, 2004, PacifiCorp filed an application with FERC for a new operating license for the Klamath Hydroelectric Project. FERC prepared a ~~final~~Final EIS for relicensing the project, but no license has been issued. Currently, the relicensing

[9] Peaking: operation of a hydropower projects to meet peak electrical demands.

proceeding ~~is in abeyance~~[10]remains active. Until a decision is made regarding its license application, PacifiCorp will continue to operate the dams under annual licenses from FERC.

As part of the process for the 2004 relicensing application, a variety of stakeholders (individuals, ~~tribes,~~ Indian Tribes, fishing interests, and conservation groups) expressed a strong desire that the four hydroelectric dams be decommissioned and removed to address declining fisheries in the lower Klamath River and reopen approximately 43 miles of blocked mainstem river habitat between Iron Gate and Keno Dams and hundreds of miles of stream habitat in Upper Klamath Basin tributaries. Fish considerations were a major subject during the relicensing process.

~~During relicensing, several agencies, led by the~~ The National Oceanic and Atmospheric Administration (NOAA) Fisheries Service~~, in addition to other agencies with 10(a) authorities,~~ recommended to FERC under ~~Section 10(a) authority of the~~ Federal Power Act~~,~~ Section 10(a) removal of the Four Facilities as the ~~preferred measure to protect declining Klamath River fisheries~~best alternative to contribute to restoration of all fish species of concern in the Klamath watershed. Concurrently under Section 18 authority of the Federal Power Act, NOAA Fisheries Service (the Secretary of Commerce's authority under the ~~Department of Commerce~~FPA has been delegated to the NOAA Fisheries Service) and DOI prescribed mandatory fishways and passage at each mainstem dam. Flows were conditioned from J. C. Boyle for riparian habitat, whitewater recreation, and attraction flows for fish passage by DOI under Section 4(e) authority. The fishway prescriptions by the ~~Department of Commerce~~NOAA Fisheries Service and the DOI were strongly supported by basin tribes, fishing interests, and conservation groups to address declining fisheries in the lower Klamath River and to reopen blocked habitat. The fishway prescriptions and the DOI's ~~prescriptions~~conditions were challenged by PacifiCorp and others under the Energy Policy Act of 2005, in a trial-type hearing that considered disputed issues of material fact relating to the prescriptions and conditions. The resulting Administrative Law Judge decision (*In the Matter of: Klamath Hydroelectric Project, Docket* Number 2006-NMFS-0001, September 27, 2006) found that ~~the agencies met their~~ PacifiCorp failed to meet its burden of proof regarding most of the factual issues in dispute. FERC conducted environmental analysis of the proposed project, including the mandatory terms and conditions and prescriptions in 2007. However, the FERC relicensing proceedings are ~~in abeyance at present~~still active; accordingly, the mandatory terms and conditions and fishway prescriptions, and the terms of Biological Opinions issued by the USFWS and NOAA Fisheries Service to FERC for the new license, have not been incorporated as terms of the Klamath Hydroelectric Project ~~annual permits~~license.

Before FERC ~~may issue any new FERC license for~~relicenses the Klamath Hydroelectric Project, the states of Oregon and California must also issue water quality certification under Section 401 of the Clean Water Act. The California State Water Resources Control Board (SWRCB) cannot issue certification until environmental documentation ~~sufficient for consideration of the alternative of conditioning certification on dam~~

---

[10] ~~Abeyance: a state of temporary suspension~~

removal, consistent with the requirements of the CEQA, is completed. The certification proceedings are currently being held in abeyance as requested in Section 6.5 of the KHSA. The SWRCB held a hearing on July 7, 2012, on this matter. The SWRCB decided to continue holding the certification in abeyance, however, SWRCB then noted they could not continue to do so indefinitely. In a February 2009 letter addressing their CEQA Notice of Preparation, the agency noted that failing to process the water quality certification in a timely manner risks a FERC determination that the Board has waived of certification, and the State of California would have no regulatory authority to address water quality issues associated with the Klamath Hydroelectric Project during the FERC relicensing.

1.34 KHSA and KBRA

The KHSA was an outcome of the FERC's Alternative Dispute Resolution Procedures as outlined in the Energy Policy Act of 2005[11] (18 C.F.R.FR 385.601, et seq.) wherein the parties elected to set aside differences to reach resolution on a settlement that is in furtherance of the interests of all of the parties. As established in Section 1.2 of the KHSA, many of the parties to the settlement maintain that removal will help restore basin resources and all Signatorysignatory parties agree that settlement is in the public interest. As also specified in the KHSA, and in compliance with applicable law, the Secretary is undertaking a scientific and environmental analysis of potential facilities removal, and connected actions under the KBRA. The Secretary acknowledges that full implementation of the KHSA will depend on factors not entirely within the control of the settling parties and that failure to implement the KHSA, like any proposed settlement, could lead to a resumption of the underlying new licensing proceeding for the Klamath Hydroelectric Project that is pending before the FERC. As a consequence, should the FERC proceeding resume for any reason, we want to remind the reader that the analysis in this EIS/EIR was undertaken pursuant to the KHSA for the purpose of implementation of this settlement and to inform the Secretary in his determination under the KHSA regarding dam removal. This analysis and its comparison of alternatives is being conducted pursuant to NEPA and CEQA and solely in support of the determination to be made by the Secretary pursuant to the KHSA, a negotiated settlement agreement. It is not prepared to inform any other determinations made or environmental documents prepared pursuant to NEPA or CEQA outside the KHSA framework, including FERC's determination in the Klamath Hydroelectric Project licensing proceeding, which is to determine whether, and if so, under what prescriptionsconditions, to issue a new license for the Klamath Hydroelectric Project, or the States' determinations including whether,

[11] Section 442 of the Energy policy Act of 2005, Pub. L. 109-58, SS 241, 119 Stat, 594, 67475 (Aug. 8, 2005) ("EPAct") (codified in 16 U.S.C. SS 797 (e) and 811), and the underlying procedural regulations codified in 50 C.F.R. Part 221.

and under what conditions, to issue a ~~section~~Section 401 water quality certification for the Klamath Hydroelectric Project and associated environmental documents.

Negotiations leading to the KBRA began in 2005 after the water-related farming and fisheries crises ~~occurred~~ in 2001 and 2002. The negotiation process also coincided with PacifiCorp's 2004 relicensing application. The proposed KBRA was released in January 2008. The KHSA and KBRA are negotiated agreements and reflect the cooperative effort by more than 40 parties in the basin, representing different interest groups. The agreements were negotiated and written to be executed together and are referred to herein as the Klamath Settlement. Representatives of ~~federal~~Federal agencies, the states of California and Oregon, Indian Tribes, counties, farmers, and conservation and fishing groups agreed to the comprehensive solutions presented in the KHSA and KBRA[~~12~~].[13]

From the KHSA…

"By March 31, 2012, the Secretary shall use best efforts to (i) determine whether the costs of Facilities Removal as estimated in the Detailed Plan, including the cost of insurance, performance bond, or similar measures, will not exceed the State Cost Cap, and (ii) otherwise complete his determination whether to proceed with Facilities Removal as described in Section 3.3.1, provided that any such determination shall not be made until the following conditions have been satisfied:

A. Federal legislation, which in the judgment of the Secretary is materially consistent with Appendix E, has been enacted;
B. The Secretary and PacifiCorp have agreed upon acceptable terms of transfer of the Keno facility pursuant to Section 7.5.2;
C. The States of Oregon and California have authorized funding for Facilities Removal as set forth in Section 4 of this Settlement;
D. The Parties have developed a plan to address the excess costs, consistent with Section 4.10 of the Settlement, if the estimate of costs prepared as part of the Detailed Plan (including the cost of insurance, performance bond, or similar measures) shows that there is a reasonable likelihood such costs are likely to exceed the State Cost Cap; and
E. The Secretary has identified a DRE[1] designate, and, if the DRE-designate is a non-federal entity: (i) the Secretary has found that the DRE-designate is qualified; (ii) the States have concurred in such finding; the (iii) the DRE-designate has committed, if so designated, to perform Facilities Removal within the State Cost Cap (KHSA Section 3.3.4)."

~~[12] Although representatives of the federal agencies participated in negotiations for both the KHSA and the KBRA, federal agencies did not sign the KBRA.~~

[13] Although representatives of the Federal agencies participated in negotiations for both the KHSA and the KBRA, Federal agencies did not sign the KBRA.

From the KHSA…

"By March 31, 2012, the Secretary shall use best efforts to (i) determine whether the costs of Facilities Removal as estimated in the Detailed Plan, including the cost of insurance, performance bond, or similar measures, will not exceed the State Cost Cap, and (ii) otherwise complete his determination whether to proceed with Facilities Removal as described in Section 3.3.1, provided that any such determination shall not be made until the following conditions have been satisfied:

F. Federal legislation, which in the judgment of the Secretary is materially consistent with Appendix E, has been enacted;

G. The Secretary and PacifiCorp have agreed upon acceptable terms of transfer of the Keno facility pursuant to Section 7.5.2;

H. The States of Oregon and California have authorized funding for Facilities Removal as set forth in Section 4 of this Settlement;

I. The Parties have developed a plan to address the excess costs, consistent with Section 4.10 of the Settlement, if the estimate of costs prepared as part of the Detailed Plan (including the cost of insurance, performance bond, or similar measures) shows that there is a reasonable likelihood such costs are likely to exceed the State Cost Cap; and

J. The Secretary has identified a DRE[1] designate, and, if the DRE-designate is a non-Federal entity: (i) the Secretary has found that the DRE-designate is qualified; (ii) the States have concurred in such finding; the (iii) the DRE-designate has committed, if so designated, to perform Facilities Removal within the State Cost Cap (KHSA Section 3.3.4)."

[1] DRE: Dam Removal Entity

1.~~3~~4.1 KHSA

The KHSA establishes the process for additional studies, including the development of a "Detailed Plan for Facilities Removal" (Detailed Plan) and environmental review to support the Secretary's Determination as to whether removal of the four downstream-most dams on the Klamath River that are owned by PacifiCorp (1) will advance restoration of the salmonid fisheries of the basin, and (2~~)~~) is in the public interest, which includes, but is not limited to, consideration of the potential impacts on affected local communities and ~~tribes~~Indian Tribes.

The KHSA also includes provisions for the interim operation of the Four Facilities by PacifiCorp and the process to transfer, decommission, and remove the dams.

1.~~3~~4.1.1 Detailed Plan and Other Studies

The Parties[14] to the KHSA agreed further studies were needed to determine if the actions specified under the KHSA were feasible. These studies include analysis of the regional impacts of both the KHSA and the KBRA on water quality, economics, real estate, recreation, and biology.

[14] Parties: Signatories to the Klamath Hydroelectric Settlement Agreement.

The findings of these studies are summarized in the *Final Klamath Dam Removal Overview Report for the Secretary of the Interior – an Assessment of Science and Technical Information* (DOI and DOC [NOAA Fisheries Service] 2012).

In addition, the Secretary's Determination and concurrence from the states will also be based, in part, on a Detailed Plan that describes the following:

- Physical methods to remove the dams and achieve a free-flowing condition.
- As necessary and appropriate, plans for management, removal, and/or disposal of sediment, debris, and other materials.
- A plan for site remediation and restoration.
- A plan for measures to avoid or minimize adverse downstream impacts.
- A plan for compliance with all Applicable Laws, including anticipated permits and permit conditions.
- Estimated costs.
- A statement of measures to reduce risks of cost overruns, delays, or other impediments to Facilities Removal.
- The identification, qualifications, management, and oversight of a non-federalFederal Dam Removal Entity (DRE), if any, that the Secretary may designate.

The Overview Report, Detailed Plan, and other studies produced as part of the Secretarial Determination process are available online at: www.klamathrestoration.gov.

1.34.1.2 State Cost Cap

The KHSA sets a cost cap of $450 million for removal of the Four Facilities. In addition, pending regulatory approval, the KHSA allows for PacifiCorp to recover the costs of the company's net investment in the facilities, the ongoing operating costs, and the costs of replacement power. The $450 million would come from the State of California and PacifiCorp's ratepayers. Specifically, an amount not to exceed $200 million would come from additional charges to PacifiCorp customers (residing in either state) and $250 250 million from the sale of California bonds or other means at the discretion of California. The United States would not be responsible for the costs of facilities removal.

1.34.1.3 Secretarial Determination

The KHSA establishes a process for the Secretarial Determination. This process also includes decisions by the States of Oregon and California as to whether they concur with the Secretarial Determination. Implementation of the KHSA requires both federalFederal legislation and for the Secretary to make a determination, in cooperation with the Secretary of Commerce and other federalFederal agencies as appropriate, regarding facilities removal, particularly whether, in his judgment, the conditions of the KHSA have been satisfied, and whether facilities removal should proceed. This process includes existing and additional studies, environmental review, and the decision by the Secretary.

1.4.1.3.1 Affirmative Determination

If the Secretary finds that the removal of the facilities would advance restoration of the salmonid fisheries and is in the public interest, an Affirmation Determination, as defined under Section 3 of the KHSA, can be made. Once the Secretary has made an Affirmation Determination, California and Oregon would also provide notice to the Secretary and other parties within 60 days on whether each stateState concurs with the Affirmative Determination. The KHSA provides for each stateState to consider two factors when deciding to concur or not: 1) whether significant impacts identified in its environmental review can be avoided or mitigated as provided under its stateState law, and 2) whether facilities removal will be completed within the stateState cost cap (defined as the collective maximum monetary contribution from the states of California and Oregon, described below and in Section Section 4.1.3 of the KHSA).

As part of an Affirmative Determination, the Secretary will also concurrently designate the entity that will serve as the DRE. The DRE, once identified, would develop a Definite Plan for Facilities Removal which would include all the information necessary to implement the Detailed Plan as well as the additional elements listed in KHSA Section Section 7.2.A. The Secretary must consult with the Parties to the KHSA prior to designating a non-federalFederal DRE and receive concurrence from the states with that selection.

In addition to the decommissioning and removal of the Four Facilities, actions associated with an Affirmative Determination would include the transfer of Keno Dam ownership from PacifiCorp to DOI, which is analyzed as a connected action in this EIS/EIR.

1.4.1.3.2 Negative Determination

If the Secretary determines not to proceed with facilities removal, the KHSA terminates unless the Parties can agree to a remedy for the issues leading to the Negative Determination[15]. [16] Prior to adopting or public release of such a determination, the Secretary would notify the Parties of the tentative determination and its basis. The Parties would consider whether to amend the KHSA in a manner that would permit the Secretary to make an Affirmative Determination.

1.34.1.4 KHSA Implementation

If an Affirmative Determination is made, PacifiCorp would transfer ownership of each facility when the DRE provides notice that all necessary permits and approvals have been obtained for removal of a facility, all contracts necessary for facility removal have been finalized, and facility removal is ready to commence. After the transfer, the DRE would remove the facilities. The target date to begin deconstruction is January 1, 2020.

---

[15] Negative Determination: A determination by the Secretary of the Interior under Section 3 of the Klamath Hydroelectric Settlement Agreement that facilities removal should not proceed.

[16] Negative Determination: A determination by the Secretary of the Interior under Section 3 of the Klamath Hydroelectric Settlement Agreement that facilities removal should not proceed.

1.4.1.4.1 Local Power

Section 5 of the KHSA includes terms for collaborative efforts between PacifiCorp and the Parties to identify potential ways to reduce impacts of dam removal on local community power. However, the KHSA does not provide for specifics on this collaborative effort, and therefore is not included in the analysis presented in this EIS/EIR. For further information see Section 5 of the KHSA.

1.4.1.4.2 KHSA Interim Measures

The KHSA includes interim measures for the operation of the Klamath Hydroelectric Project by PacifiCorp from the effective date of the agreement (February 18, 2010) or as otherwise specified for each interim measure. If the Secretary makes an Affirmative Determination, PacifiCorp would continue to perform the interim measures until decommissioning. If there is a Negative Determination or the KHSA terminates for other reasons prior to decommissioning, then the interim measures may generally cease, except for the purposes of the Clean Water Act or the ~~Endangered Species Act~~ESA. These measures include the implementation of measures

included as part of PacifiCorp's Interim Conservation Plan[17]. (ICP).[18] Measures from the Interim Conservation PlanICP (see Appendix C of the KHSA) include funding forare included in the Habitat Conservation Plan (HCP). The HCP requires PacifiCorp to fund projects to enhance the survival and recovery of ESA-listed coho salmon, turbine venting to improve dissolved oxygen concentrations downstream offrom Iron Gate Dam, funding for the development and implementation of a Hatchery Genetics Management Plan for Iron Gate Hatchery, increased flow variability at Iron Gate Dam, and studies on fish disease. On March 13, 2012, NOAA Fisheries Service issued an Incidental Take Permit (ITP) that authorizes potential take associated with Klamath Hydroelectric Project operations and Interim Measure implementation. Under the ITP, PacifiCorp is required to implement a HCP that contains measures to minimize and mitigate Project effects on coho salmon. The HCP was developed by PacifiCorp over a period of several years with involvement from NOAA Fisheries Service, CDFG, and other stakeholders in the basin. The HCP, ITP, and supporting documents are available at http://swr.nmfs.noaa.gov/nepa.htm.

Appendix D of the KHSA provides additional measures to be implemented during the interim period. These measures include funding restoration activities, increasing monitoring activities, removing the J.C. Boyle bypass barrier, funding water quality research, funding to the Bureau of Land Management for the land management measures in Appendix C of the KHSA, possibly removing three diversions on Shovel and Negro Creeks, and funding for Iron Gate Hatchery operations and maintenance (including funding for an 8-year period after removal of Iron Gate Dam).

1.4.1.4.3 Yreka Water Supply

The City of Yreka has a municipal water supply intake on Fall Creek and a pipeline that crosses Iron Gate Reservoir; the pipeline would be affected if the Iron Gate Dam were removed. The KHSA addresses the possible impacts that facilities removal would have on the water supply pipeline for the City of Yreka and provides provisions for mitigation of impacts on this supply system. Signatories agree not to prevent use of Yreka's Water Rights permit and will study the potential risks to the water supply system from facilities removal. Necessary actions for the continued use of the Yreka water supply infrastructure would be funded and implemented as part of implementation of the KHSA (Section 7.2.3).

---

[17] As described in the KHSA, the Interim Conservation Plan was developed by PacifiCorp through technical discussions with the NOAA Fisheries Service and the USFWS describing measures for the enhancement of coho salmon and suckers listed under the ESA (see KHSA Appendix A). The Interim Conservation Plan was submitted to FERC on November 25, 2008 and can be found online through the FERC website. (http://ferc.gov).

[18] As described in the KHSA, the Interim Conservation Plan was developed by PacifiCorp through technical discussions with the NOAA Fisheries Service and the USFWS describing measures for the enhancement of coho salmon and suckers listed under the ESA (see KHSA Appendix A). The Interim Conservation Plan was submitted to FERC on November 25, 2008 and can be found online through the FERC Web site (http://ferc.gov).

1.4.1.4.4 Keno Facilities Transfer

The KHSA calls for transferring ownership and operation of Keno Dam from PacifiCorp to DOI. The Secretary and PacifiCorp are studying the proposed transfer of Keno facilities (the Keno Transfer). An Affirmative Determination by the Secretary depends on an agreement between the Secretary and PacifiCorp on terms for transfer of title of the Keno facility. Further, transfer of title shall be subject to completion of any necessary improvements to the facility to meet DOI directives and standards for dam safety identified by the DOI through its safety of dams inspection of the Keno facility. This EIS/EIR will analyze the impacts associated with the Keno Transfer as a connected action.

1.4.1.4.5 East and ~~West Side~~Westside Powerhouse Decommissioning

PacifiCorp's East and ~~West Side~~Westside facilities were proposed for decommissioning in PacifiCorp's 2004 relicensing application, and their decommissioning through the FERC process is described in the KHSA (KHSA 6.4.1(B)). Removing the two facilities would result in the loss of 3.8 megawatts of generating capacity and the removal of the generating infrastructure. The dams and associated infrastructure were built in 1921, and would require upgrading and maintenance to remain in compliance with DOI and FERC standards. This would include the installation of fish screens, which would require major construction changes and associated maintenance. The Link River Dam, which is the point of diversion for the two generating facilities, is already owned by Reclamation.

As noted above, the East and ~~West Side~~Westside facilities decommissioning ~~is not dependant on an Affirmative Determination, and will~~ would be carried out through application to the FERC. ~~This application will require future~~ FERC will conduct any necessary environmental ~~compliance~~ analysis and make a FERC determination. This EIS/EIR uses a programmatic analysis to evaluate the impacts associated with the East and Westside facilities decommissioning as a connected action.

1.~~3~~4.2 KBRA

As a result of the Klamath Basin issues surrounding the limited availability of water to support agricultural, tribal, environmental, and fishery needs in many years, the United States[19]~~;~~;[20] the States of California and Oregon; the Klamath, Karuk, and Yurok Tribes; Reclamation's Klamath Project Water Users; and other Klamath Basin stakeholders (collectively the Parties) negotiated the KBRA to resolve the water conflicts among the many users, restore stressed fisheries, and identify reliable power supplies. The ~~KBRA is~~ KBRA is intended to result in effective and durable solutions. The goals of the KBRA are to (1~~)~~) restore and sustain natural fish production and provide for full participation ~~in~~

[19] ~~Agencies involved in KBRA negotiations include: NOAA Fisheries Service, U.S. Forest Service, U.S. Department of the Interior (including, the Bureau of Indian Affairs, Bureau of Land Management, Bureau of Reclamation, and Fish and Wildlife Service).~~

[20] Agencies involved in KBRA negotiations include: NOAA Fisheries Service, U.S. Forest Service, U.S. Department of the Interior (including, the Bureau of Indian Affairs, Bureau of Land Management, Bureau of Reclamation, and Fish and Wildlife Service).

in ocean and river harvest opportunities of fish species throughout the Klamath Basin~~;~~ ; (2~~)~~) establish more reliable water and power supplies which sustain agricultural uses, communities, ~~and~~ and NWRs; and (3) contribute to the public welfare and the sustainability of all ~~Klamath~~ Klamath Basin communities. The Parties view these ~~agreements as~~ agreements as an important ~~part of~~ part of the resolution of long-standing, complex, and difficult-to-resolve concerns ~~over~~ over resources in the Klamath Basin.

Negotiations leading to the KBRA began in 2005 after the water-related farming and fisheries crises occurred in 2001 and 2002. The negotiation process also coincided with PacifiCorp's 2004 relicensing application. The proposed KBRA was released in January 2008. The KBRA includes plans and programs that interrelate with each other and with facilities removal as contemplated by the KHSA, and is intended to benefit fish throughout the basin, water users in the Upper Klamath Basin, and the community overall. The KBRA brings many parties together, including ~~federal and state~~Federal and State agencies, Indian Tribes, Reclamation's Klamath Project irrigators, and on- and off-Project water users to support one another's efforts to restore fish populations in the Klamath Basin and provide for sustainable communities with a strong agricultural base. The KBRA has required each party to make some concessions in order to secure assurances on other important interests. These compromises include:

- Through the agreement, the Klamath, Karuk, and Yurok Tribes, the signatory ~~tribes~~Indian Tribes, have agreed to ~~not fully exercise their senior~~ water rights ~~to achieve fisheries restoration and to withdraw claims for damages due to the loss of those fisheries.~~assurances as defined in KBRA Section 15.3. Under the KBRA, the tribes would benefit from a suite of fisheries restoration and reintroduction measures that would complement dam removal pursuant to the KHSA, improvements in water quantity and quality in the lakes and rivers of the basin, and other habitat improvements that would support a sustainable fishery throughout the basin.
- ~~Most~~ Representative organizations of water users and irrigators, both on-Project and off-Project, agreed to limit their water diversions in exchange for increased predictability about seasonal water deliveries and affordable power supplies~~.~~.[21] Increased predictability allows individual landowners to more efficiently plan annual operations and avoid the economic impacts that result from uncertainty. The economic impacts felt at the individual level ripple up through the whole community, so this increased certainty benefits everyone. As reintroductions of currently threatened and endangered fish species are successfully implemented, the KBRA envisions that landowners will benefit from

[21] Off-project water users may also be eligible for affordable power benefits without reducing their surface water diversions, if other criteria are met (See KBRA § 17.3.2.C).

regulatory assurances (under the ESA[22]) that their operations would not be additionally burdened by new regulatory restrictions to the extent legally possible.

Under this system of compromises, the question of who "goes first" becomes critical. Some of the provisions in the agreement may take over 10 years to be implemented and ~~so~~ many of the proposed actions need to be started in good faith. The KBRA establishes a framework for interim actions and planning efforts that would involve the broader community and protect the Parties' interests during the interim period. The interim period is the time between the signing of the KBRA and full implementation of the limits on water diversions to Reclamation's Klamath Project. The plans and programs described in the KBRA lead through a series of milestones that culminate in the formal relinquishment of claims for damages, permanent assurances related to tribal water rights, and limitations on water diversions to Reclamation's Klamath Project.

Programmatic Analysis
A program-level analysis is appropriate when a project consists of a series of smaller projects or phases that may be implemented separately. Under the programmatic approach, future projects or phases may require additional, project-specific environmental analysis.

Programmatic Analyses Completed in this Document
KBRA
East Side and West Side Powerhouse Decommissioning
Trap and Haul around Keno Impoundment
Yreka Water Supply Pipeline

An Affirmative Determination and ~~federal~~Federal authorizing legislation are two early key milestones towards full implementation of the KBRA. Following an Affirmative Determination, the key milestones leading to the publication of a Secretarial Notice, which make ~~federal~~Federal water assurances permanent and is a prerequisite to other water rights assurances and diversion limitations, are described below:

1) "The application deadline under Section 15.3.8.A for full implementation of the On-Project Plan has passed.
2) The required environmental analysis regarding the proposed project to reconnect the Wood River Wetlands to Upper Klamath Lake as described in Section 18.2.3 is completed, and any necessary funding to implement the preferred alternative of the required environmental analysis is authorized by Congress or that funding is otherwise committed by state, local, tribal, or private sources.
3) The required environmental analysis regarding the proposed project to reconnect Agency Lake and Barnes Ranches to Upper Klamath Lake as described in Section 18.2.2.C is completed, and any necessary funding to implement the preferred

[22] These regulatory assurances do not apply to the Clean Water Act, the Porter-Cologne Water Quality Control Act, or to any other authorities beyond the Endangered Species Act.

alternative of the required environmental analysis is authorized by Congress or that funding is otherwise committed by state, local, tribal or private sources.

~~4)~~ Funding has been authorized for the Water Use Retirement Program described in Section 16.2.2~~; and~~

4) .

5) The physical removal of all or part of each of the Hydroelectric Facilities has occurred and achieved a free-flowing condition and volitional fish passage." (KBRA Section 15.3.4.A).

Programmatic Analysis
For purposes of CEQA, the KBRA analysis is programmatic, as described in Section 15168 of the CEQA Guidelines. A program-level document is appropriate when a project consists of a series of smaller projects or phases that may be implemented separately. Under the programmatic EIR approach, future projects or phases may require additional, project-specific environmental analysis.

Analysis Completed in this Document
KHSA – Project Level
Keno Transfer – Project Level
KBRA – Programmatic Level
East Side and West Side Powerhouse Decommissioning – Programmatic Level
Trap and Haul around Keno Impoundment – Programmatic Level

~~Following publication of the Secretarial Notice, the Klamath, Karuk, and Yurok Tribes would make appropriate filings making tribal water rights assurances permanent and releasing breach of trust claims against the federal government. The key milestones that lead towards these tribal concessions include the following:~~

~~1) Federal authorizing legislation enacted~~

~~2) Publication of the Secretarial Notice and its associated milestones~~

~~3) Funding secured for implementation of the Phase I and Phase II Fisheries Restoration Plans, Phase I Fisheries Reintroduction Plans, Fisheries Monitoring Plan, the voluntary Water Use Retirement Program, and the Interim Flow and Lake Level Protection Program and Regulatory Assurance Programs~~

~~4) Funding secured for tribal resource management programs and for the Mazama Forest purchase~~

~~5) Removal of the hydroelectric facilities as provided under the KHSA~~

~~6) Approval of The Klamath Tribes request for an interim fishing site between Iron Gate Dam and I-5~~

Once the ~~federal~~Federal and tribal water rights assurances have been made permanent, the diversion limits on Reclamation's Klamath Project, including a Refuge Allocation, would become permanent.

~~The federal lead agency~~The Federal Lead Agency is analyzing the KBRA as a connected action. NEPA defines connected actions as those actions that are closely related or cannot or will not proceed unless other actions are taken previously or simultaneously (40 Code of Federal Regulations (CFR) 1508.25(a)(1)(ii)).[23] Some actions or component elements of the KBRA are independent obligations and thus have independent utility from the KHSA, but the implementation of several significant elements of the KBRA package would be different, if the determination under the KHSA is not to pursue full dam removal (see Table 1-1). Recognizing that implementation of many elements of the KBRA ~~are~~ is unknown and not reasonably foreseeable at this time, the connected action analysis is being undertaken at a programmatic level~~.~~. Consequently, appropriate NEPA compliance will be completed for the KBRA in the future. The KBRA and KHSA are available in their entirety from the ~~web site klamathrestoration.gov~~Web site http://klamathrestoration.gov/. The updated table of KBRA programs (since February 2010) is available at: http://216.119.96.156/Klamath/2011/06/RevisedCostEstimates.pdf.

Table 1-1. Linkage of KBRA Programs, Plans, Commitments to Dam Removal[1]

Program, Plan, or Commitment	Linked to Dam Removal and Secretarial Determination	KBRA Programs Included in this analysis as a Connected Actions under NEPA
Fisheries Programs:		
Fish Habitat Restoration Activities	T	
Fisheries Restoration Phase I Plan	T	
Fisheries Restoration Phase II Plan	T	
Fisheries Reintroduction Plan – Phase I, Oregon	T	
Fisheries Reintroduction Plan – Phase II, Oregon	T	
Fisheries Reintroduction Plan – California	T	
Fisheries Monitoring Plan	T	
Additional Water Storage Projects:		X
Williamson River Delta Project		X
Agency Lake and Barnes Ranches Project		X
Wood River Wetland Restoration Project		X
Future storage opportunities		X
Water Resources Program:		
Water Diversion Limitations for Reclamation's Klamath Project Including National Wildlife Refuges	O	
Water Deliveries for National Wildlife Refuges in Klamath Reclamation Project Area	O	
Groundwater Technical Investigations		X
On-Project Plan		X

[23] We acknowledge, however, that the actions that constitute KBRA could also be analyzed as ~~a~~ cumulative or similar ~~action~~actions under 40 CFR 1508.25(a)(2) and (3). We note that all three definitions (connected action, cumulative actions, and similar actions) are within the section that provides parameters for the "scope" of the action, which determines both the range of alternatives and the impacts to be considered in an EIS. Ultimately, however, we believe the important point is not the labeling but the analysis and whether the decision (in this case, whether to remove four dams) is informed by an EIS that is proper in scope.

Table 1-1. Linkage of KBRA Programs, Plans, Commitments to Dam Removal[1]

Program, Plan, or Commitment	Linked to Dam Removal and Secretarial Determination	KBRA Programs Included in this analysis as a Connected Actions under NEPA
Commitments among Project Irrigators, Party Tribes, and U~~.S.~~nited States Related to Water Use/Rights	O	
Commitments Related to Finance Issues (§§ 15.4.2., 15.4.4.)		X

Table 1-1. Linkage of KBRA Programs, Plans, Commitments to Dam Removal[1]

Program, Plan, or Commitment	Linked to Dam Removal and Secretarial Determination	KBRA Programs Included in this analysis as a Connected Actions under NEPA
Operation of Klamath Reclamation Project Facilities (Link River and Keno Dams)	O	
Water Use Retirement Program (WURP)		X
Off-Project Water Settlement (OPWAS)		X
Off-Project Reliance Program		X
Power for Water Management Program and Plans		X
Drought Plan		X
Emergency Response Plan		X
Climate Change Assessment		X
Environmental Water Management		X
Interim Flow and Lake Level Program		X
Regulatory Assurances Programs:		
Fish Entrainment Reduction	T	
General Conservation Plan or Habitat Conservation Plan	T	
Regulatory Assurances from Non-Regulatory Parties	T	
County and Tribal Programs:		
Klamath County Economic Development Plan		X
California Water Bond Legislation (Siskiyou County Economic Development Funding)	O	
Tribal Programs Fisheries and Conservation Management		X
Tribal Programs Economic Revitalization		X
Mazama Forest Project		X
Klamath Tribes Interim Fishing Site		X

Notes

T means timing is related to dam removal or Secretarial Determination

O means other relationship to dam removal or Secretarial Determination through funding or other key milestones described in the KBRA

X means this Program, Plan, or Commitment is considered a connected action under NEPA for this analysis

1 As explained above, for purposes of this EIS/EIR, we have determined that the KBRA should be evaluated in its entirety as a connected action. The purpose of this table is to show those individual activities under the KBRA that are not linked to the removal of the ~~four facilities~~Four Facilities in order to provide an understanding of the potential effect to the KBRA in the absence of facilities removal. It shows~~-~~ those individual KBRA activities that are expressly linked to removal of the ~~four facilities~~Four Facilities and those individual activities under the KBRA that are not linked to facilities removal. In the absence of facilities removal these activities may still proceed independently but the KBRA will not include all of the components present in its current form and some activities could be substantially altered or even avoided by parties who seek dam removal as a primary pre-condition for the commencement of their obligations. While we have decided to analyze the KBRA in its entirety as a connected action, we believe it also appropriate to show the relationship to dam removal of each of its component parts.

1.~~4~~ 5 NEPA/CEQA

1.~~4~~5.1 NEPA/CEQA Requirements

This document is a joint EIS/EIR, developed to satisfy the requirements of both NEPA and CEQA by disclosing to decision-makers and the public, significant environmental impacts of the Proposed Action, identifying feasible mitigation measures, and describing a reasonable range of alternatives prior to rendering any final decisions or issuing any permits, agreements, or authorizations on the Proposed Action~~.~~ or alternative. For the purposes of NEPA/CEQA analysis, the Proposed Action is to remove the four lower PacifiCorp dams on the Klamath River. As explained in Section 1.3.2, the KBRA and other actions ~~(Keno Dam transfer)~~ are being discussed programmatically as actions connected to the Proposed Action. ~~It is anticipated~~CDFG recognizes that additional ~~CEQA analyses will be necessary prior to dam removal as contemplated in the KHSA.~~

~~The impact~~ environmental analysis ~~in this EIS/EIR addresses short-term and long-term effects of the Proposed Action and alternatives to the Proposed Action that would occur from the time that the record of decision is signed through the end of the deconstruction~~ may be required by any California public entity with an approval or permitting obligation if required by CEQA.

In general the period~~. The EIS/EIR also includes the~~ of analysis ~~of the Keno Facility Transfer and the KBRA. Analysis of the KBRA as it relates to the Secretarial Determination~~ for this EIS/EIR extends, where possible, for 50 years through ~~2060, the term of the agreement. This analysis of KBRA is being completed at a programmatic level~~2061. Certain contractual commitments in the KBRA extend beyond 50 years or are perpetual. Certain effects of actions ~~contained in KBRA~~ as well as contract commitments in the KBRA and KHSA are expected to extend beyond 50 years. (See, for example, KBRA §§ 15.3.10).

This EIS/EIR has been prepared by the DOI, as lead NEPA agency, and the CDFG, as lead CEQA agency (collectively referred to herein as the Lead Agencies). Recognizing that elements of the Proposed Action would occur in California and Oregon, CDFG collaborated with DOI ~~to~~, with input from the State of Oregon, to make a reasonable, good faith effort in disclosing all significant environmental effects of the Proposed Action and the alternatives. Absent certain circumstances, CEQA does not apply to any project or portion thereof located outside of California which will be subject to environmental review pursuant to NEPA (Public Resources Code § 21080(b)(14); CEQA Guidelines ~~§~~ § 15277).

NEPA requires the lead ~~federal~~Federal agency to request the participation of other government agencies or Indian Tribes with jurisdiction by law or special expertise, collectively referred to as Cooperating Agencies. Table 1-2 lists the governmental

entities and Indian Tribes that have agreed to be Cooperating Agencies in the preparation of the EIS/EIR.

CEQA requires a ~~lead agency~~Lead Agency to identify a list of agencies that are expected to use the EIR in their decision-making. For the Proposed Action, CDFG anticipates that the California Coastal Commission, The ~~California State Water Resources Control Board,~~SWRCB and the California North Coast Regional Water Quality Control Board (CNCRWQCB) will use this EIS/EIR in their decision-making.

Table 1-2. Cooperating Agencies

Agency/Entity
National Oceanic and Atmospheric Administration Fisheries Service
U.S. Forest Service
U.S. Environmental Protection Agency
Karuk Tribe
The Klamath Tribes
Quartz Valley Indian ~~Reservation~~Community
Resighini Rancheria
Yurok Tribe
Hoopa Valley Tribe
Humboldt County
Trinity County
California State Water Resources Control Board
California North Coast Regional Water Quality Control Board
Oregon Department of Environmental Quality
Oregon Department of State Lands
Oregon Department of Fish and Wildlife
Oregon Water Resources Division
Klamath River Compact Commission
Klamath Water and Power Authority

Note: DOI is the Lead Agency under NEPA for this EIS/EIR, and although several agencies under the DOI have assisted with EIS/EIR development, including BLM, BIA, BOR, USGS, and USFWS, these agencies have not been included as separate Cooperating Agencies under NEPA. For the list of preparers of this EIS/EIR, please see Chapter 8.

1.~~4~~5.2 Purpose and Need/Project Objectives

1.~~4~~5.2.1 Purpose and Need

The stated Purpose and Need statement below has changed since the publication of the Notice of Intent in order to provide further clarification. These changes are not substantive and do not change any alternatives.

The Proposed Action is to remove the four lower PacifiCorp dams on the Klamath River. The need for the Proposed Action is to advance restoration of the salmonid fisheries in the Klamath Basin consistent with the KHSA and the connected KBRA. The purpose is to achieve a free flowing river condition and full volitional fish passage as well as other goals expressed in the KHSA and KBRA. By the terms of the KHSA, the Secretary will determine whether the Proposed Action is appropriate and should proceed. In making this determination, the Secretary will consider whether removal of the Four Facilities will advance the restoration of the salmonid fisheries of the Klamath Basin, and is in the

public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes.

1.45.2.2 Project Objectives

This Draft Environmental Impact Report (Draft EIR) is prepared in accordance with the California Environmental Quality Act (CEQA, Public Resources Code sectionSection 21000 et seq.).., to evaluate the potential environmental impacts associated with the implementation of the KHSA and KBRA to inform decision makers, including the Governor of the State of California, representatives of affected and responsible agencies, the public, and other interested parties of the potential environmental effects that may result from implementation of the Agreements as proposed. This Draft EIR describes potential impacts relating to a wide variety of environmental issues and methods by which these impacts can be mitigated or avoided.

As required by CEQA, a lead agencyLead Agency must identify the objectives sought by the proposed project. For this project, CDFG as lead agencyLead Agency has identified the following objectives:

1. Advance restoration of the salmonid fisheries in the Klamath Basin.
2. Restore and sustain natural production of fish species throughout the Klamath Basin in part by restoring access to habitat currently upstream of impassable dams.
3. Provide for full participation in harvest opportunities for sport, commercial, and tribal fisheries.
4. Establish reliable water and power supplies, which sustain agricultural uses and communities and NWRs.
5. Improve long-term water quality conditions consistent with designated beneficial uses.
6. Contribute to the public welfare and the sustainability of Klamath Basin communities.
7. To be consistent with the goals and objectives of KHSA and KBRA.

1.5 .3 Oregon Concurrence

The State of Oregon, and more specifically the "Klamath Team" consisting of OWRD, Oregon Department of Fish and Wildlife, and Oregon Department of Environmental Quality, will follow a distinct process for determining concurrence with an Affirmative Determination by the Secretary of Interior (as defined pursuant to Executive Order No. 10-10 by the Governor of Oregon) should such a determination be made.

The Klamath Team will evaluate two questions in order to determine concurrence:

1. Whether significant impacts identified in its environmental review can be avoided or mitigated as provided under State law.

2. Whether the facilities removal will be completed within the State Cost Cap.

The Klamath Team will provide the results of its evaluation in a recommendation to the Governor, for transmittal to the Secretary of Interior as a concurrence, if appropriate.

1.6 References

Administrative Law Judge. 2006. FERC Project 2082. Klamath Hydroelectric Project Decision.

Bortleson, Gilbert C. and Marvin O. Fretwell. 1993. A Review of Possible Causes of Nutrient Enrichment and Decline of Endangered Sucker Populations in Upper Klamath Lake, Oregon. U.S. Geological Survey, Water Resources Investigations Report 93-4087.

California Department of Fish and Game (CDFG). 2004. September 2002 Klamath River Fish-Kill: Final analysis of Contributing Factors and Impacts, July 2004. Northern California Region, the Resources Agency, State of California. Available at http://www.pcffa.org/KlamFishKillFactorsDFGReport.pdf

~~California Department of Fish and Game.~~CDFG. 2006. California Wildlife: Conservation Challenges: California's Wildlife Action Plan. Chapter 11: North Coast- Klamath Region. Prepared by the U.C. Davis Wildlife Health Center for the California Department of Fish and Game. Available at: http://www.dfg.ca.gov/wildlife/wap/report.html

Chesney, William R. and Erich M. Yokel, 2003. Annual Report Shasta and Scott River Juvenile Salmonid Outmigrant Study, 2001-2002 Project 2a1. California Department of Fish and Game, Steelhead Research and Monitoring Program, January 2003.

Congressional Research Service. 2005. Klamath River Basin Issues and Activities: An Overview. September 22, 2005.

Department of the Interior, Klamath Basin Fisheries Task Force. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program, Prepared with assistance of William M. Kier Associates, U.S. Fish and Wildlife Service, Yreka, CA.

Department of Interior (DOI), and Department of Commerce (DOC), National Oceanic Atmospheric Administration (NOAA) Fisheries Service. 2012. Final Klamath Dam Removal Overview Report for the Secretary of the Interior. An Assessment of Science and Technical Information. August 2012. Accessed online: http://klamathrestoration.gov. Accessed on August 10, 2012.

Federal Energy Regulatory Commission. (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.

Gresh, T., J. Lichatowich and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific ecosystem: evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. Fisheries 25(1): 15-21

Hamilton J., Rondorf D., Hampton M., Quiñones R., Simondet J., and Smith T. 2011. Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River.

Institute for Fisheries Resources (IFR) and Pacific Coast Federation of Fishermen's Associations. (PCFFA). 2006. Appendix to: Comments on Application and Section 4 Recommendations for Klamath Hydroelectric Project, FERC No .P-2082-027. Klamath Falls, OR, Institute for Fisheries Resources.

Jarvis, R.L. 2002. Effects on Waterfowl of the 2001 Water Allocation Decisions. In: Water Allocation in the Klamath Reclamation Project, 2001: An Assessment of Natural Resource, Economic, Social, and Institutional Issues with a Focus on the Upper Klamath Basin. A report by Oregon State University and the University of California. December.

Klamath Basin Restoration Agreement. (KBRA). 2010. Signed PortlandSalem, OR. February 18, 2010. Accessed on May 18, 2011. Available at: http://klamathrestoration.gov/sites/ klamathrestoration.gov/files/Klamath-Agreements/Klamath-Basin-Restoration-Agreement-2-18-10signed.pdfkeep-me-informed/klamath-agreements.

Klamath Hydroelectric Settlement Agreement (KHSA). 2010. Signed PortlandSalem, OR. February 18, 2010. Accessed Online May 18, 2011. Available at: http://klamathrestoration.gov/sites/ klamathrestoration.gov/files/Klamath-Agreements/Klamath-Hydroelectric-Settlement-Agreement-2-18-10signed.pdfkeep-me-informed/klamath-agreements.

Larson R. and Brush B.J. 2010. Upper Klamath Basin Wetlands: An Assessment. U.S. Fish and Wildlife Service, Klamath Falls, Oregon.

National Academies Press.National Oceanic Atmospheric Association (NOAA) Fisheries Services. 2009. Klamath River Basin, 2009 Report to Congress. Available at: http://www.nmfs.noaa.gov/pr/pdfs/klamath2009.pdf.

National Research Council (NRC). 2003. Endangered and Threatened Fishes in the Klamath River Basin; Causes of Decline and Strategies for Recovery. Available at: http://www.nap.edu/openbook.php?isbn=0309090970

~~National Research Council.~~NRC. 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. Washington, DC. 2004. Accessed on: July 12, 2010. Available at: http://books.nap.edu/openbook.php?record_id=10838&page=52

~~NOAA Fisheries 2009. Klamath River Basin, 2009 Report to Congress. Available at http://www.nmfs.noaa.gov/pr/pdfs/klamath2009.pdf~~

~~PacifiCorp. 2004a. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland,~~

Oregon. February.

PacifiCorp. 2004b. Water resources for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Prepared by PacifiCorp, Portland, Oregon.

Risley, John C. and Antonius Laenen. 1998. Upper Klamath Lake Nutrient-Loading Study - Assessment of Historic Flows in the Williamson and Sprague Rivers. U.S. Geological Survey Water-Resources Investigations Report 98-4198.

Sheets, Ed. 2011. Personal Communication

Shuford W.D., Thomson D.L, Mauser D.M., and Beckstrand J. 2004. Abundance, distribution, and phenology of nongame waterbirds in the Klamath Basin of Oregon and California in 2003. Point Reyes Bird Observatory Conservation Science. Report to U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuge Complex. July.

Snyder, Daniel T. and Jennifer L. Morace, 1997. Nitrogen and Phosphorus Loading from Drained Wetlands Adjacent to Upper Klamath and Agency Lakes, Oregon. U.S. Geological Survey, Water Resources Investigations Report 97-4059.

, State of Oregon. 2009. Water Rights in Oregon, Oregon Water Resources Department Centennial Edition 2009- Accessed on the webWeb at: http://www.oregon.gov/OWRD/ADJ/docs/Status_of_the_Adjudication.pdf downloaded on December 15, 2010.

Oregon, State of Oregon.. 2010. Office of the Governor, Executive Order No. 10-03. Determination of a State of Drought Emergency in Klamath County and Contiguous Counties Due to Drought and Extreme Weather Conditions. March 16, 2010. Accessed on July 22, 2011. Available at: http://governor.oregon.gov/Gov/docs/executive_orders/eo_1003.pdfAvailable at: http://cms.oregon.egov.com/gov/docs/ executive_orders/eo_1003.pdf

PacifiCorp. 2004a. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February.

PacifiCorp. 2004b. Water resources for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Prepared by PacifiCorp, Portland, Oregon.

Risley, John C. and Antonius Laenen. 1998. Upper Klamath Lake Nutrient-Loading Study - Assessment of Historic Flows in the Williamson and Sprague Rivers. U.S. Geological Survey Water-Resources Investigations Report 98-4198.

Shuford W.D., Thomson D.L, Mauser D.M., and Beckstrand J. 2004. Abundance, distribution, and phenology of nongame waterbirds in the Klamath Basin of Oregon and California in 2003. Point Reyes Bird Observatory Conservation Science. Report to U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuge Complex. July.

Snyder, Daniel T. and Jennifer L. Morace, 1997. Nitrogen and Phosphorus Loading from Drained Wetlands Adjacent to Upper Klamath and Agency Lakes, Oregon. U.S. Geological Survey, Water Resources Investigations Report 97-4059.

Sullivan, Annett B., Michael L. Deas, Jessica Asbill, Julie D. Kirshtein, Kenna Butler, and Jennifer Vaughn (. 2008). Klamath Water Quality from Link River Dam to Keno Dam, Oregon, 2008. Open-File Report 2009-1105. Prepared by the U.S. Geological Survey in cooperation with the Bureau of Reclamation.

U.S. Fish and Wildlife Service (USFWS). 1986. Klamath River Fisheries Investigation Program. Annual Report 1985. July 1986. Available online at: http://www.fws.gov/arcata/reports/annual%20reports/AFWO_1986_annual_report.pdf. Available online at: http://www.fws.gov/arcata/reports/annual%20reports/AFWO_1986_annual_report.pdf. Accessed on: June 29, 2011.

U.S. Fish and Wildlife Service (USFWS**).** 1988. Endangered and threatened wildlife and plants: Determination of endangered status for the shortnose sucker and Lost River sucker. Federal Register 53: 27130-27134.

U.S. Fish and Wildlife Service.USFWS. 1992. Investigations on the Lower Tributaries to the Klamath River. Klamath River Fisheries Assessment Program. Annual Progress Report FY 1991. February.

U.S. Fish and Wildlife Service. _____. 1993. Lost River (Deltistes luxatus) and Shortnose (Chasmistes brevirostris) Sucker Recovery Plan. Portland, Oregon. 108 pp.

U.S. Fish and Wildlife Service. _____. 2008. Formal Consultation on the Bureau of Reclamation's Proposed Klamath Project Operations from 2008 to 2018. April 2, 2008.

U.S. Fish and Wildlife Service. _____. 2009. Klamath Basin National Wildlife Refuge Complex, Pacific Southwest Region. Refuge History Website, http://www.fws.gov/klamathbasinrefuges/history.html.Refuge History Web site, http://www.fws.gov/klamathbasinrefuges/history.html. Accessed July 28, 2011.

U.S. Fish and Wildlife Service. _____. 2010. Effects of the Klamath Basin Restoration Agreement on Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges. Prepared by Dave Mauser, Supervisory Wildlife Biologist, USFWS, Klamath Basin National Wildlife Refuge, and Tim Mayer, Regional Hydrologist, USFWS, Water Resources Branch.

Wood, Tamara M. 1999. Sediment Oxygen Demand in Upper Klamath and Agency Lakes, Oregon, 1999. U.S. Geological Survey, Water-Resources Investigations Report Report 01-4080.

Wood, T.M., G.R. Hoilman, and M.K. Lindenberg. 2006. Water-quality conditions in Upper Klamath Lake, Oregon, 2002–04: U.S. Geological Survey Scientific Investigations Report 2006-5209.

Chapter 2

Proposed Action and

Description of the Alternatives

This chapter includes an overview of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) requirements for a project description. It also includes a description of the alternatives formulation process to select a reasonable range of alternatives and a description of the Proposed Action and alternatives to the Proposed Action.

2.1 NEPA Requirements

Federal law outlines the required components of the "alternatives" section of an Environmental Impact Statement (EIS) (40 CFR Part 1502.14), which include the following:

(a) Rigorous exploration and objective evaluation of all reasonable alternatives, and for alternatives which were eliminated from study, a brief discussion of the reasons for their having been eliminated.

(b) Substantial treatment of each alternative considered in detail, including the proposed action, so that reviewers may evaluate their comparative merits.

(c) Inclusion of reasonable alternatives that are not within the jurisdiction of the lead agency.

(d) Inclusion of the alternative of no action.

(e) Identification of the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identification of such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Inclusion of appropriate mitigation measures that are not already included in the proposed action or alternatives.

2.2 CEQA Requirements

The CEQA Guidelines[1] developed by the California Natural Resources Agency include prescriptive requirements for the components of the "project description" section of an Environmental Impact Report (EIR). The required components from Section 15124 of the CEQA Guidelines are listed below. Table 2-1 indicates the chapter and section in which each component is included in this EIS/EIR.

Table 2-1. Location of CEQA Guidelines Section 15124 Project Description Components

Component	Location
(a) Map of project location and Boundaries	Section 1.1
(b) Project objectives	Section 1.4.2
(c) General description of the project's characteristics	Section 2.4.3
(d) Statement of the intended uses of the EIR	Section 1.4.1
(d)(1)(B) A list of permits and other approvals required to implement the project	Chapters 6 and 7

(a) The precise location and boundaries of the proposed project shall be shown on a detailed map, preferably topographic. The location of the project shall also appear on a regional map.

(b) The document will include a statement of objectives sought by the proposed project. A clearly written statement of objectives will help the lead agency develop a reasonable range of alternatives to evaluate in the EIR and will aid the decision-makers in preparing findings or a statement of overriding considerations, if necessary. The statement of objectives should include the underlying purpose of the project.

(c) A general description of the project's technical, economic, and environmental characteristics, considering the principal engineering proposals, if any, and supporting public service facilities.

(d) A statement briefly describing the intended uses of the EIR.

(1) This statement shall include the following, to the extent that the information is known to the lead agency:

(A) A list of the agencies that are expected to use the EIR in their decision-making.

[1] Title 14, California Code of Regulations, §§ 15000–15387.

(B) A list of permits and other approvals required to implement the project.

(C) A list of related environmental review and consultation requirements required by ~~federal, state~~Federal, State, or local laws, regulations, or policies. To the fullest extent possible, the lead agency should integrate CEQA review with these related environmental review and consultation requirements.

(2) If a public agency must make more than one decision on a project, all its decisions subject to CEQA should be listed, preferably in the order in which they occur.

2.3 Alternatives Development

Both NEPA and CEQA require EIS/EIRs to identify a reasonable range of alternatives and provide guidance on the identification and screening of such alternatives. For this EIS/EIR, the Lead Agencies followed a structured, documented process to identify and screen alternatives for inclusion in the EIS/EIR. Figure 2-1 illustrates the process that the Lead Agencies conducted to identify and screen alternatives.

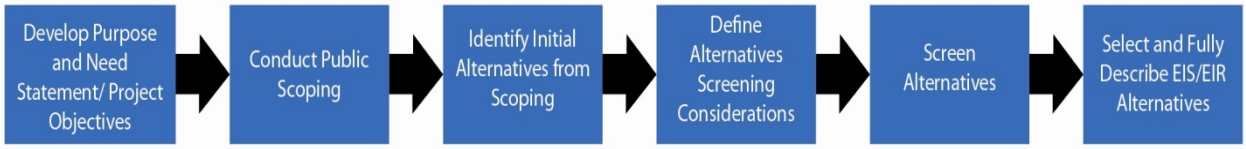


Figure 2-1. Alternatives Development and Screening Process.

During public scoping, the public provided input regarding potential alternatives to the Proposed Action. The Lead Agencies reviewed the purpose and need/project objectives statement, public scoping comments, and previous studies in their initial effort to develop conceptual alternatives. This resulted in an initial list of action alternatives described in Appendix A, Alternatives Formulation Report. The initial list included more than 18 alternatives; however, some were determined to have limited functionality as full alternatives because they focused on techniques for improving natural resources conditions that are already a part of the Klamath Basin Restoration Agreement (KBRA~~) and~~). These alternatives were screened out. The Lead Agencies then developed and applied a set of screening considerations to determine which of the remaining alternatives should move forward for further analysis. Some alternatives were evaluated based on preliminary analysis conducted during the EIS/EIR

> Alternatives may have moved forward for detailed analysis in the EIS/EIR if they do not fully meet the purpose and need/project objectives but may be able to reduce environmental effects or help create a reasonable range of alternatives.

development, as discussed in Appendix A.

Both NEPA and CEQA include provisions that alternatives meet (or meet most of) the purpose and need/project objectives, and be potentially feasible. Under CEQA, alternatives do not need to meet all of the project objectives; alternatives should be included if they can meet most of the objectives and avoid or substantially lessen significant environmental impacts of the project. The alternatives that moved forward for more detailed analysis in this EIS/EIR are those that best meet the NEPA purpose and need and CEQA objectives, minimize negative effects, are feasible, and represent a range of reasonable alternatives. Some alternatives do not fully meet the purpose and need/project objectives, but they have potential to minimize some types of environmental effects or help create a reasonable range of alternatives for consideration by decision-makers. Table 2-2 presents the screening results for the 18 initial alternatives. A full description of the alternatives and the rationale for screening the alternatives is presented in Appendix A, the Alternatives Formulation Report.

Alternatives may have moved forward for detailed analysis in the EIS/EIR if they do not fully meet the purpose and need/project objectives but may be able to reduce environmental effects or help create a reasonable range of alternatives.

The Klamath Hydroelectric Settlement Agreement (KHSA) Section 3.2.1(iii), signed by Secretary of the Interior Ken Salazar on February 18, 2010, directs the Secretary to undertake environmental review in support of the Secretarial Determination. All alternatives carried forward for further analysis in the EIS/EIR were analyzed using existing studies and other appropriate data as suggested in KHSA Section 3.2.1 (i), where such analysis met criteria in 40 CFR 1502.22 and 43 CFR 46.125 to incorporate available information. As part of developing the basis for the Secretarial Determination, the KHSA requires in Section 3.3.2 that the Secretary prepare a Detailed Plan, including the identification, qualifications, management, and oversight of a non-Federal DRE, if any, that the Secretary may designate. KHSA Section 3.3.4.D requires that an estimate of costs be prepared as part of the Detailed Plan. The Detailed Plan analysis provides most of the information for the project description for Alternatives 2 and 3, and this information was used to analyze these two action alternatives. As described in KHSA Section 3.2.1(i), the Federal Energy Regulatory Commission (FERC) record is used to form the project description for Alternatives 4 and 5. Alternatives 4 and 5 were analyzed to ensure that the review of reasonable fish passage alternatives was comprehensive. In addition, at the time of developing a reasonable range of alternatives, the Lead Agencies recognized that the inclusion of Alternatives 4 and 5 would provide an assessment of the short- and long-term effects from a broader range of reasonable alternatives, as defined under CEQA. Alternatives 4 and 5 are outside the authority of the Department of the Interior, the Four Facilities proposed for removal are privately owned structures, and there was no provision in the KHSA to include them in the Detailed Plan. The result is differing levels of available information for alternatives carried forward in the EIS/EIR consistent with the elements of each action alternative.

Table 2-2. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 1	No Action/ No Project	Implement none of the action alternatives; Klamath Hydroelectric Project would continue current operations.	Alternative 1 moved forward to the EIS/EIR for further review because it is required under NEPA and CEQA.
Alternative 2	Full Facilities Removal of Four Dams (Proposed Action)	Remove four dams and related facilities.	Alternative 2 moved forward to the EIS/EIR for further review because it fully meets the purpose and need/project objectives.

Table 2-2. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 3	Partial Facilities Removal of Four Dams	Remove main areas of four dams to allow a free-flowing river and volitional fish passage; related facilities and/or abutments may remain.	Alternative 3 moved forward to the EIS/EIR for further review because it fully meets the purpose and need/project objectives.
Alternative 4	Fish Passage at Four Dams	Construct fish passage facilities to provide upstream and downstream passage at four dams.	Alternative 4 has been retained for further analysis because the No Action alternative, per the requirements of NEPA, may not presume the types of conditions that FERC might require should it re-issue a license under the Federal Power Act. Consequently, without this alternative, there would be no analysis in this document on fish passage. The ~~lead agencies~~Lead Agencies believe it is appropriate to include in the alternatives for further consideration our best assessment of probable fish passage. By bringing the fish passage alternative forward, the public will be better informed, which will in turn help foster better decision-making by the Secretary, all of which being consistent with the goals of NEPA.
Alternative 5	Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate	Remove Copco 1 and Iron Gate Dams, construct fish passage at J.C. Boyle and Copco 2 Dams.	While Alternative 5 does not fully meet the purpose and need/project objectives, it moved forward to the EIS/EIR for further review because it could lessen potential construction-related environmental and power generation effects of the Proposed Action. Additionally, it would lessen water quality effects of the two larger reservoirs. Consideration of this alternative would give the Secretary a reasonable range of alternatives to inform decision-making.
Alternative 6	Fish Passage at J.C. Boyle, Remove Copco 1, Copco 2, and Iron Gate	Remove Copco 1, ~~Copco~~ Copco 2, and Iron Gate Dams, construct upgraded fish passage at J.C. Boyle.	The EIS/EIR will fully analyze effects of removing all dams, constructing fish passage facilities at all dams, and a combination of these measures as a part of Alternatives 2, 4, and 5. Potential effects of Alternative 6 will be fully analyzed through these other alternatives. Alternative 6 will not move forward for further analysis.
Alternative 7	Sequenced Removal of Four Dams	Sequence dam removal over three to five years.	Alternative 7 will not be carried forward for more detailed analysis in the EIS/EIR because it would not reduce environmental effects of the Proposed Action, and may increase effects to fish associated with sediment release from the reservoirs over multiple years.

Table 2-2. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 8	Full Facilities removal of Four Dams without KBRA	Remove four dams and related facilities but do not implement KBRA elements.	Alternative 8 will not be carried forward for more detailed analysis in the EIS/EIR because it does not meet most of the purpose and need/project objectives and would not reduce environmental effects of the Proposed Action. The effects of removing the four dams and related facilities will be fully analyzed under Alternative 2.
Alternative 9	Trap and Haul Fish	Capture fish at Iron Gate Dam and transport them upstream of J.C. Boyle Dam.	Alternative 9 will not move forward for further analysis because it does not meet the purpose and need under NEPA or most of the project objectives under CEQA.
Alternative 10	Fish Bypass: Bogus Creek Bypass	Create fish bypass using Bogus Creek, Cold Creek, Little Deer Creek, and a constructed canal to connect to Copco 1 Reservoir.	Alternative 10 will not move forward for more detailed analysis in the EIS/EIR because it does not meet any elements of the purpose and need under NEPA or project objectives under CEQA.
Alternative 11	Fish Bypass: Alternative Tunnel Route	Create fish bypass using Bogus Creek and a 5-mile tunnel to connect to Copco Reservoir.	Alternative 11 will not move forward for more detailed analysis in the EIS/EIR because it does not meet any elements of the purpose and need under NEPA or project objectives under CEQA.
Alternative 12	Notching Four Dams	Notch four dams to create a free-flowing river.	Alternative 12 is very similar to Alternative 3, and would result in the same type of impacts. Therefore, this alternative will not move forward for more detailed analysis in the EIS/EIR as a separate alternative.
Alternative 13	Federal Takeover of Project	Use authority of the Federal Power Act for government to take over dams and initiate removal.	Alternative 13 will not move forward for more detailed analysis in the EIS/EIR because the environmental impacts would be generally the same (and have generally the same timeframe) as ~~those~~the dam removal impacts under Alternative 2.
Alternative 14	Full Removal of Five Dams	Remove Keno Dam in addition to four downstream dams.	Alternative 14 will not be carried forward for more detailed analysis in the EIS/EIR because it does not fully meet the purpose and need/project objectives (because it is not consistent with the KHSA) and it would not avoid or lessen potential adverse environmental effects of the Proposed Action.
Alternative 15	Full Removal of Six Dams	Remove Keno and Link River Dams in addition to four downstream dams.	Alternative 15 will not be carried forward for more detailed analysis in the EIS/EIR because it does not fully meet the purpose and need/project objectives (because it is not consistent with the KHSA) and it would not avoid or lessen potential environmental effects of the Proposed Action. Implementation of Alternative 15 would also not be likely to meet Endangered Species Act requirements or tribal trust water rights within Upper Klamath Lake.

Table 2-2. Initial Alternatives

Alternative Number	Alternative Name	Description	Screening Result
Alternative 16	Dredge Upper Klamath Lake	Remove sediments in Upper Klamath Lake to remove phosphorus and increase storage capacity.	Alternative 16 will not move forward for more detailed analysis in the EIS/EIR because it does not meet the purpose and need under NEPA or most of the project objectives under CEQA.
Alternative 17	Predator Control	Control seal, sea lion, and cormorant populations that are salmonid predators.	Alternative 17 will not move forward for more detailed analysis in the EIS/EIR because it does not meet the purpose and need under NEPA or project objectives under CEQA. Moreover, it would be difficult to permit because of biological concerns.
Alternative 18	Partition Upper Klamath Lake	Create an "inner lake" that may improve water quality.	Alternative 18 will not move forward for more detailed analysis in the EIS/EIR because it does not meet the purpose and need under NEPA or project objectives under CEQA.

Key:
CEQA: California Environmental Quality Act
EIS/EIR: Environmental Impact Statement/Environmental Impact Report
FEIS: Federal Energy Regulatory Commission Environmental Impact Statement
FERC: Federal Energy Regulatory Commission
KBRA: Klamath Basin Restoration Agreement
KHSA: Klamath Hydroelectric Settlement
NEPA: National Environmental Policy Act

~~The Klamath Hydroelectric Settlement Agreement (KHSA) Section 3.2.1(iii), signed by Secretary of the Interior Ken Salazar on February 18, 2010, directs the Secretary to undertake environmental review in support of the Secretarial Determination. All alternatives carried forward for further analysis in the EIS/R were analyzed using existing studies and other appropriate data as suggested in KHSA Section 3.2.1 (i), where such analysis met criteria in (40 CFR 1502.22 and 43 CFR 46.125) to incorporate available information. As part of developing the basis for the Secretarial Determination, the KHSA requires in Section 3.3.2 that the Secretary prepare a Detailed Plan, including the identification, qualifications, management, and oversight of a non-federal DRE, if any, that the Secretary may designate. KHSA Section 3.3.4.D requires that an estimate of costs be prepared as part of the Detailed Plan. The Detailed Plan analysis provides most of the information for the project description for Alternatives 2 and 3, and this information was used to analyze these two action alternatives. As described in KHSA Section 3.2.1(i), the FERC record is used to form the project description for Alternatives 4 and 5. Alternatives 4 and 5 were analyzed to ensure that the review of reasonable fish passage alternatives was comprehensive. In addition, at the time of developing a reasonable range of alternatives, the lead agencies recognized that the inclusion of Alternatives 4 and 5 would provide an assessment of the short- and long-term effects from a broader range of reasonable alternatives, as defined under CEQA. Alternatives 4 and 5 are outside the authority of the Department of the Interior, the four facilities proposed for removal are privately owned structures, and there was no provision in the KHSA to include them in the Detailed Plan. The result is differing levels of available~~

~~information for alternatives carried forward in the EIS/R consistent with the elements of each action alternative.~~

As a result of the initial alternative screening, four action alternatives and the No Action/No Project alternative were selected to move forward for analysis in the EIS/EIR. Table 2-3 presents the alternatives carried forward for analysis in the EIS/EIR. These alternatives represent a reasonable range of alternatives for analysis to provide context for decision-makers. Analysis of these alternatives will provide the Secretary with information needed to make a decision, and potentially to mix and match elements of the alternatives, if needed, to create an alternative that would reduce environmental impacts and increase environmental benefits.

Table 2-3. Alternatives Selected for Analysis in the EIS/EIR

Alternative Number	Alternative Name	Description
Alternative 1	No Action/-No Project	Implement none of the action alternatives; Klamath Hydroelectric Project would continue current operations.
Alternative 2	Full Facilities Removal of Four Dams (Proposed Action)	Remove four dams and related facilities.
Alternative 3	Partial Facilities Removal of Four Dams	Remove main areas of four dams to allow a free-flowing river and volitional fish passage; related facilities and/or abutments may remain.
Alternative 4	Fish Passage at Four Dams	Construct fish passage facilities to provide upstream and downstream passage at four dams.
Alternative 5	Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate	Remove Copco 1 and Iron Gate Dams, construct fish passage at J.C. Boyle and Copco 2 Dams.

2.4 Proposed Action and Alternatives

The following sections describe the alternatives under evaluation in this EIS/EIR. Appendix A includes more detailed descriptions of these alternatives.

2.4.1 Facilities Common to All Alternatives

All of the alternatives, except for the No Action/No Project Alternative, include actions at the Four Facilities of the Klamath Hydroelectric Project: the J.C. Boyle, Copco 1, Copco 2, and Iron Gate dam sites. Table 2-4 outlines characteristics of the Four Facilities.

Table 2-4. Dam and Powerhouse Components

	J.C. Boyle	Copco 1	Copco 2	Iron Gate
Dam type	Concrete and earthfill embankment	Concrete	Concrete	Earthfill embankment
Dam maximum height	68 feet	135 feet	33 feet	189 feet
Dam crest length	692 feet	410 feet	335 feet	740 feet
Reservoir surface area	420 acres	1,000 acres	N/A	944 acres
Reservoir storage volume	2,629 acre-feet	40,000 acre-feet	73 acre-feet	53,800 acre-feet
Type of facility to allow water to flow past dam	Overflow spillway with control gates and diversion culvert	Overflow spillway with control gates and diversion tunnel	Overflow spillway with control gates	Uncontrolled overflow spillway and diversion tunnel

Source: ~~Federal Energy Regulatory Commission (~~FERC~~)~~ 2007; ~~Department of the Interior (DOI) 2011~~Reclamation 2012a

Each of the facilities generates power using various methods for water delivery to the power generation facility as summarized in Table 2-5.

Table 2-5. Power Generation Facilities

	J.C. Boyle	Copco 1	Copco 2	Iron Gate
Type of facility to divert water for power generation	Concrete tower with screened water intake	Intakes at upstream end of dam	Diversion intake with gate	Concrete tower with water intake
Water conveyance system to power generation facility	638 feet of steel pipe (14-foot diameter), 2 mile concrete flume, 1,660 foot tunnel, and into two 10.5 foot penstock pipes 956 feet long	Two 10-foot and one 14-foot diameter penstock pipes	2,440 feet of concrete-lined tunnel, 1,313 feet of wood-stave pipeline, 1,110 feet of additional concrete-lined tunnel, and into two penstock pipes (16-foot diameter)	One 12-foot diameter penstock pipe
Power generation mechanism	2 turbines	2 turbines	2 turbines	1 turbine
Powerhouse Type	Concrete foundations with concrete pads for access, no building	Enclosed building	Enclosed building	Concrete foundations with concrete pads for access, no building
Power Capacity	98 MW	20 MW	27 MW	18 MW

Source: FERC 2007; ~~DOI 2011~~Reclamation 2012a

Key:

MW: megawatt

2.4.1.1– J.C. Boyle Dam and Powerhouse

The J.C. Boyle facilities consist of a reservoir, embankment dam, concrete spillway, fish ladder, water intake structure, water conveyance system, and powerhouse. The narrow reservoir is created by an embankment dam with a concrete spillway as shown in ~~Figure~~ Figure 2-2. The concrete spillway has flow control gates on the crest along with a fish ladder and water intake structure for diverting water to power generation facilities. The water conveyance system transmits diverted water several miles downstream to the powerhouse on the Klamath River.

At J.C. Boyle Dam, a portion of Klamath River flow is diverted into the power generation system and the non-diverted water is used to maintain flow in the fish ladder with the excess flow going over the spillway as necessary. The fish ladder discharge and spillway discharge combine and flow through the section of river referred to as the "Bypass Reach," which contains less flow than other sections of the river. Water diverted at the dam for power generation is conveyed through a steel pipe, concrete canal, tunnel, and penstock pipe to the powerhouse. The powerhouse is approximately four river miles downstream from the dam. After water runs through the power generation facilities, it rejoins the Klamath River.

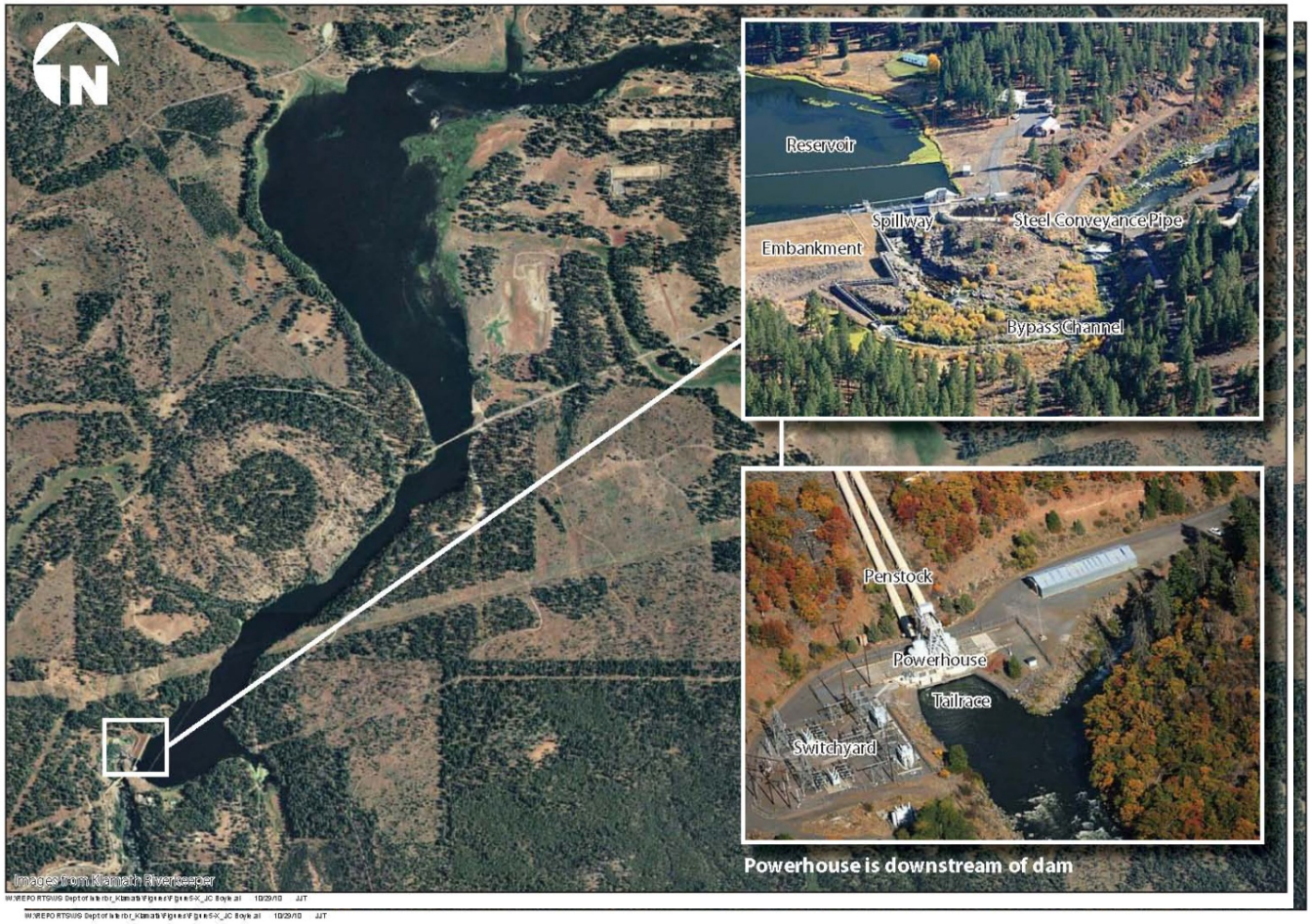


Figure 2-2. J.C. Boyle Dam and Powerhouse.

J.C. Boyle powerhouse is generally operated as a peaking facility when river flows are too low to allow for continuous operations, such as the summer low flow period. Power demand peaks during weekday afternoons in the summer. Peaking power generation occurs in the late afternoons and early evenings to meet this demand, which allows the reservoir to refill during the night when power demand is minimal. Figure 2-3 shows early summer flows in 2011 as an example of how peaking operations affect flow downstream ~~of~~from the powerhouse. The reach between the powerhouse and the upstream end of Copco 1 Reservoir is referred to as the "Peaking Reach." Historically, flows in this reach fluctuated rapidly to meet demand and peaking operations for power generation.

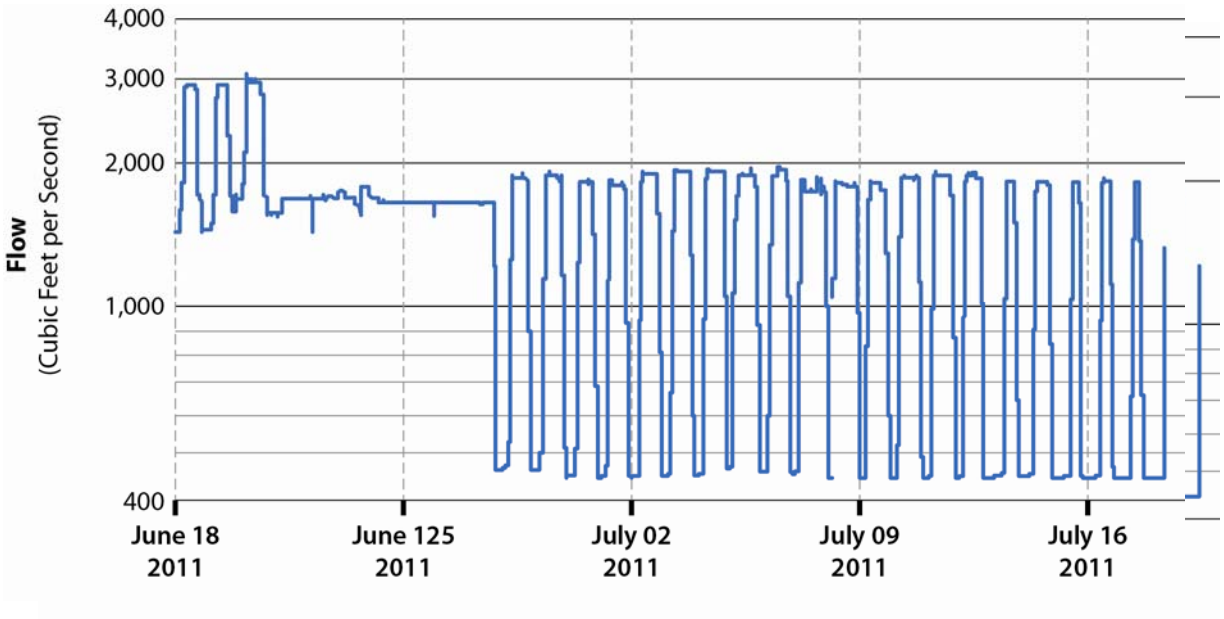


Figure 2-3. Example Flows in Peaking Reach downstream from J.C. Boyle Powerplant (United States Geological Survey [USGS] station 11510700).

Source: USGS 2011

~~**Figure 2-3. Example Flows in Peaking Reach downstream from J.C. Boyle Powerplant (United States Geological Survey [USGS] station 11510700)**~~

2.4.1.2~~–~~ Copco 1 Dam and Powerhouse

The Copco 1 facilities consist of a reservoir, concrete dam, concrete spillway, water intake structure, and powerhouse. Copco 1 Dam (Figure 2-4) is in a bedrock canyon on the Klamath River at River Mile (RM) 198.6. Construction records show that the concrete dam includes 465 tons of 30-pound steel rails for reinforcement.

Water is routed past the dam, through the power generation facilities, and/or over the concrete spillway. Water diversion for power generation is via two intake structures on the right dam abutment (these descriptions refer to river right and river left when looking downstream). Water flows into the intakes and down to the powerhouse, located at the base of the dam, through steel penstock pipes. Excess water not diverted for power generation is allowed to flow over the concrete spillway and down the face of the dam. The entire width of the dam creates the spillway, which is controlled by gates that run across the top of the spillway. Water that flows over the spillway rejoins water diverted for power generation near the base of the dam at the powerhouse. Copco 1 had been built with the intention that a fishway passage would be constructed as a mitigation measure for salmon. However, by the completion of Copco 1, the idea of fishway passage had

been abandoned due to its impracticality, and a hatchery was planned in lieu of fish passage (Lane and Lane 1981).

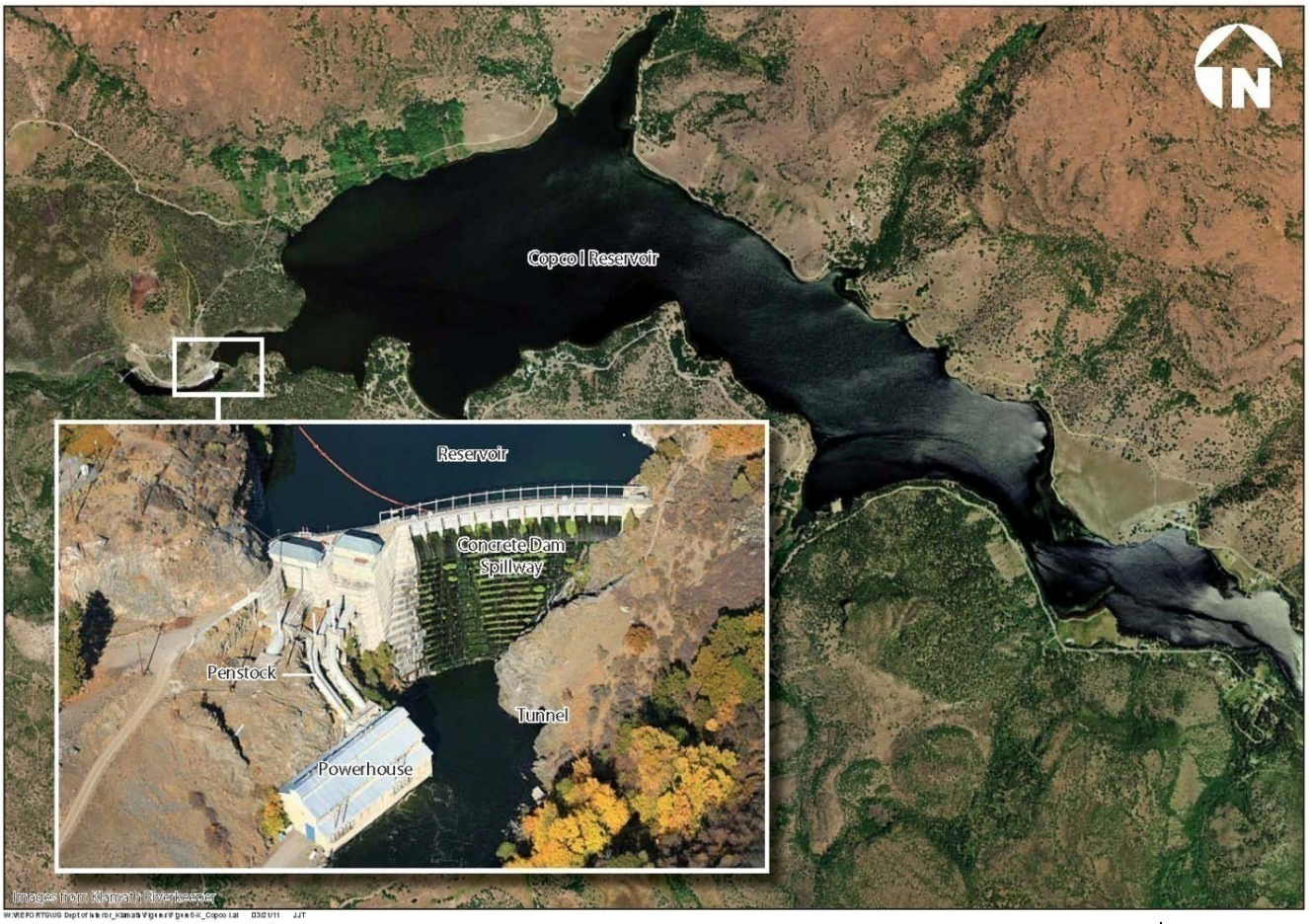

Copco I Reservoir
Reservoir
Concrete Dam
Spillway
Penstock
Tunnel
Powerhouse
Image: from Klamath Riverkeeper

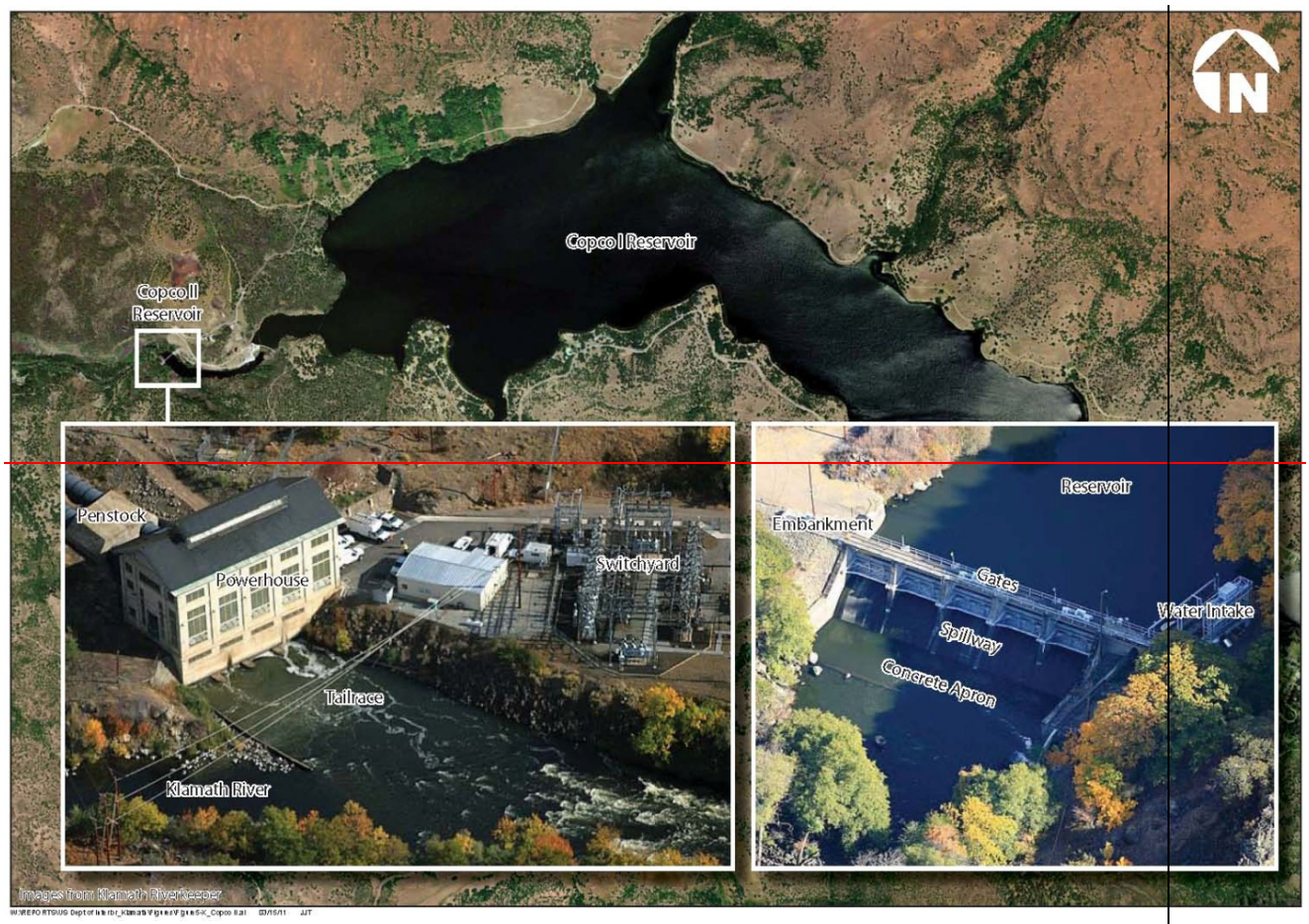
Figure 2-4. Copco 1 Dam and Powerhouse

2.4.1.3 Copco 2 Dam and Powerhouse

The Copco 2 facilities consist of a concrete dam, water diversion intake, water conveyance system for power generation, penstock pipes, powerhouse, and switchyard. The dam is at the bottom of a confined canyon on the Klamath River at RM 198.3. Copco 2 Dam is a concrete dam that spans the river with an earthen embankment section that fully spans the bottom of the canyon (see Figure 2-5).

At Copco 2 Dam, flow is diverted on river left through a water intake structure and conveyed through the power generation system. River flow in excess of diverted water is allowed to flow over the concrete spillway. An existing metal flumepipe through the dam provides an additional 5 cubic feet per second (cfs) to the Bypass Reach below the dam.

Copco 2 Powerhouse is 1.5 miles downstream of from Copco 2 Dam. Diverted river water flows from the dam through 2,440 feet of concrete-lined tunnel, 1,313 feet of pipeline, an additional 1,110 feet of concrete-lined tunnel, and two steel penstocks.



~~*Figure 2-5. Copco 2 Powerhouse (left photo) and Dam*~~

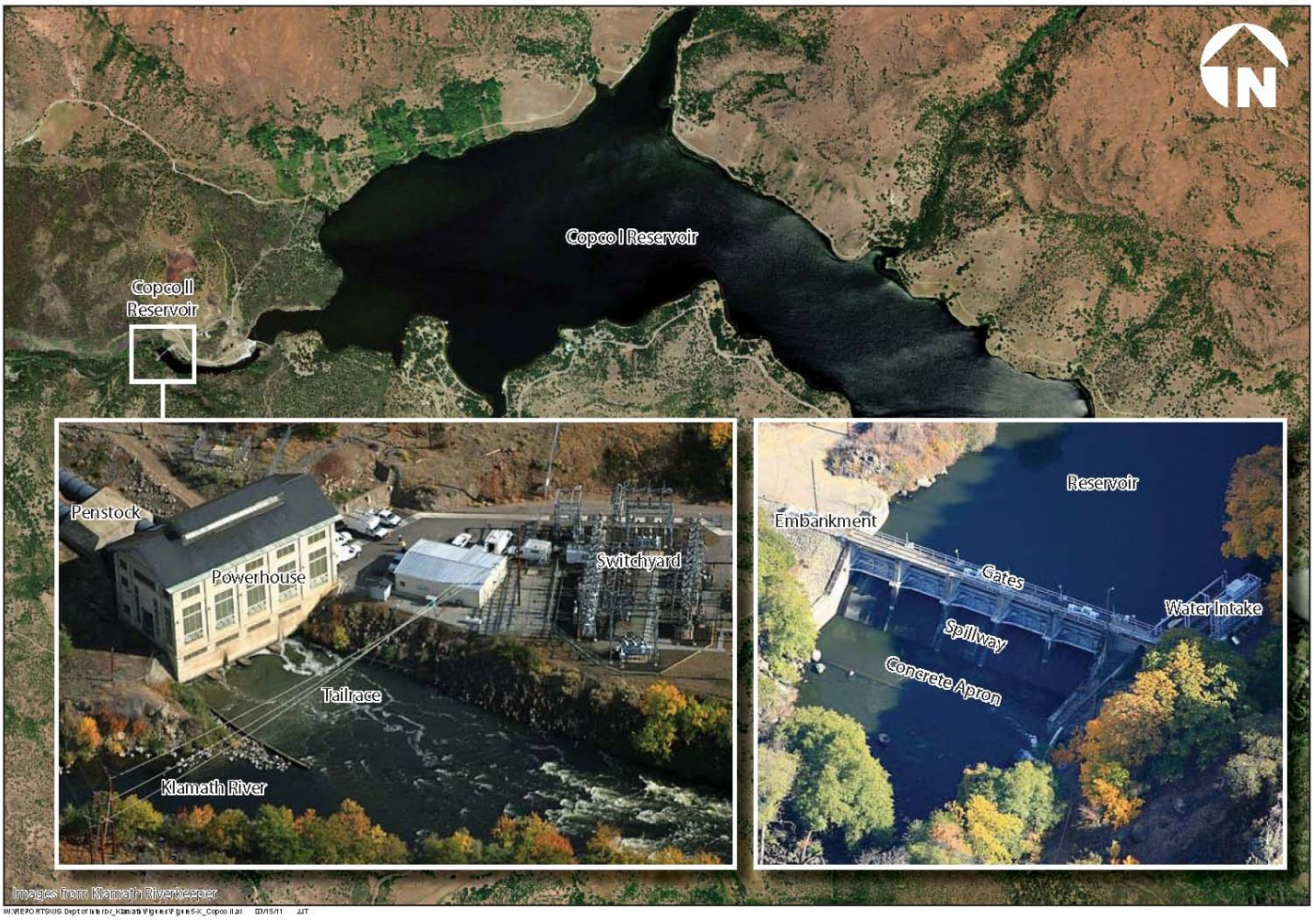


Figure 2-5. Copco 2 Powerhouse (left photo) and Dam.

2.4.1.4~~.~~ Iron Gate Dam and Powerhouse

The Iron Gate facilities consist of a reservoir, earthfill embankment dam, concrete spillway, water intake structure, penstock pipes, and power generation facility (see ~~Figure~~ Figure 2-6). The embankment dam is in a bedrock canyon at RM 190.1.

Water for power generation is drawn from the reservoir using a concrete water intake tower on the left side of the reservoir~~.~~.[2] Water is transported down the face of the dam through penstock pipes and into the powerhouse immediately downstream ~~of~~from the dam on the left bank of the river. The powerhouse consists of one turbine with concrete structural slabs and no overhead building structure.

Water not diverted for power generation is allowed to flow freely over the concrete spillway on the right side of the dam. There are no gates or flow controls for the ~~spillway and~~ spillway and flow is directed to the base of the dam where it converges with power

[2] Unlike other dams in the region including Shasta Dam, there is no low level intake to tap cold water in the hypolimnium at Iron Gate Dam.

Figure 2-6. Iron Gate Dam, Reservoir, and Power Generating Facilities.

generation return flows to resume flow down the Klamath River. The Iron Gate Dam has the original bypass tunnel used during construction of the dam that allows water in the reservoir to be drawn down over 125 feet.

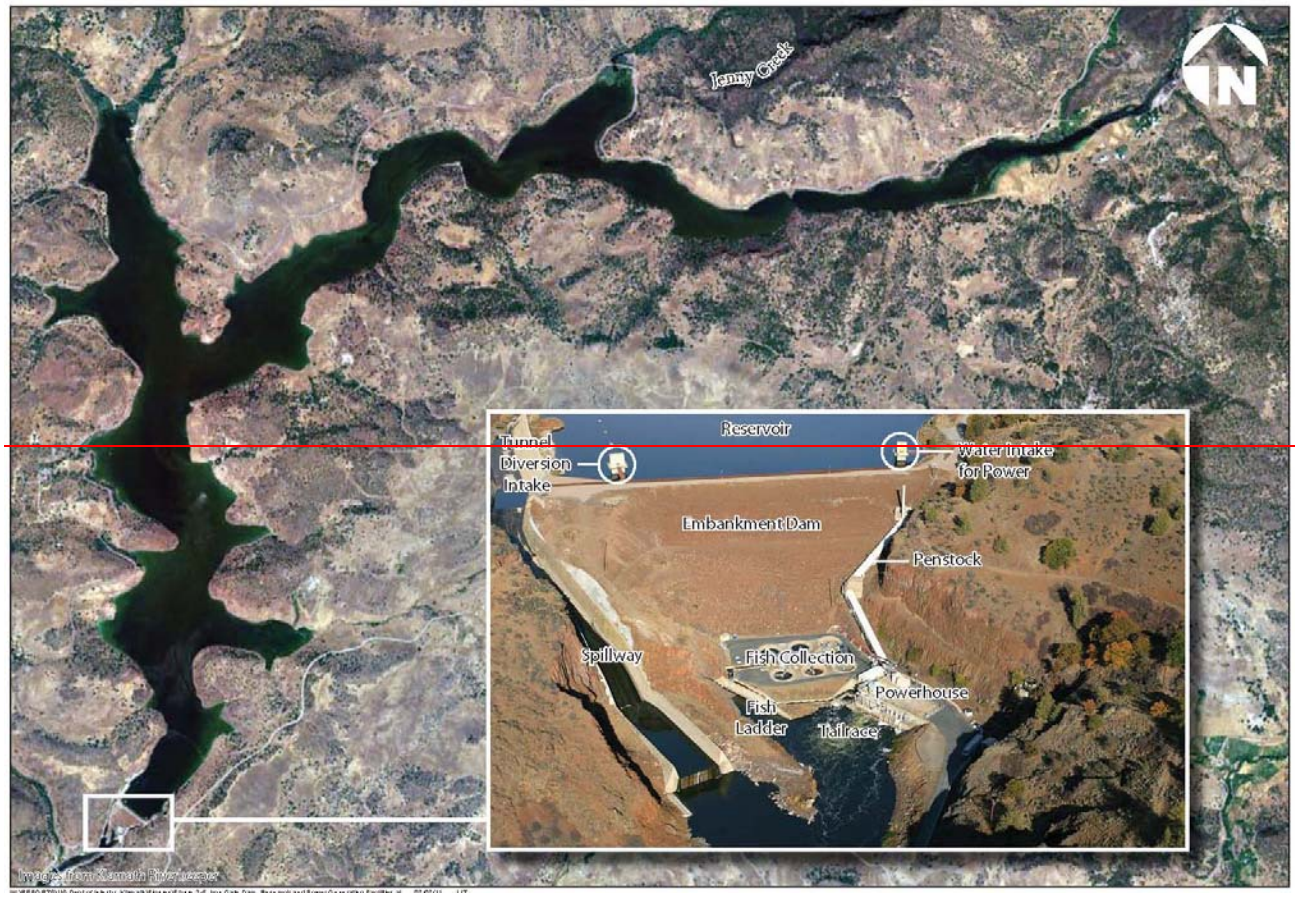


Figure 2-6. Iron Gate Dam, Reservoir, and Power Generating Facilities

The Iron Gate Fish Hatchery, located immediately below Iron Gate Dam, was constructed to mitigate for the loss of 16 miles of fish habitat between Iron Gate Dam and Copco 2 Dam.

2.4.2 Alternative 1: No Action/No Project Alternative

NEPA requires an EIS to "include the alternative of no action" (40 CFR Part 1502.14(d)). CEQA requires an EIR to include a No Project Alternative. CEQA Guidelines ~~Section~~ Section 15126.6(e)(2) states that "The 'no project' analysis shall discuss the existing conditions at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services." For the Klamath Facilities Removal EIS/EIR, NEPA's No Action Alternative and CEQA's No Project Alternative describe the same conditions, and this alternative is referred to as the No Action/No Project Alternative.

The No Action/No Project Alternative represents the state of the environment without the Proposed Action or any of the alternatives. In this instance, the No Action/No Project

Alternative would be no change from current management conditions, other than as noted below, with the dams remaining in place. The No Action/No Project Alternative would only include the portions of the KBRA that are ongoing resource management activities. These resource management actions could receive additional funding and could be expanded or accelerated through the KBRA; however, they were started or under consideration before the KBRA was developed and would move forward even without the KBRA. Therefore, the No Action/No Project Alternative includes the following resource management actions:

- **Williamson River Delta Project** – As part of this project, levees were breached on Williamson River in November 2008 to restore historic wetlands, benefit water quality, and provide habitat for threatened and endangered fish. This project also provides 28,800 acre-feet of additional storage in Upper Klamath Lake.

- **Agency Lake and Barnes Ranches Project** – The diked and drained portion of the ranches are currently used by Reclamation as pumped storage. The lands have been transferred from Reclamation to the United States Fish and Wildlife Service (USFWS) and incorporated into the National Wildlife Refuge (NWR) system so that the dikes can be breached to reconnect wetlands to Upper Klamath Lake and add 63,770 acre feet of storage Upper Klamath Lake. USFWS is studying options to breach the dikes.

- **Fish Habitat Restoration** – restoration activities are ongoing throughout the basin under current authorities and funding levels. These restoration activities include, but are not limited to, restoration and permanent protection of riparian vegetation, water quality improvements, restoration of stream channel functions, measures to prevent and control excessive sediment inputs, remediation of fish passage problems, and prevention of entrainment into diversions. Specific types of activities include floodplain rehabilitation, large woody debris placement, fish passage correction, cattle exclusion, riparian vegetation planting, mechanical thinning to promote conifers, fire treatment, purchase of conservation easements/land, road decommissioning, gravel augmentation (main stem), and treatment of fine sediment sources. The fish habitat restoration program that would be implemented under the KBRA would include these same types of activities but is described under the Proposed Action.

- **Climate Change Assessment –** this assessment is intended to ensure that long-term climate change in the Klamath Basin is assessed early and continuously, allowing the Parties to collaboratively respond in a manner that protects basin interests from the adverse effects of climate change for as long as practicable, and to manage the resources of the basin on the basis of the best available science.

The KHSA outlines 20 Interim Measures (IMs) for the Klamath Hydroelectric Project that would be implemented until construction begins (if the Secretary makes an Affirmative Determination). Under the No Action/No Project Alternative, the KHSA

would not move forward. However, several of these IMs have already been implemented, or would likely be implemented with a Negative Determination. Table 2-6 includes the IMs that are part of the No Action/No Project Alternative because:

- IMs are included in PacifiCorp's ~~proposed~~ Habitat Conservation Plan (~~National Oceanic and Atmospheric Administration [NOAA] Fisheries Service 2011~~PacifiCorp 2012) (IMs 2, 4, 5, and 6~~, and 13~~);
- IMs are included in an Environmental Assessment from BLM and are scheduled to move forward before the Secretary makes a determination (IMs 7 and 8); or
- IMs represent a continuation of existing operations (IMs 13, 14, and 17).

IM 7 (J.C. Boyle Gravel Placement) would start before the Secretary makes a determination, but it would end with a Negative Determination. Gravel placement would occur for approximately one year under the No Action/No Project Alternative before a determination is made; therefore, only one year of implementation of IM 7 is included in the No Action/No Project Alternative. IMs 3 (Iron Gate Turbine Venting) and 12 (J.C~~.~~ . Boyle Bypass Reach and Spencer Creek Gaging) have already been implemented and are therefore part of existing conditions. The remaining IMs would end with a Negative Determination and are not included in the No Action/No Project Alternative.

PacifiCorp included IMs 2, 4, 5, and 6 in a Habitat Conservation Plan (HCP) and National Oceanic and Atmospheric Administration (NOAA) Fisheries Service has analyzed them in accompanying NEPA environmental documents, biological opinions, and findings documents. NOAA Fisheries Service has completed an Environmental Assessment (NOAA Fisheries Service 2012a) and a Finding of No Significant Impact (NOAA Fisheries Service 2012b) for incidental take and implementation of IMs and related project operations for a 10-year period. BLM has completed an Environmental Assessment and Finding of No Significant Impact related to IMs 7 and 8 (BLM 2011).

PacifiCorp would need to obtain a long-term operating license from the FERC to replace the existing annual license. PacifiCorp would continue seeking a new license from FERC.

Table 2-6. Interim Measures included in the No Action/No Project Alternative

Interim Measure	Description
IM2 – California Klamath Restoration Fund/Coho	PacifiCorp would fund actions to enhance survival and recovery of coho salmon, including habitat restoration and acquisition.

Enhancement	
IM4~~-~~ – Hatchery and Genetics Management Plan	PacifiCorp would fund the development and implementation of a Hatchery and Genetics Management Plan for the Iron Gate Hatchery.
IM5~~-~~ – Iron Gate Flow Variability	PacifiCorp and Reclamation would annually evaluate the feasibility of enhancing fall and early winter flow variability to benefit salmonids downstream ~~of~~from Iron Gate Dams. In the event that fall and early winter flow variability can feasibly be accomplished, PacifiCorp would develop and implement flow variability plans. This IM would not adversely affect the volume of water available for Reclamation's Klamath Project or wildlife refuges.
IM6~~-~~ – Fish Disease Relationship and Control Studies	PacifiCorp has established a fund to study fish disease relationships downstream ~~of~~from Iron Gate Dam. PacifiCorp would consult with the Klamath River Fish Health Workgroup regarding selection, prioritization, and implementation of such studies.
IM7~~-~~ – J.C. Boyle Gravel Placement and/or Habitat Enhancement (one year only)	PacifiCorp would provide funding for the planning, permitting, and implementation of gravel placement or habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir within 90 days of the effective date.
IM8 ~~-~~ – J.C. Boyle Bypass Barrier Removal	PacifiCorp would remove the sidecast rock barrier approximately 3 miles upstream of the J.C. Boyle Powerhouse in the ~~bypass reach.~~Bypass Reach. This IM would help with safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout.
IM13 ~~-~~ – Flow Releases and Ramp Rates	PacifiCorp would maintain current operations including instream flow releases of 100 cfs from J.C. Boyle Dam to the J.C. Boyle Bypass Reach and a 9-inch per hour ramp rate below the J.C. Boyle powerhouse prior to transfer of the J.C. Boyle facility.
IM14 ~~-~~ – 3,000 cfs Power Generation	Upon approval by OWRD, PacifiCorp would continue maximum diversions of 3,000 cfs at J.C. Boyle Dam for power generation prior to decommissioning of the facility.
IM17 ~~-~~ – Fall Creek Flow Releases	PacifiCorp would continue to provide a continuous flow release to the Fall Creek ~~bypass reach~~Bypass Reach targeted at 5 cfs.

Key:
IM: Interim Measure
OWRD: Oregon Water Resources Department

~~PacifiCorp is including these IMs in a Habitat Conservation Plan (HCP) and analyzing them in accompanying NEPA environmental documents, biological opinions, and findings documents for NOAA Fisheries Service and USFWS. These documents are intended to inform Federal Endangered Species Act (ESA) Section 10 Incidental Take Permits (ITPs) by NOAA Fisheries Service and USFWS for implementation of interim conservation measures and related project operations for a ten-year period. Further background is provided in the notices of availability for the ESA Section 10 permit applications and related Environmental Assessment (NOAA Fisheries Service 2011). BLM has completed an Environmental Assessment and Finding of No Significant Impact related to IMs 7 and 8 (BLM 2011).~~

~~PacifiCorp would need to obtain a long-term operating license from the Federal Energy Regulatory Commission (FERC) to replace the existing annual license. PacifiCorp would resume relicensing proceedings with FERC to obtain the required long-term operating license.~~

For the purposes of this analysis, the No Action/No Project Alternative would continue current operations with the dams remaining in place and PacifiCorp operating under the current annual license. The existing license has no requirements for additional fish

passage or implementation of the prescriptions that are currently before FERC in the relicensing process. PacifiCorp would continue to operate the Iron Gate Hatchery under its current operations. Flows would remain similar to current flows, which are released from Reclamation's Klamath Project and passed through the Klamath Hydroelectric Project. Figure 2-7 shows modeled future flows in ~~a~~ dry ~~year~~conditions (represented by the flows exceeded 90 percent of the time, or 90 percent exceedence), ~~an~~ average ~~year~~conditions (flows exceeded 50 percent of the time), and ~~a~~ wet ~~year~~conditions (flows

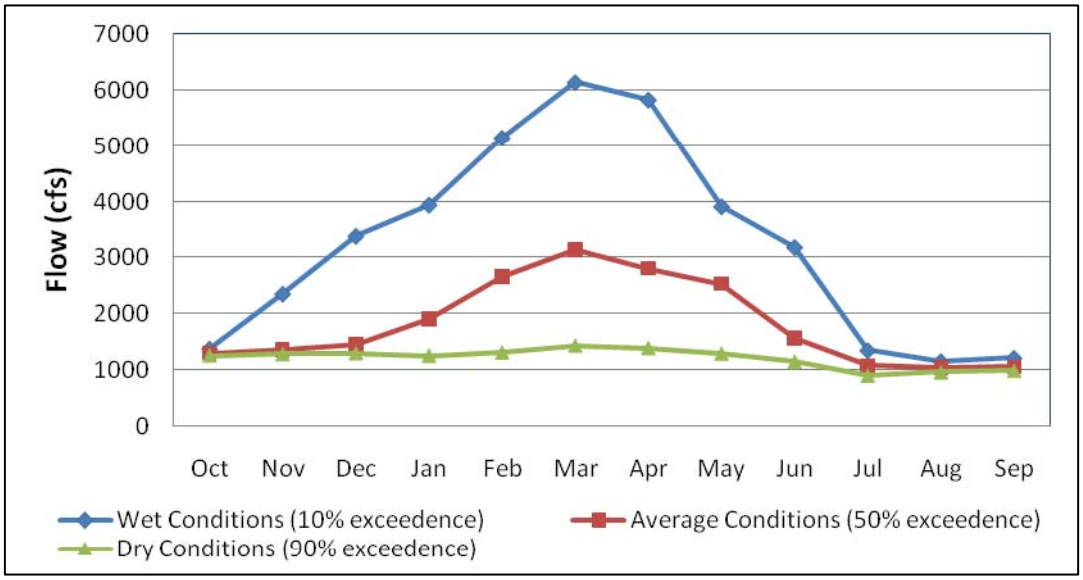


Figure 2-7. No Action/No Project Flows below Iron Gate Dam in Wet, Average, and Dry Conditions.

exceeded 10 percent of the time). These exceedence plots do not represent a flow pattern in any specific year. A ~~"~~90~~%~~ percent exceedence~~"~~ flow is a flow that would be exceeded 90 percent of the time; therefore, it is generally representative of a dry year because most years have greater flows. ~~Biological opinions~~The biological opinions on Reclamation's Klamath Project operations, and a biological opinion on FERC's licensing of the Klamath Hydroelectric Project may change in the future as understanding of species or their populations change~~s~~; however, these changes are unknown at this time and not included in the hydrologic assumptions.

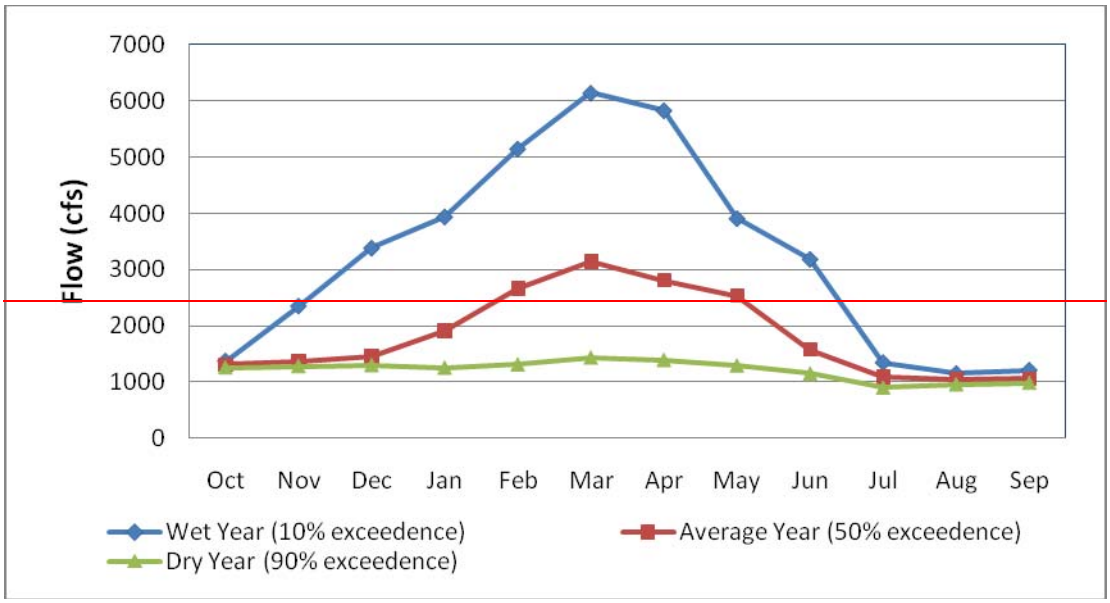


Figure 2-7. No Action/No Project Flows below Iron Gate Dam in Wet, Average, and Dry Years

The U
maintenance of Reclamation's Klamath Project (USFWS 2008). This biological opinion outlines measures to improve the habitat for the Lost River sucker and shortnose sucker affected by Reclamation's Klamath Project operations. Among other measures to protect the suckers, the biological opinion requires that specific surface elevations of Upper Klamath Lake be maintained to meet certain criteria.

The National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries Service) also issued a biological opinion to Reclamation requiring releases from Reclamation's Klamath Project to produce specified rates of flow for the Klamath River downstream ~~of~~from Iron Gate Dam, based on the habitat needs of coho salmon (NOAA Fisheries Service 2010). Target flow rates in the Klamath River downstream ~~of~~from Iron Gate Dam vary by month, and are dependent in part on the amount of water entering Upper Klamath Lake.

PacifiCorp would continue to coordinate operations with Reclamation and operate the Klamath Hydroelectric Project in compliance with existing NOAA Fisheries Service and USFWS biological opinions issued for Reclamation's Klamath Project. Under the No Action/No Project Alternative, the Four Facilities would continue to be subject to requirements in PacifiCorp's current annual FERC permit:

- Operating the peaking facility at J.C. Boyle such that the river does not rise or fall more quickly than 9 inches per hour and that minimum flows immediately downstream ~~of~~from the dam are maintained at 100 cfs.
- Maintaining minimum flows downstream ~~of~~from Iron Gate Dam.
- Limiting the change in the rate of the release of water from Iron Gate Dam to no more than 250 cfs per hour or a three-inch change in river stage~~.~~ (FERC 2007).

PacifiCorp also currently coordinates with Reclamation to meet ramp rates in the NOAA Fisheries Service biological opinion on Reclamation's Klamath Project:

- When flows at Iron Gate Dam are 3000 cfs or above, Iron Gate Dam ramp down rates will follow the rate of decline to inflows to Upper Klamath Lake combined with accretions between Keno Dam and Iron Gate Dam.
- When flows at Iron Gate Dam are between 1,750 cfs and 3,000 cfs, Iron Gate Dam ramp down rates will be 300 cfs or less per 24 hour period and no more than 125 cfs per 4 hour period.
- When flows at Iron Gate Dam are 1,750 cfs or less, Iron Gate ramp down rates will be 150 cfs or less per 24 hour period and no more than 50 cfs per two hour period~~.~~ (NOAA Fisheries Service 2010).

The No Action/No Project Alternative would include other regulatory conditions that would affect conditions in the Klamath Basin. To improve water quality, the Oregon Department of Environmental Quality (ODEQ) and California North Coast Regional Water Quality Control Board (NCRWQCB) cooperated to develop Total Maximum Daily Loads (TMDLs) for impaired water bodies within the basin. TMDLs are pollution control plans that identify the pollutant load reductions that are necessary from point and nonpoint sources to meet water quality standards. Table 2-7 shows the status of the TMDLs in the Klamath ~~basin~~Basin. The California and Oregon Klamath River TMDLs focus on reducing high water temperatures, increasing dissolved oxygen levels, and reducing nutrient concentrations in the mainstem Klamath River (NCRWQCB 2010a, ODEQ 2010). Major tributaries in the ~~lower~~Lower Klamath Basin, such as the Scott, Shasta, and Trinity Rivers, are not included in the technical analyses (i.e., modeling efforts) for the California Klamath TMDLs but the entire Klamath Basin is included in the associated Implementation Plan (NCRWQCB 2010b).

The TMDLs within the basin are expected to result in improvements to water quality conditions over time, but the pace of achieving improvements and the implementation mechanisms are unknown. Section 3.2, Water Quality, describes these TMDLs in detail.

Table 2-7. Status of TMDLs in the Klamath ~~River~~ Basin

Water Body	Pollutant/Stressor	Agency	Original Listing Date	TMDL Completion Date[1]
Oregon				
Upper Klamath Lake Drainage	Temperature, dissolved oxygen, and pH	ODEQ	1998	2002
Upper Klamath and Lost Rivers	Temperature, dissolved oxygen, pH, ammonia toxicity, and chlorophyll-*a*	ODEQ	1998	2011
California				
Lower Lost ~~River~~[2] River (Tule Lake, Lower Klamath Lake National Wildlife Refuge, and Mt Dome)[2]	pH and nutrients	USEPA	1992 (Nutrients), 2002 (pH)	2008
Klamath River	Temperature, organic enrichment/low dissolved oxygen[3], nutrient, and ~~microcystin~~ microcystin[4]	NCRWQCB	~~1996, 1998, 2006, and 2008~~1992 (Temperature and nutrients), 1998 (Dissolved oxygen), 2006 and 2010 (Microcystin)	2010
Shasta River	Temperature and dissolved oxygen	NCRWQCB	~~1998 and 2008~~1992 (Dissolved oxygen), 1994 (Temperature)	2007
Scott River	Temperature and sediment	NCRWQCB	~~1992, 1996, and 1998~~1992 (Sediment), 1996 (Temperature)	2006
Salmon River	Temperature	NCRWQCB	~~1996~~1992	2005
Trinity	Sediment	USEPA	~~1994 and 2006~~1992	2001
South Fork Trinity	Sediment	USEPA	~~1994 and 2002~~1992	1998

Notes:

[1] The TMDL completion date is the year the USEPA approved or is expected to approve the TMDL.

[2] The Upper Lost River upstream of the Oregon border, Clear Lake Reservoir, and tributaries ~~are~~were listed for water temperature and nutrients. In 2004, North Coast Regional Board staff completed an analysis of beneficial uses and water quality conditions in the Upper Lost River watershed and concluded that the listing ~~is~~was not warranted.

~~Key:~~

~~TMDL: Total Maximum Daily Load~~

~~ODEQ: Oregon Department of Environmental Quality~~

~~USEPA: U.S. Environmental Protection Agency~~

~~NCRWQCB: North Coast Regional Water Quality Control Board~~

The TMDLs within the basin are expected to result in improvements to water quality conditions, but the improvements cannot be quantified due to uncertainties regarding the timing and magnitude of mitigation projects, necessary to achieve water quality standards. Section 3.2, Water Quality, describes these TMDLs in detail.

2.4.3 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

The Full Facilities Removal of Four Dams Alternative (the Proposed Action) includes the removal of the Four Facilities as described in the KHSA. This alternative would include the complete removal of dams, power generation facilities, water intake structures, canals, pipelines, ancillary buildings, and dam foundations. During deconstruction the four reservoirs would be closed to recreation. This alternative would include the transfer of Keno Dam to the Department of the Interior (DOI), decommissioning of PacifiCorp's East Side/West Side facilities, and the implementation of the KBRA as connected actions as defined under NEPA.

The result of the Proposed Action would be that the Klamath River would have no dams downstream from Keno Dam. Operation of Reclamation's Klamath Project and the related river flows, measured at the United States Geological Survey gauge downstream from Iron Gate Dam, would be according to the hydrologic model outputs in KBRA Appendix E-5. Figure 2-8 shows simulated future flows at the Iron Gate Gauge during a dry year (represented by the flows exceeded 90 percent of the time, or 90 percent exceedence), an average year (flows exceeded 50 percent of the time), and a wet year (flows exceeded 10 percent of the time)[3].

[3] Minimum flows may change in the future. Hydrologic modeling assumed that the Drought Plan would include a minimum flow of 800 cfs (DOI 2011). The final Drought Plan or future ESA actions could change the minimum flows; however, these assumptions reflect the best available information at the time of the modeling.

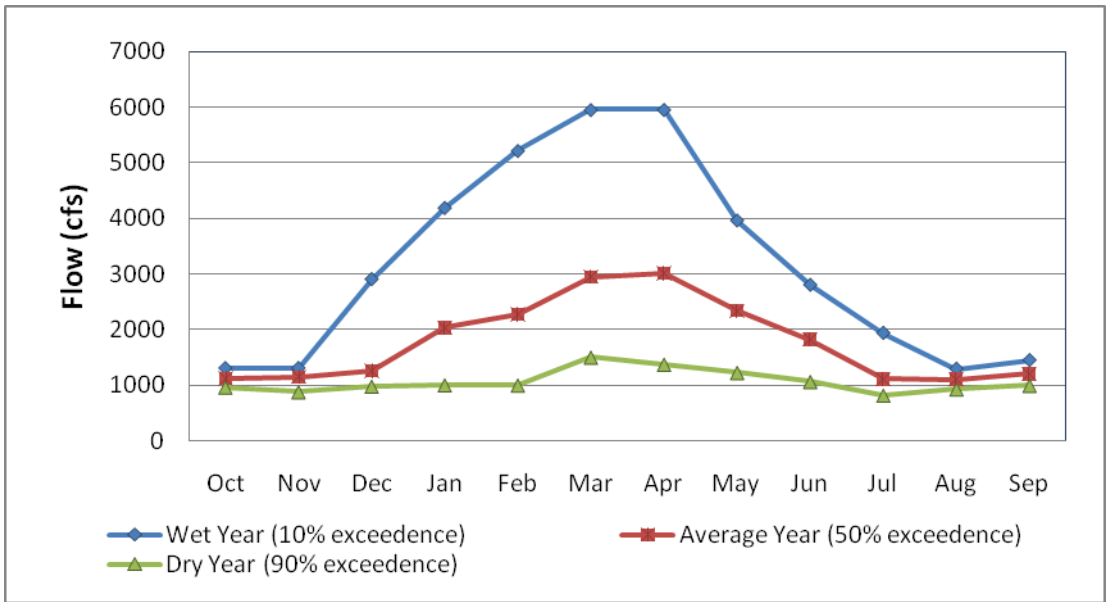


Figure 2-8. Proposed Action Flows at the Iron Gate Gauge in Wet, Average, and Dry Years

~~Removing the Four Facilities would release some of the sediment currently stored behind the dams into the downstream river system. Table 2-8 shows the quantity of sediment in Iron Gate, Copco 1, and J.C. Boyle reservoirs; the sediment in storage in Copco 2 reservoir is negligible. The sections below describe how much sediment would erode from each site.~~

~~Reservoir drawdown schedules were selected to minimize release of sediment during critical times for sensitive species. The lead agencies studied multiple drawdown scenarios to optimize performance for these sensitive fish. The challenge in selecting a drawdown period was to avoid impacts to migrating adult fish (salmonids, sturgeon, and lamprey), migrating juvenile smolts, and rearing of juveniles. During summer, there are juveniles rearing, green sturgeon adults, and spring-run Chinook salmon migrating. During fall, there are adult coho salmon, steelhead, and fall-run Chinook salmon migrating, and smolts outmigrating. During spring, there are smolts outmigrating, adult green sturgeon, and steelhead and spring-run Chinook adults migrating. Drawdown would primarily occur during winter because it would be the least harmful season; however, there are still species and life stages that may be affected, such as adult migrating steelhead and lamprey.~~

~~Table 2-8. Sediment Stored In Reservoirs~~[3] Listing applies only to the mainstem Klamath River.

Reservoir	Source area[1] (acres)	Period of Sediment Accumulation	Sediment Accumulation Volume (yd^3)
Iron Gate	135,680	40 yr (1962-2002)	4,700,000
Copco 1	174,720	84 yr (1918–2002)	7,400,000
J.C. Boyle	144,000	44 yr (1958–2002)	1,000,000

Total[4] Listings occurred in 2006 for the mainstem Klamath River from the Oregon-California State line to Iron Gate Dam (including Copco and Iron Gate Reservoirs), and in 2010 for the mainstem Klamath River from Iron Gate Dam to the Trinity River.

Key:

TMDL = Total Maximum Daily Load
ODEQ = Oregon Department of Environmental Quality
USEPA = **13,100,000**U.S. Environmental Protection Agency

Key:
yd^3: cubic yards
yr: Year
Source: Department of the Interior 2011
Notes:
[1] Source Area refers to the sub-basin that drains to the reservoir.

NCRWQCB = North Coast Regional Water Quality Control Board

2.4.3 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

The Full Facilities Removal of Four Dams Alternative (the Proposed Action) includes the removal of the Four Facilities as described in the KHSA. This alternative would include the complete removal of dams, power generation facilities, water intake structures, canals, pipelines, and ancillary buildings. During deconstruction the reservoirs would be closed to recreation. This alternative would include the transfer of Keno Dam to the Department of the Interior (DOI), decommissioning of PacifiCorp's East Side/West Side facilities, and the implementation of the KBRA as connected actions as defined under NEPA. For purposes of CEQA, the proposed project is Alternative 2.

The result of the Proposed Action would be that the Klamath River would have no dams downstream from Keno Dam. Operation of Reclamation's Klamath Project and the related river flows, measured at the United States Geological Survey gauge downstream from Iron Gate Dam, would be according to the hydrologic model outputs in modeled KBRA hydrology (Reclamation 2012b). Figure 2-8 shows simulated future flows at the Iron Gate Gauge during dry conditions (represented by the flows exceeded 90 percent of

the time, or 90 percent exceedence), average conditions (flows exceeded 50 percent of the time), and wet conditions (flows exceeded 10 percent of the time).[4]

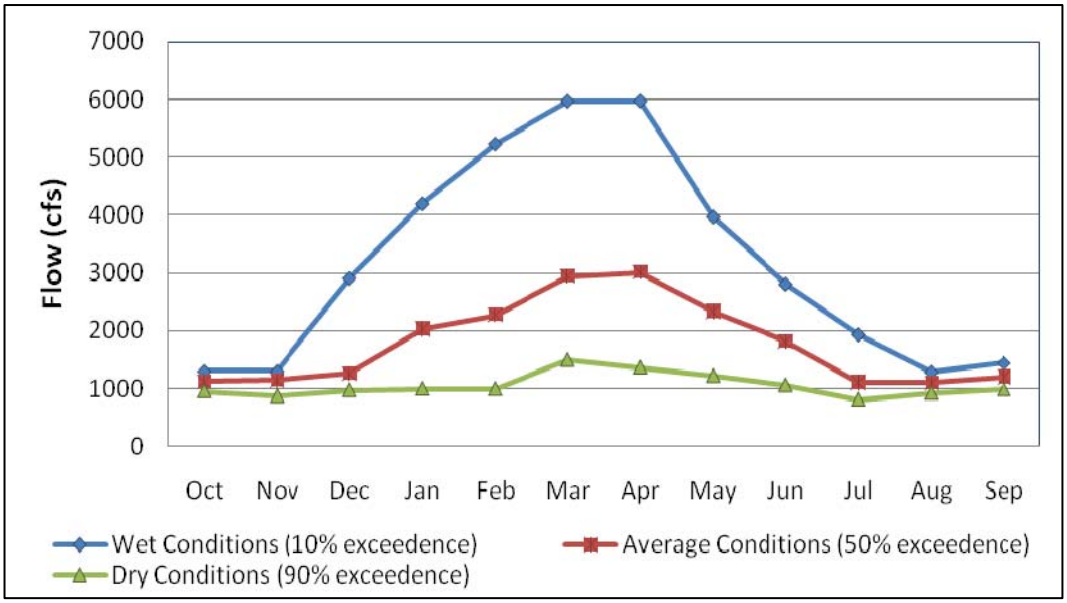


Figure 2-8. Proposed Action Flows at the Iron Gate Gauge in Wet, Average, and Dry Conditions.

Removing the Four Facilities would release some of the sediment currently stored behind the dams into the downstream river system. The call-out box on the next pages, "Sediment Weight and Volume in the Four Facilities and Erosion with Dam Removal," provides information on the quantity and type of sediment in the Four Facilities.

Reservoir drawdown schedules were selected to minimize release of sediment during critical times for sensitive species. The Lead Agencies studied multiple drawdown timing scenarios to avoid or minimize impacts to aquatic species, especially anadromous fishes. The challenge in selecting a drawdown period was to avoid impacts to migrating adult fish (salmonids, sturgeon, and lamprey), migrating juvenile smolts, and rearing of juveniles. During summer, there are juveniles rearing, green sturgeon adults, and spring-run Chinook salmon migrating. During fall, there are adult coho salmon, steelhead, and fall-run Chinook salmon migrating, and smolts outmigrating. During spring, there are smolts outmigrating, adult green sturgeon, and steelhead and spring-run Chinook adults migrating. Drawdown would primarily occur during winter because it would be the least

[4] Minimum flows may change in the future. Hydrologic modeling assumed that the Drought Plan would include a minimum flow of 800 cfs (Reclamation 2011). The final Drought Plan or future ESA actions could change the minimum flows; however, these assumptions reflect the best available information at the time of the modeling.

harmful season; however, there are still species and life stages that may be affected, such as adult migrating steelhead and lamprey.

Prior to construction, IMs as described in the KHSA (KHSA Section 1.2.4) would be implemented and would control operations of the hydroelectric facilities. Some of these IMs would be implemented in the No Action/No Project Alternative, but the remaining would be included in the Proposed Action. Some of the IMs propose studies, planning efforts, or the continued funding of existing facilities that do not constitute new actions with the potential to affect the environment and are therefore not analyzed in this EIS/EIR. Table 2-~~9~~10 presents these IMs included in the Proposed Action that would not result in environmental effects.

The remaining IMs are also included in the Proposed Action and will be analyzed in Chapter 3 of this EIS/EIR (see Table 2-~~9~~11). As discussed under the No Action/No Project Alternative, one year of IM7 would be implemented before the Secretary makes a determination. The remaining seven years, however, would only occur in the case of an Affirmative Determination and are therefore included in the Proposed Action.

Sediment Weight and Volume in the Four Facilities and Erosion with Dam Removal

Sediment in the reservoirs is primarily composed of silt and clay (fine sediment) with lesser amounts of cobble and gravel (Reclamation 2012b). Distribution of sediment varies within each of the reservoirs. In J.C. Boyle Reservoir, sediment primarily resides in the area nearest to the dam, with thicknesses up to 20 feet. Both Copco 1 and Iron Gate Reservoirs have generally even distributions of sediment with thicknesses increasing towards the dams. The maximum thickness of the Copco 1 Reservoir sediment is approximately 10 ft. The maximum deposition within the main stem of Iron Gate Reservoir is around 5 ft, with deposition thickness of near 10 ft in the Jenny Creek arm of Iron Gate Reservoir. Copco 2 Reservoir does not retain appreciable amounts of sediment. The current volume and weight of sediment for each reservoir is given in Table 2-8.

There is uncertainty associated with the reservoir computations because the volume estimates are based upon the drill hole sediment thicknesses (Reclamation 2012a, 2012b). There were between 28 to 31 drill holes in each reservoir used to develop maps of reservoir sediment thickness and it was necessary to interpolate the sediment thicknesses between the holes. This introduces some uncertainty in the volume estimates as reported in Table 2-8. While the uncertainty in the volume estimate is noticeable, the sediment analysis is not sensitive to the degree of uncertainty in the volume estimates. If the reservoir sediment volumes were on the higher end of the uncertainty estimate or the lower end of the uncertainty estimate, the dam removal plan would remain the same.

Table 2-8. Stored Sediment in the Klamath Hydroelectric Project, Fall 2009

	Volume (yd^3)	Uncertainty[1] (+/- yd^3)	Dry Weight (tons)	% Fine Sediment by mass	Fine Sediment[2] (tons)	Sand Sediment[3] (tons)
J.C. Boyle	1,000,000	+/- 300,000	290,000	66%	190,000	100,000
Copco 1	7,440,000	+/-1,500,000	1,880,000	87%	1,630,000	260,000
Iron Gate	4,710,000	+/-1,300,000	1,430,000	85%	1,210,000	230,000
Total[4]	13,150,000	+/-2,000,000	3,600,000	85%	3,020,000	590,000
Total Copco 1 and Iron Gate[4]	12,150,000	+/-2,000,000	3,320,000	85%	2,830,000	490,000

Source: *Reclamation 2012b*

[1] Uncertainty resulted from interpolation between drill holes and is calculated as a +/- amount shown (Reclamation 2012b).
[2] Fine Sediment is sediment with a diameter less than 0.063 millimeters
[3] Sand Sediment is sediment with a diameter between 0.063 and 2 millimeters
[4] Amounts of sediment (volumes and weights) from individual reservoirs may not equal the total amounts indicated because all volumes and weights taken from Reclamation (2012b) were rounded to the nearest 10,000th unit. Copco 2 Reservoir does not retain measureable amounts of sediment and therefore is not included in the estimates of total stored sediment.
[5] Average dry densities vary between reservoirs and within the reservoir depending upon compaction and grain size distribution. The dry unit weight varies between 44.4 and 16.3 lb/ft^3(Reclamation 2012b). See Table 3.11-2 for more information.

Table 2-9. Estimated Amount of Sediment in the Reservoirs in 2020 and Erodible Sediment[1] with Dam Removal

Reservoir	Estimated 2020 Total			
	Total Volume (yd^3)	Total Sediment (tons)	Fine Sediment[2] (tons)	Sand Sediment[3] (tons)
J.C. Boyle	1,190,000	340,000	220,000	120,000
Copco 1	8,250,000	2,090,000	1,800,000	290,000
Iron Gate	5,690,000	1,730,000	1,460,000	280,000
Total[4]	15,130,000	4,160,000	3,480,000	680,000
Total Copco 1 and Iron Gate[4]	13,940,000	3,820,000	3,260,000	560,000

	Percent Erosion		Fine Sediment[1] Erosion		Sand Sediment[2] Erosion	
	Minimum Erosion (%)	Maximum Erosion (%)	Minimum (tons)	Maximum (tons)	Minimum (tons)	Maximum (tons)
J.C. Boyle	27%	51%	60,000	110,000	30,000	60,000
Copco 1	45%	76%	820,000	1,370,000	130,000	220,000
Iron Gate	24%	32%	350,000	460,000	70,000	90,000
Total[4]	36%	57%	1,230,000	1,950,000	230,000	370,000
Total Copco 1 and Iron Gate[4]	36%	56%	1,170,000	1,830,000	200,000	300,000

Source: *Reclamation 2012b*

[1] Erosion will primarily occur during the drawdown period in the winter and spring of 2020. The erosion rates were based on the hydrologic conditions recorded for the March to June flow volume at Keno gage on the Klamath River from water year 2001(90% exceedance) and 1984 (10% exceedance). Additional erosion and sediment transport could occur in the following year that would be indistinguishable from background sediment regime.
[2] Fine Sediment is sediment with a diameter less than 0.063 millimeters
[3] Sand Sediment is sediment with a diameter between 0.063 and 2 millimeters
[4] Amounts of sediment (volumes and weights) from individual reservoirs may not equal the total amounts indicated because all volumes and weights taken from Reclamation (2011) were rounded to the nearest 10,000th unit. Copco 2 Reservoir does not retain measureable amounts of sediment and therefore is not included in the estimates of total stored sediment.

By 2020, an approximately 15.1 million yd^3 (4.16 million tons) of sediment would be deposited behind the dams. During drawdown, approximately 36 to 57 percent of the 2020 volume or an estimated 5.4 and 8.6 million yd^3 (1.2 to 2.3 million tons) of reservoir sediment will be eroded (see Table 2-9). The range in erosion volume is primarily dependent upon whether it is a dry year or wet year, respectively. The vast majority of the erosion will occur during the drawdown process and be a combination of direct erosion of the sediment by moving water and slumping of the fine sediment toward the river. The remaining sediment will erode more slowly because it will harden and dry following drawdown. With the return to riverine conditions, erosion and sediment transport will occur but will be indistinguishable from the background sediment regime.

Table 2-10. KHSA Interim Measures that would not produce Environmental Effects

Interim Measure	Description
IM1 – Interim Measures Implementation Committee	PacifiCorp would work with a committee to monitor IM implementation
IM9 – J.C. Boyle Powerhouse Gage	PacifiCorp would fund the continued operation of the existing gage below J.C. Boyle Powerhouse.
IM10 – Water Quality Conference	PacifiCorp would fund a basin-wide technical conference on water quality.
IM15 – Water Quality Monitoring	PacifiCorp would fund long-term baseline water quality monitoring to support dam removal, nutrient removal, and permitting studies, and would also fund ~~-~~blue-green algae (i.e., periphyton) and toxin monitoring.
IM 18 – Hatchery Funding	PacifiCorp would fund Iron Gate Hatchery operations and maintenance.
IM21 - BLM Land Management Provisions	PacifiCorp would fund BLM's continued land management activities including road maintenance, invasive weed management, cultural resource management, and recreation.

Key:
IM: Interim Measure
BLM: Bureau of Land Management

The ~~remaining IMs are also included in the Proposed Action~~ongoing resource management activities, TMDLs, biological opinions, and ~~will be analyzed in Chapter 3 of this EIS/R (see Table 2-10). As discussed~~other regulatory conditions described under the No Action/No Project Alternative~~, one year of IM7~~ would ~~be implemented before the Secretary makes a determination. The remaining seven years, however, would only~~ also occur ~~in the case of an Affirmative Determination and are therefore included in the Proposed Action~~under this alternative.

2.4.3.1~~-~~ Deconstruction Actions

2.4.3.1.1 J.C. Boyle Dam and Powerhouse

Full removal of the J.C. Boyle Dam and Powerhouse would include removal of the dam, spillway and gates, powerhouse, powerhouse equipment, and concrete fish ladder. This alternative would also include removal of ancillary facilities, such as the canal and pipeline that convey water to the powerhouse. The extensive headcut downstream ~~of~~from the forebay overflow discharge canal would be filled and stabilized with a portion of the material removed from the dam structure. Further, the dam removal entity (DRE) would fill the tailrace (where the powerhouse discharges water) to restore natural river conditions in this area. In order to access the dam for deconstruction, the DRE would perform a controlled reservoir drawdown using the spillway gates, conveyance pipeline and canal, and diversion conduit.

The deconstruction process would begin by gradually drawing down the reservoir. Reservoir drawdown would release water into the concrete canal (the power generation intake), the spillway, and the bypass conduit through the dam depending on the water surface elevation in the reservoir. Water would flow through the Bypass Reach throughout reservoir drawdown. As the reservoir was drawn down, the DRE would remove facilities from the top down. The DRE would start by removing the spillway gates, the spillway bridge, and the upstream concrete intake structure for the powerhouse

canal. The DRE would use cranes and excavators for removal, and might also need blasting to remove concrete facilities.

Table 2-~~10.~~11. KHSA Interim Measures Analyzed in the Proposed Action

Interim Measure	Description
IM7- J.C. Boyle Gravel Placement and/or Habitat Enhancement (final 7 years)	PacifiCorp would provide funding for the planning, permitting, and implementation of gravel placement or habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir within 90 days of the effective date.
IM11- Interim Water Quality Improvements	PacifiCorp would fund studies or pilot projects developed in consultation with the Implementation Committee regarding the following: • Development of a Water Quality Accounting Framework • Constructed Treatment Wetlands Pilot Evaluation • Assessment of In-Reservoir Water Quality Control Techniques • Improvement of J.C. Boyle Reservoir Dissolved Oxygen PacifiCorp would provide funding for implementation of projects approved by the ODEQ and the State and Regional Water Boards, and to cover project operation and maintenance expenses related to those projects.
IM16 - Water Diversions	PacifiCorp would seek to eliminate three screened diversions from Shovel and Negro Creeks and would seek to modify its water rights as listed above to move the points of diversion from Shovel and Negro Creeks to the mainstem Klamath River.
IM19 - Hatchery Production Continuity	PacifiCorp would evaluate hatchery production options that do not rely on the current Iron Gate Hatchery water supply. The study will assess groundwater and surface water supply options, water reuse technologies or operational changes that could support hatchery production in the absence of Iron Gate Dam. Based on the study results, PacifiCorp would propose a post-Iron Gate Dam Mitigation Hatchery Plan to provide continued hatchery production for eight years after the removal of Iron Gate Dam.[1]
IM20 - Hatchery Funding After Removal of Iron Gate Dam	After removal of Iron Gate Dam and for a period of eight years, PacifiCorp would fund 100 percent of hatchery operations and maintenance costs necessary to fulfill annual mitigation objectives developed by the CDFG in consultation with the NOAA Fisheries Service.[1]

Key:
CDFG: California Department of Fish and Game
IM: Interim Measure
KBRA: Klamath Basin Restoration Agreement
NOAA Fisheries Service: National Oceanic and Atmospheric Administration
ODEQ: Oregon Department of Environmental Quality
Notes:
1. ~~Funding for~~ Implementation of IMs 19 and 20 would ~~be a component of~~ support the Fish Reintroduction Plans under the KBRA (see Section 2.4.3.~~9~~10).

The DRE would install a temporary cofferdam to isolate the work area near the spillway to continue deconstruction activities. To the extent possible, the DRE would use debris from deconstruction for the cofferdam. The cofferdams would likely be constructed using a combination of concrete rubble, rock, and earthen materials that would come from the dams. The cofferdam would isolate the left side of the dam to allow the DRE to deconstruct the concrete portion of the spillway using a hoe-ram (an excavator with a hydraulic hammering attachment) or by drilling and blasting. The DRE would also remove other concrete facilities (including the fish ladder, intake structure, power canal, forebay structures, and powerhouse) using a hoe-ram or drilling and blasting.

After reservoir drawdown, the DRE would remove the embankment dam, working from the top down with standard excavation equipment. The DRE would place portions of the excavated rockfill on the upstream embankment to create an isolation cofferdam. After removing the embankment, the DRE would breach the cofferdam and allow materials to naturally erode. For a full description of the deconstruction activities at the Four Facilities see the Detailed Plan which can be found on KlamathRestoration.gov (Reclamation 2012a).

Estimated waste quantities for ~~full facilities removal~~Full Facilities Removal at the J.C. Boyle ~~Development~~facility include 40,000 cubic yards (yd^3) of concrete, 140,000 yd^3 of earthfill, and 3,000 tons of mechanical and electrical items at the dam. The DRE would fill the original borrow pits on the right abutment of J.C. Boyle Dam with ~~deconstruction~~ waste concrete and earthfill. The DRE would haul materials on existing unpaved roads to the disposal sites along the cleared transmission line corridor, and place some material within ravines below the transmission lines (see Figure 2-9). The existing haul roads would require some initial clearing and minor improvements. The DRE would grade disposal sites for drainage and revegetate to prevent erosion.

The DRE would use surplus waste concrete and earth materials to fill the eroded scour hole on the hillside below the spillway structure to restore the area to near pre-dam conditions. For the remaining waste that would not be disposed on-site, the DRE would separate reinforcing steel from the concrete and haul the steel to a recycling facility in Klamath Falls, Oregon. The DRE would also haul mechanical and electrical equipment to Klamath Falls to be transferred to a suitable recycling facility outside the project boundaries.

Trapped sediments within the reservoir consist primarily of ~~small particles of~~ silts and clays that would be easily eroded and flushed out of the reservoir into the river. Modeling studies indicate that drawdown would erode and flush ~~41~~approximately 27 to ~~65~~51 percent of the stored sediment from J.C. Boyle Reservoir downstream during the drawdown period (~~DOI 2011~~see above call-out box for more information on sediments and erosion). Once eroded from the reservoir, the fine sediment would continue to be suspended in the river water downstream to the ocean. Large quantities of sediment would remain in place after dam removal, primarily on areas above the active channel. The remaining sediments would consolidate (dry out and decrease in thickness) and would decrease the depth of the

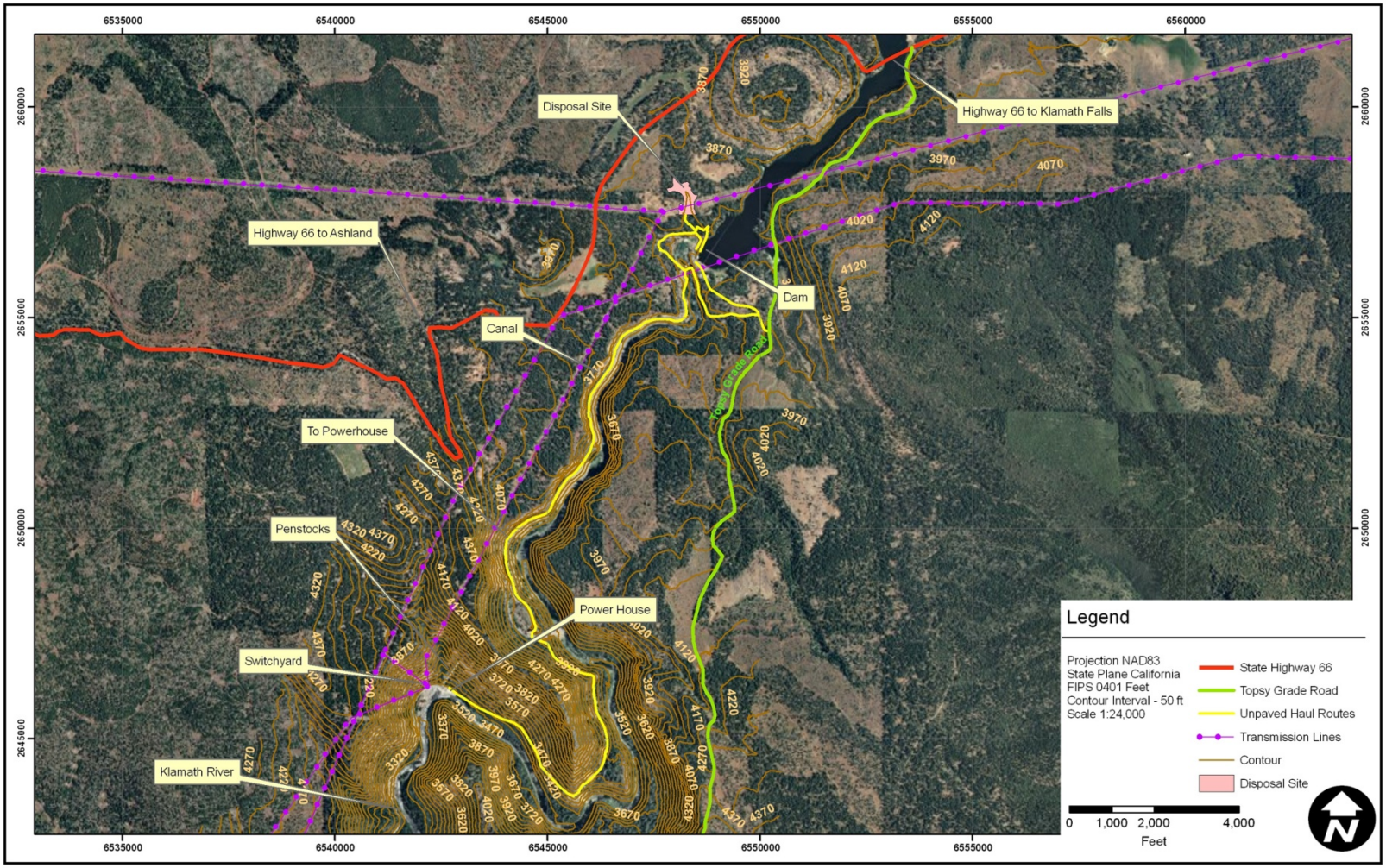


Figure 2-9. J.C. Boyle Haul Roads and Disposal Sites.

remaining sediment. Modeling studies show a change in sediment depth of up to 61 percent of original depth (~~DOI 2011~~Reclamation 2012b). Similar shrinkage of sediment layers would be expected for Copco 1 and Iron Gate Reservoirs.

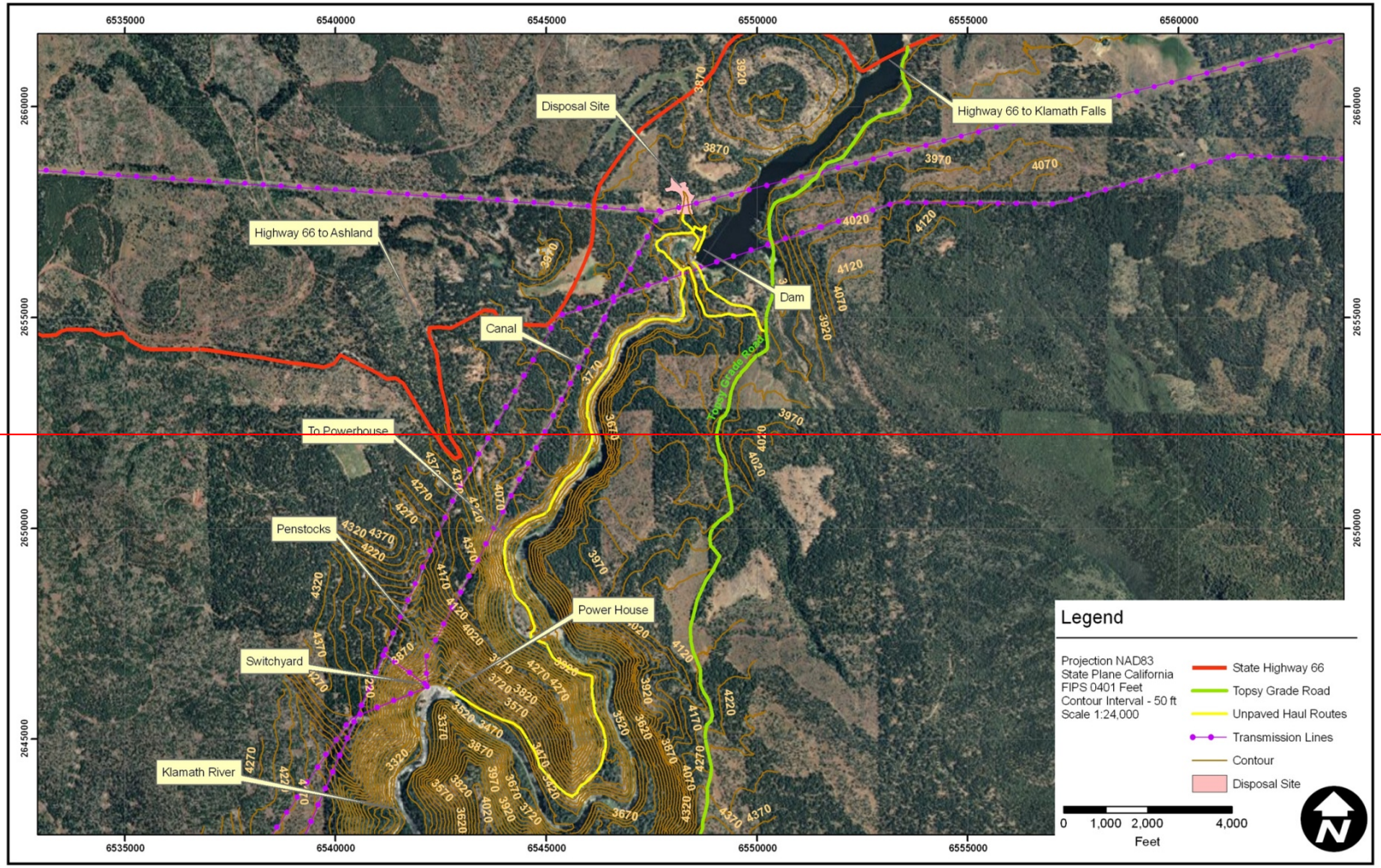


Figure 2-9. J.C. Boyle Haul Roads and Disposal Sites

2.4.3.1.2 Copco 1 Dam and Powerhouse

Under the Proposed Action, the DRE would remove the entire Copco 1 Dam from canyon wall to canyon wall and five feet below the existing streambed (a total of 130 feet from the top of the dam). Removing all facilities would include removal of the concrete water intake structure, concrete gate houses, penstock pipes and supports, powerhouse, power generation support facilities, switchyard, and unused transmission lines.

The deconstruction process would begin by gradually drawing down the reservoir. Reservoir drawdown would release water through three primary locations: over the spillway, through the penstock pipes, and through the diversion tunnel. Use of the diversion tunnel would require removal of three gates, three valves, and a concrete plug to make it operable. Three new gates would be placed on the diversion tunnel; these could be remotely operated. The concrete dam could safely allow flows that overtop the dam crest during dam removal without dam safety or flood concerns. The DRE would construct multiple "notches" in the dam to allow the reservoir to drain; the notches would be 20-foot wide openings that would be a minimum of 16 feet deep.

As the reservoir was drawn down, the DRE would remove facilities from the top down. The DRE would start by removing the spillway gates and the spillway deck bridge, using cranes and excavators. The DRE would then remove the concrete dam in 8-foot-high sections using drilling and blasting. Dam removal would be challenging because the dam has large boulders embedded in the concrete and is reinforced with steel rails.

After removal of the concrete dam down to the water level, the DRE would construct a cofferdam to isolate one side of the dam and remove water from the working area. The DRE would remove the dry portion of the dam to 5 feet below the existing riverbed and then divert the river through the new opening. The DRE would then isolate the other side of the dam and remove it. The DRE would use mechanical means (such as hydraulic shears that break concrete by shearing it like scissors or an excavator with a hoe-ram attachment) to excavate the reinforced concrete in deck, wall, and floor slabs for remaining features (including powerhouse and diversion intake structure).

The estimated waste quantity for Full Facilities Removal at Copco 1 Dam is 62,000 yd^3 of concrete and 1,200 tons of mechanical and electrical items at the dam and powerhouse. The DRE would remove debris from the dam deconstruction, including concrete rubble and reinforcing steel, using a large tower crane on the right side of the river or by hauling from the downstream toe of the dam using trucks. The DRE would bury concrete rubble on the right abutment within an on-site disposal area (see Figure 2-10). After disposal was complete, the DRE would grade the areas for drainage and revegetate to prevent erosion.

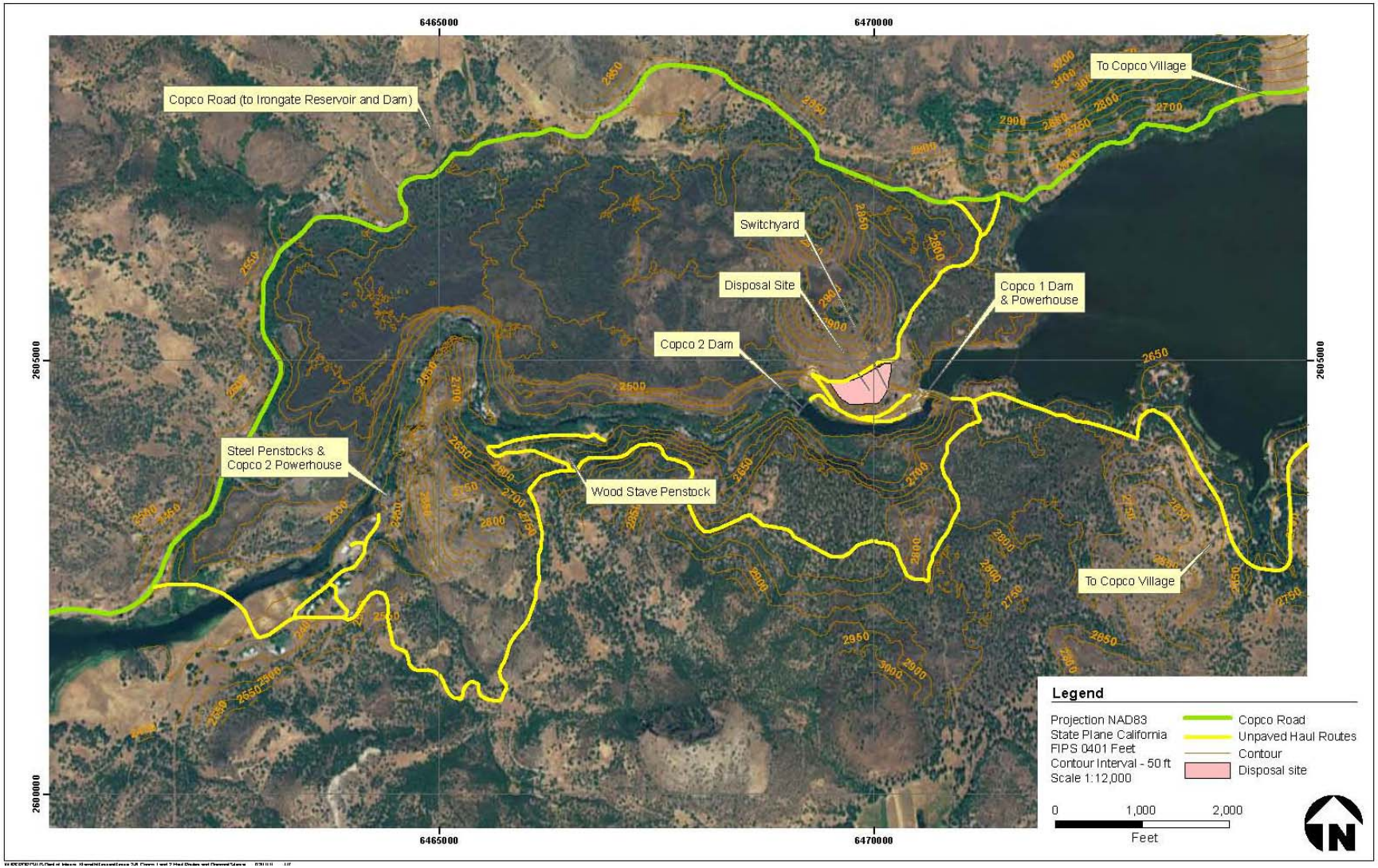


Figure 2-10. Copco 1 and Copco 2 Haul Roads and Disposal Sites.

The DRE would separate reinforcing steel from the concrete and haul it to a local recycling facility in Yreka, California. The DRE would haul mechanical and electrical equipment to Yreka, California for transfer to a salvage company or disposal outside the project boundaries.

The concrete dam and powerhouse are in a steep, narrow canyon. The existing access roads would require substantial upgrades to handle the hauling of excavated concrete and provide access for a large, crawler-mounted crane. Crane access may also be available from the left abutment using existing unpaved roads.

Modeling studies indicate that the initial drawdown would flush ~~46 to 81~~approximately 45-76 percent of the ~~7,440,000~~8 million yd^3 of the fine sediments (silts and clays) stored behind the dam ~~(DOI 2011~~when the dams are removed (see above call-out box for more information on sediments and erosion). Once eroded from the reservoir, the fine sediment would continue to be suspended in the river water downstream to the ocean. After drawdown, the remaining sediments would consolidate (dry out and decrease in thickness). Copco 1 Reservoir sediments would likely consolidate substantially, which would decrease the depth of the remaining sediment.

2.4.3.1.3 Copco 2 Dam and Powerhouse

The Proposed Action would include removal of the dam, spillway and gates, water intake structure, pipelines, penstock, power generation equipment, and unused transmission lines. The DRE would also reshape the embankment on river right to create a stable slope that blends into the natural hillslopes and river channel. Restoration would include filling in the tailrace channel between the powerhouse and the river to restore natural river conditions. The Copco 2 substation at the powerhouse and a switchyard on a bluff north of the river would remain in service following dam removal.

Because of the small reservoir size, a river diversion and work area isolation plan would be sufficient for dam removal. The DRE would start by removing the spillway gates and the spillway bridge using cranes and excavators. Next, the river flow would be lowered and routed through the spillway gates while a cofferdam would be constructed to isolate the left half of the dam. The river flow would be routed through the right two spillway gates as the left two spillway gates and spillway would be removed using mechanical techniques. The techniques would include use of hydraulic shears or hoe-ram attached to a track-hoe. The shears would be able to cut, or shear through the concrete like scissors while the hoe-ram is able to jackhammer the concrete into small pieces that can be removed. After the left spillway was removed, the river would be diverted through the vacated structure and the right portion of the dam would be removed using similar mechanical techniques. The remaining reinforced concrete walls and water intake structure on the side of the river would be removed after the dam is removed. The power generation water conveyance pipes and powerhouse would be removed using conventional track-hoes and off-road dump trucks.

Copco 2 Dam is a concrete dam in a confined canyon with poor access. The existing access roads would require substantial upgrades to handle the hauling of the excavated concrete and provide access for a large, crawler-mounted crane. The access bridge across the Klamath River downstream ~~of~~from the powerhouse could require improvements to handle the construction equipment loads.

Estimated waste quantities for ~~full facilities removal~~Full Facilities Removal at Copco 2 Dam and Powerhouse include more than 12,000 yd^3 of concrete, 1,500 yd^3 of earthfill, and 2,000 tons of mechanical and electrical items at the dam. The DRE would bury concrete rubble on the right abutment within an on-site disposal area (see Figure 2-10). The DRE would handle and dispose of reinforcing steel, concrete, and mechanical and electrical equipment in the same manner as removal of the Copco 1 facilities. Approximately 550 tons of creosote treated wood from the wood-stave conveyance pipe would have to be transported to an off-site disposal facility 120 miles from the site.

2.4.3.1.4 Iron Gate Dam and Powerhouse

The Proposed Action would include removal of the earthen dam, diversion tunnel gate structure, concrete water intake structure, powerhouse generation facility, penstock and its concrete supports, unused transmission lines, and the switchyard. The DRE would bury the concrete spillway to restore the pre-dam appearance of the right abutment bedrock canyon. Further, the DRE would fill the tailrace (where the powerhouse discharges water) to restore natural river conditions in this area.

The Proposed Action would include removal of the fish handling facilities at the base of the dam, but the Iron Gate Fish Hatchery would remain in place. PacifiCorp would need to identify and secure an alternate water source for the fish hatchery to remain operational because the water supply pipe from the penstock intake structure to the fish hatchery would be removed with the dam. PacifiCorp would fund eight years of hatchery operations after decommissioning of Iron Gate Dam, after which the parties will be responsible for identifying funding for continued operation if necessary.

The DRE would draw down the reservoir by releasing water through the ~~bypass~~diversion tunnel and into the power generation facilities. The DRE would begin excavation of the embankment on the very narrow top section, which would be a slow process because of the confined work area. As the excavation worked down from the top, the width of the excavation footprint would be wider and additional equipment could be used. The DRE would remove the riprap during embankment excavation. The DRE would then remove reinforced concrete from remaining structures (including intake structures, fish handling facilities, and powerhouse) using mechanical methods if possible (or drilling and blasting if necessary). The construction of temporary cofferdams would be necessary to divert water when removing the base of the dam and create isolated work areas. These cofferdams would be built using materials from the dam removal process and removed upon completion of the work.

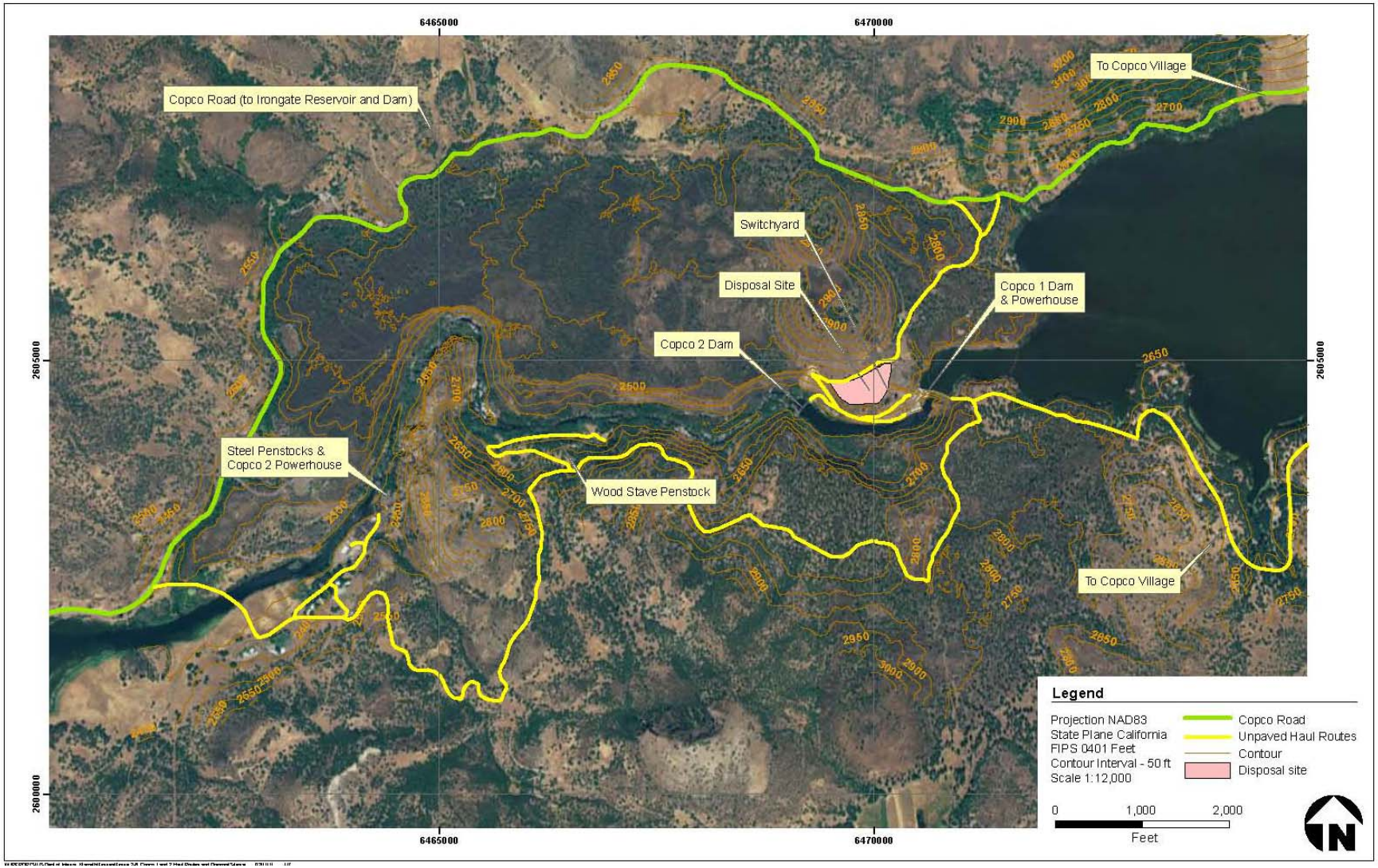


Figure 2-10. Copco 1 and Copco 2 Haul Roads and Disposal Sites

Estimated waste quantities for full removal of Iron Gate Dam and powerhouse include 12,000 yd^3 of concrete, 1.1 million yd^3 of earthfill, and 1,000 tons of mechanical and electrical items at the dam and powerhouse. Removal would also generate waste from four buildings with a combined area of 2,300 square feet.

An original borrow site approximately 0.75 miles upstream ~~from~~of the dam on the left abutment would serve as a disposal site for earth and concrete waste (see Figure 2-11). Another disposal site would be the existing concrete-lined side-channel spillway, chute, and terminal structure, which could accept up to 300,000 yd^3 of excavated material. As the excavation descended, the DRE would need to construct ramps out of the canyon. The DRE would stockpile some rockfill for later use as slope protection for the upstream cofferdam. The DRE would dispose of reinforcing steel, concrete, and mechanical and electrical equipment in the same manner as for the Copco 1 and Copco 2 sites.

Existing haul roads would require improvements to handle two-way traffic of large construction equipment between the dam and the disposal site. The access bridge across the Klamath River downstream ~~of~~from the dam could also require improvements to handle the construction equipment loads.

~~DOI modeling~~Modeling studies indicate that this drawdown would flush ~~25~~24 to ~~38~~32 percent of the trapped sediments in the reservoir (primarily silts and clays) (see above call-out box for more information on sediments and erosion). Once eroded from the reservoir, the fine sediment would continue in suspension all the way to the ocean. The remaining sediments would consolidate after drawdown, and restoration efforts would stabilize the remaining sediment.

~~The City of Yreka's water supply pipeline passes under the upstream end of the Iron Gate Reservoir and would become exposed to high-velocity river flows after dam removal. Reconstructing the pipe further under ground would likely require digging in bedrock, which would be complicated and expensive. Therefore, the DRE would construct a new, elevated pipeline and steel pipeline bridge to support the pipe above the river. The prefabricated steel pipe bridge would be wide enough to accommodate the pipeline and walkway on the deck. The pipeline bridge would likely be three spans with a center span of 200 feet and two end spans of 100 feet. The spans would be supported on concrete piers. The new pipeline would be connected to the existing buried pipeline at each end of the bridge. In order to avoid a disruption to the City's water supply, the permissible outage period would be limited by the available storage tank capacity.~~

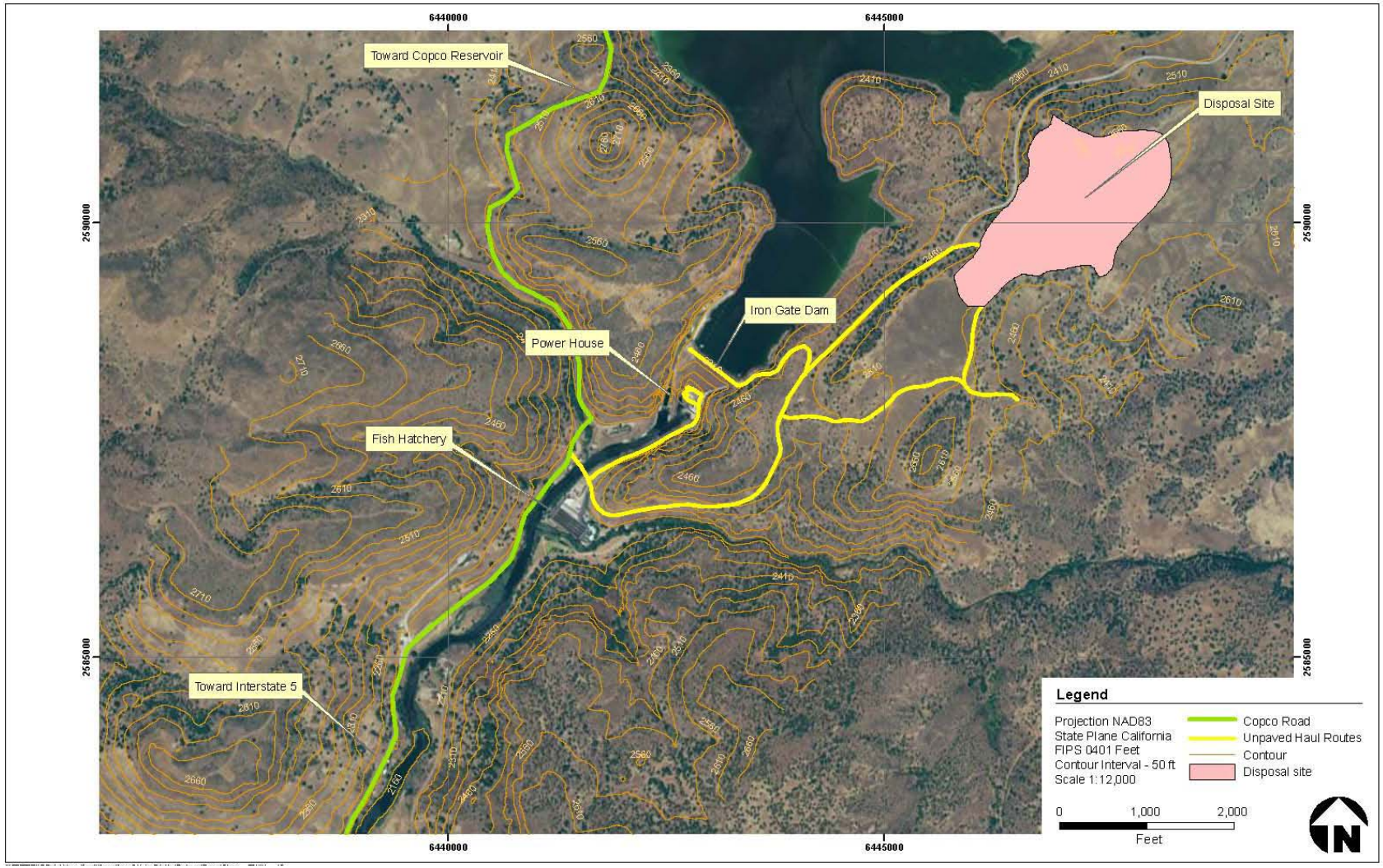


Figure 2-11. Iron Gate Haul Roads and Disposal Sites

2.4.3.2 Schedule

The DRE would begin preparatory work in May 2019. The initial schedule for this alternative would stop power generation at the Iron Gate and J.C. Boyle facilities on December 31, 2019. Power generation would stop at Copco 2 Powerhouse in April 2020 and would cease at Copco 1 in October 2019. Table 2-~~11~~12 shows the schedule to draw down J.C. Boyle, Copco 1, and Iron Gate Reservoirs. (Copco 2 has no drawdown limitations or sediment stored in the reservoir.) The Lead Agencies designed drawdown rates to protect slope stability, public safety, and structures near the reservoirs. The drawdown periods were scheduled to avoid sediment release into downstream areas during critical times for sensitive aquatic species. The end dates in Table 2-9 may vary depending on year type; these dates reflect an average water year, but the draw down might be longer in wet years or shorter in dry years.

Table 2-~~11~~12. Drawdown Plans for J.C. Boyle, Copco 1, and Iron Gate Reservoirs

	J.C. Boyle	Copco 1			Copco 2	Iron Gate
		Phase 1	Phase 2	Phase 3		
Start Date	1/1/2020	11/1/2019	1/1/2020	2/15/2020	6/1/2020	1/1/2020
Starting Elevation (feet)	3,793	2,606	2,590	2,529	2,484	2,328
End Date	2/1/2020	11/17/2019	2/~~4~~11/2020	~~2/24~~3/15/2020	6/30/2020	2/11/2020
Ending Elevation (feet)	3,762	2,590	2,529	2,484	2,460	2,202
Average Drawdown (feet/day)	1	1	1.~~7~~5	~~2.25~~1.5	0.8	3

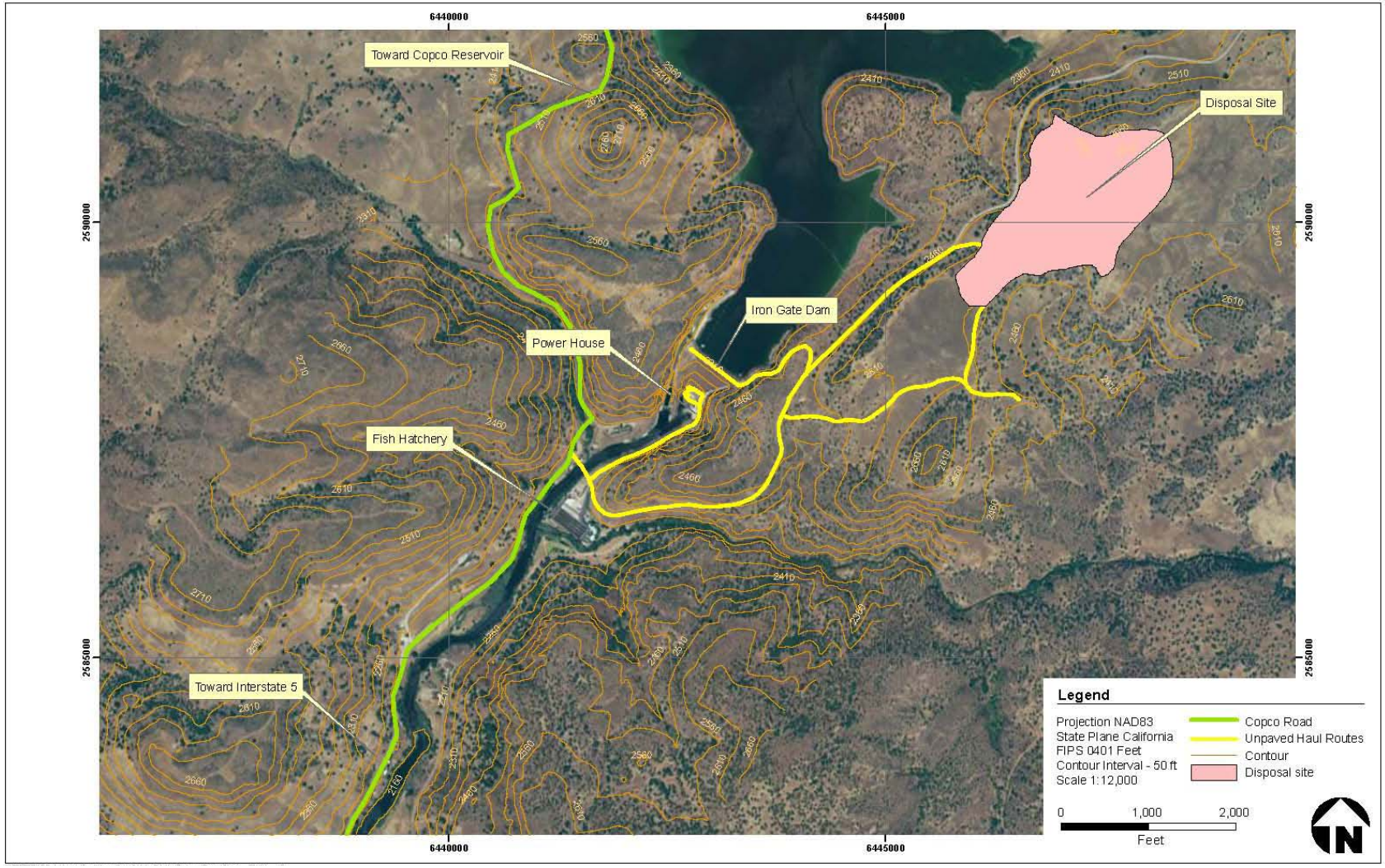


Figure 2-11. Iron Gate Haul Roads and Disposal Sites.

Figure 2-12 provides a schedule for the Proposed Action based on construction requirements for removal.

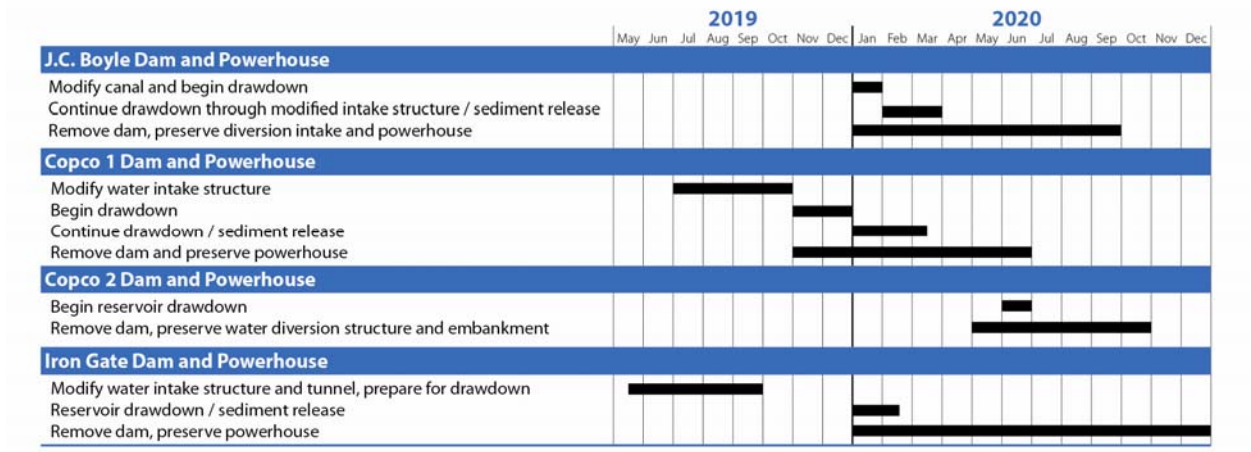


Figure 2-12. Anticipated Schedule for Full Facilities Removal

2.4.3.3 Workforce

The size of the construction workforce at each site would vary, and the peak times for construction would be staggered. Table 2-~~12~~13 shows the construction workforce needed for the Proposed Action.

Table 2-~~12.~~13. Workforce Projections for the Proposed Action

Facility	Estimated Average Construction Workforce	Duration	Estimated Peak Workforce	Peak Period
J.C. Boyle	25 to 30 people	10 months	40 - 45	Jul 2020 - Sep 2020
Copco 1	30 to 35 people	12 months	50 - 55	Nov 2019 - Apr 2020
Copco 2	25 to 30 people	7 months	35 - 40	May 2020 - Aug 2020
Iron Gate	35 to 40 people	18 months	75 - 80	Jun 2020 - Sep 2020

2.4.3.4 Environmental Measures

The Lead Agencies have several standard procedures and management practices that they incorporate into projects to avoid adverse effects to the environment. Key elements of these measures are summarized below, and a more complete description is presented in Appendix B. All the procedures and practices identified in this EIS/EIR are incorporated into each action alternative analyzed in this EIS/EIR.

2.4.3.4.1 Best Management Practices

For all deconstruction and/or construction activities, the DRE would implement standard pollution prevention measures as part of project design specifications and standard construction practices. These measures would include the following:

(1) Storm water erosion and sediment control measures for all deconstruction and/or construction activities;

(2) Proper control of non-stormwater discharges;

(3) Water application to exposed soil surfaces in active construction areas at least three times per day when needed for dust abatement; and

(4) Hazardous spill prevention and response measures.

The Proposed Action would include the transfer of PacifiCorp land surrounding the Four Facilities (Parcel B lands) to a ~~state~~State agency. This agency would install fencing around these lands for the purposes of land management. It would prevent cattle access but would allow wildlife to pass.

2.4.3.4.2 Terrestrial Resource Avoidance

The DRE would take actions to avoid impacts that could include fencing wetlands, training employees about species present, excluding workers and construction activities on areas with sensitive species, and filling trenches and holes quickly to avoid trapping wildlife. Measures would be implemented during construction to avoid or reduce impacts to special-status birds and migratory birds in compliance with the Endangered Species Act, Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act. Specific avoidance measures would be developed in consultation with California Department of Fish and Game (CDFG), Oregon Department of Fish and Wildlife (ODFW), and USFWS.

2.4.3.4.3 Repair Road Damage

The DRE would repair any construction-related damage to surrounding roads.

2.4.3.4.4 Health and Safety Plan

The DRE would prepare and implement a worker Health and Safety Plan prior to the start of construction activities.

2.4.3.4.5 Hazardous Materials Disposal

If hazardous materials are encountered during construction or deconstruction activities, the DRE would use protocols for proper handling, transport, and disposal of the materials.

2.4.3.4.6 Traffic Signs

The DRE would install signs to route construction traffic and warn other motorists about construction activities.

2.4.3.4.7 Work Area Isolation for Dam Removal

The DRE would need to control water and isolate the work area from flowing water and aquatic organisms throughout the duration of construction. The DRE could control water in most areas using gravity diversions; however, pumps could be required to dewater

isolated ponding. Pumps would be screened to prevent entrainment of fish. Prior to pumping, the DRE would conduct a fish rescue, as described below, within the screened area isolating the pump.

The DRE would work in wet conditions in areas that cannot be dried. For in-water work, physical barriers would isolate the work area. Barriers would consist of bulk bags, which are fabric bags filled with sand or gravel that can be stacked as "bricks" to temporarily isolate work areas. Alternately, the DRE could use steel sheets, concrete blocks, gravel berms, inflatable berms or plastic sheeting as physical barriers to isolate work areas. All barriers would be temporary, and would be removed after completing work.

A fish rescue would be conducted in all areas that cannot be drained in a manner that allows ~~fish~~ fish to volitionally depart the area. Fish rescue activities would follow each ~~states'~~state's regulations, rules, and policies and would be in accordance with the NOAA Fisheries Service and ~~USFWS~~ USFWS biological opinions on the Proposed Action.

2.4.3.5 Reservoir Restoration

Under the Proposed Action, there would be substantial erosion of the reservoir sediment while the reservoirs were being drawn down. The eroded sediment would then be transported downstream. Following drawdown of the reservoirs, the DRE would complete restoration actions including revegetation, recreation area maintenance, and recreation area decommissioning, described in this section.

Following drawdown of the reservoirs, revegetation efforts would be initiated to support establishment of native wetland and riparian species on newly exposed reservoir sediment. Access for ground application equipment is expected to be limited immediately following drawdown due to terrain, slope, and sediment instability. Upper areas would be reseeded from a barge until the reservoir levels become too low to operate and access the barge. As the reservoirs are drawn down trucks will be used to apply hydroseed to all accessible areas. Aerial application would be necessary for precision applications of material near the sensitive areas and the newly established river channel, as well as in the remaining areas inaccessible by barge or truck.

Additional fall seeding might be necessary to supplement areas where spring hydroseeding was unsuccessful. In cases where mulch moved/degraded or otherwise exposed bare soil, aerial hydroseeding would be used again for the fall re-seeding. In other cases, where establishment failed, yet the mulch remained intact, new seed material applications might need to be incorporated in order to re-establish seed/soil contact sufficient for germination.

2.4.3.5.1 J.C. Boyle

Sediment in J.C. Boyle Reservoir is concentrated in the historical active channel and most of the sediment is near the dam. During drawdown, most of the sediment near the dam would be eroded from the reservoir area given the steep slopes on the reservoir floor. After drawdown, there would be minor amounts of sediment consolidation on the

floodplain areas. Herbaceous species would be planted or would naturally recruit in the spring following drawdown. Woody species would gradually establish on the river terraces as they propagated from the outer edges of the reservoir.

2.4.3.5.2 Copco 1

Among the reservoirs that would be removed, Copco 1 Reservoir contains the majority of the sediment and is the widest of the reservoirs. Most of the erosion would be focused in the main channel of the Reservoir where the thickness of the remaining sediment would be the greatest. Significant alluvial surface (the benches) would be exposed with drawdown of Copco 1. However, it is possible that reservoir sediment would remain in some of the side channels, particularly if dam removal occurred in a dry year.

After drawdown, the remaining sediments would begin to consolidate and decrease in thickness. Sediment erosion analysis indicates that allowing one high flow event (greater than 7,000 cfs) to pass through the reservoir area would minimize the need for sediment excavation after reservoir drawdown as part of the restoration effort. The erosion processes would be expected to occur during the winter season during the drawdown effort when the sediment would be the most erodible. Reestablishment of herbaceous species would occur soon after the revegetation in the spring. Woody species would be planted along the river banks and would establish over a period of years.

2.4.3.5.3 Iron Gate

The reservoir sediment at Iron Gate Reservoir is relatively thin and the only thicknesses over 5 ~~ft~~ feet were found in the Jenny Creek delta. The river corridor is relatively narrow throughout the Iron Gate reach and the side slopes of the reservoir area are mostly steeper than 20 percent, with a substantial area steeper than 40 percent. Most of the sediment remaining after dam removal would be less than 3 feet thick.

There are far fewer alluvial surfaces in Iron Gate Reservoir than there are in Copco 1 Reservoir, and the resulting riparian corridor would be much narrower at Iron Gate Reservoir than at Copco 1 Reservoir. The tributaries are heavily vegetated with woody species upstream of Iron Gate Reservoir (Philip Williams & Associates 2009) and the tributaries are expected to reestablish a similar riparian and geomorphic condition in the exposed reservoir areas.

2.4.3.6 Recreation Facilities

The Proposed Action would change recreational opportunities from lake-based recreation to river-based recreation. Table 2-~~13~~14 shows the change to existing facilities under the Proposed Action.

2.4.3.7 Keno Transfer

As a connected action to removal of the Four Facilities, PacifiCorp would transfer ownership and operational responsibility of the Keno facility to the DOI. Reclamation is working with PacifiCorp on an Agreement in Principle for the transfer. They have a draft agreement, which will be further developed in preparation for a possible Affirmative Determination.

Table 2-~~13.~~14. Recreation Facilities under the Proposed Action

Site Name	Existing Facilities	Facilities Following Dam Removal

Table 2-~~13.~~14. Recreation Facilities under the Proposed Action

Site Name	Existing Facilities	Facilities Following Dam Removal
Sites at J.C. Boyle Reservoir (Oregon)		
Pioneer Park	Two day-use areas with picnic tables, fire rings, and portable toilets	All facilities would be removed
Topsy Campground	Campground, day-use area, boat launch	Site would be converted to river access facility. Boat ramp would either be extended to the river channel or removed. Other facilities would remain.
Sites at Copco 1 Reservoir (California)		
Mallard Cove	Day-use picnic area and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted.
Copco Cove	Picnic area and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted.
Sites at Iron Gate Reservoir (California)		
Fall Creek Trail	Day-use area and trail	This site would remain. There would be no improvements or changes.
Jenny Creek	Day-use area and campground	This site would remain. There would be no improvements or changes.
Wanaka Springs	Day-use area, campground, boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Camp Creek	Day-use area, campground, boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Juniper Point	Primitive campground and boat dock	All facilities would be removed. Parking area would be regraded, seeded, and planted
Mirror Cove	Campground and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Overlook Point	Day-use area	All facilities would be removed. Parking area would be regraded, seeded, and planted
Long Gulch	Picnic area and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Dutch Creek	Day-use area	All facilities would be removed. Parking area would be regraded, seeded, and planted
Iron Gate Fish Hatchery Public use Area	Day-use area and boat launch	This site would remain. There would be no improvements or changes.

~~Source: O'Meara et al 2010~~Source: Reclamation 2011

~~2.4.3.7 Keno Transfer~~

~~As a connected action to removal of the Four Facilities, PacifiCorp would transfer ownership and operational responsibility of the Keno facility to the DOI. Reclamation is working with PacifiCorp on an Agreement in Principal for the transfer. They have a draft agreement, which will be further developed in preparation for a possible Affirmative Determination.~~

Prior to the transfer, ~~PacifiCorp would complete~~ any necessary improvements to the facility in order to meet DOI Directives and Standards for dam safety would be completed. Prior to the transfer, the facility would be operated under the terms of the existing contract signed in 1968 between PacifiCorp and Reclamation. Following the transfer, DOI would continue to operate the facility consistent with the terms of the same contract and with historic practices (KHSA Sections 7.5.3 ~~&~~ and 7.5.4). Thus, operations under DOI would be consistent with the historic operations of the facility in place since the existing contract was signed on January 4, 1968; therefore, there would be no changes to operations or the surrounding areas as a result of the transfer. Future upgrades at the Keno facility by DOI (such as a new fishway) would be subject to additional NEPA compliance. Potential seasonal trap and haul operations around Keno Dam would be part of the KBRA, as described in Section 2.4.3.10.

~~2.4.3.8 East Side/West Side Facility Decommissioning~~2.4.3.8 East and Westside Facilities – Programmatic Measure

In the event of an ~~affirmative~~ Affirmative Secretarial Determination~~, under~~ and as a ~~plan outlined in~~connected action to removal of the ~~KHSA~~Four Facilities, PacifiCorp would apply to FERC for a partial surrender of its license of the East and ~~West Side~~Westside facilities in order to decommission the generating facilities (KHSA section 6.4.1(A)). Under a plan outlined in the KHSA, PacifiCorp would be responsible for the decommissioning and for recovering its costs through "standard ratemaking procedures" (KHSA 6.4.1(B)). Once the decommissioning ~~was~~ is completed, the lands associated with the East and ~~West Side~~Westside facilities would be ~~transferred to DOI.~~ disposed of in accordance with the KHSA.

The two facilities were proposed for decommissioning in PacifiCorp's 2004 relicensing application. Removing the two facilities would result in the loss of 3.8 megawatts (MW) of generating capacity and the removal of the generating infrastructure. The dams and associated infrastructure were built in 1921, and would require upgrading and maintenance to remain in compliance with DOI and FERC standards. The Link River Dam, which is the point of diversion for the two generating facilities, is already owned by Reclamation. There would be no diversions at Link River Dam after decommissioning.

2.4.3.9 ~~-~~ City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Yreka's Water Supply Pipeline passes under the upstream end of the Iron Gate Reservoir and would become exposed to high-velocity river flows after dam removal that would damage the pipeline and require its relocation. The exact details of the pipeline relocation have not yet been determined at the same level of detail as the rest of the Proposed Action; therefore, this measure is analyzed at a programmatic level of detail. Reconstructing the pipe further under ground would likely require digging in bedrock, which would be complicated and expensive. For the purposes of this analysis, the EIS/EIR assumes the DRE would construct a new, elevated pipeline and steel pipeline bridge to support the pipe above the river. The prefabricated steel

pipe bridge would be wide enough to accommodate the pipeline and walkway on the deck. The pipeline bridge would likely be three spans with a center span of 200 feet and two end spans of 100 feet. The spans would be supported on concrete piers. The new pipeline would be connected to the existing buried pipeline at each end of the bridge. In order to avoid a disruption to the Yreka's water supply, the permissible outage period would be limited to 12 hours and would need to occur during the winter. The permissible outage period would be based on the available storage tank capacity for Yreka, which should be able to meet supplies for up to 72 hours in the winter (Taylor 2010). Subsequent detailed evaluation and continued consultation with Yreka could change the configuration of the pipeline; additional environmental compliance will be completed as necessary.

2.4.3.10 KBRA – Programmatic Measures

As described in Chapter 1, the ~~KBRA~~ Federal lead agency is analyzing the KBRA as a connected ~~to the KHSA.~~ action.The Klamath Basin Restoration Agreement (KBRA) is also a negotiated agreement that reflects a basin-wide approach to addressing the current resources challenges. The KBRA was negotiated concurrently with the KHSA and has been signed by most of the parties to the KHSA, but the Federal agencies are not yet parties to the KBRA. The KBRA will be signed by ~~the United States upon congressional authorization.[5]~~ Federal agencies when Congress authorizes them to do so.[6] The complete KBRA package entails various commitments and actions that have been or will be proposed and/or undertaken in the basin by ~~federal, state~~Federal, State, local, tribal, and private interests. Some of the KBRA actions could have effects (whether adverse or beneficial) on the same environmental resources that would be affected by dam removal. Some KBRA actions are expressly preconditioned by and therefore hinge upon dam removal, and an ~~affirmative~~Affirmative Secretarial Determination. Some KBRA actions are ~~federal~~Federal but are not expressly linked to dam removal, and some actions ~~are completely between private~~involve only non-Federal parties.

NHPA Section 106 Process
DOI elected to utilize the NEPA process to meet the Federal requirements of Section 106 of the National Historic Preservation Act (NHPA) as allowed under 36 CFR Section 800.8(c). DOI defines the undertaking, for purposes of Section 106 of the NHPA, as the removal of the four PacifiCorp dams which may be a result of the Secretarial Determination. The proposed undertaking has the potential to affect historic properties triggering compliance with Section 106 of the NHPA. The analysis and consultations concerning any effects of the Proposed Action and alternatives on historic properties are integrated into the NEPA review and documentation pursuant to the criteria identified in 36 CFR Section 800.8(c)(1)-(4).

2.4.3.10.1 NEPA-Specific Analysis

The ~~**federal lead agency**~~Federal Lead Agency, the DOI, is analyzing the KBRA as a connected action to the proposed Secretarial Determination under the KHSA.

~~[5] Under the KHSA and KBRA (Agreements) the United States will be a party to the KBRA at the time of a Secretarial determination under the KHSA, and obligated to implement the KBRA according to its terms.~~

[6] Under the KHSA and KBRA (Agreements) certain agencies of the United States ("Federal Agency Parties") shall become parties to the KBRA upon enactment of authorizing legislation that authorizes and directs them to become parties (KBRA Section 1.2.2).

NEPA defines connected actions as those actions that are closely related to or cannot or will not proceed unless other actions are taken previously or simultaneously (40 CFR 1508.25(a)(1)(ii)).[7] Some actions or component elements of the KBRA are independent obligations and thus have independent utility from the KHSA, but the implementation of several significant elements of the KBRA ~~package~~ would be different, if the ~~determination~~Secretarial Determination under the KHSA is not to pursue full dam removal. Recognizing that implementation of many elements of the KBRA are unknown and not reasonably foreseeable at this time, the connected action analysis under NEPA is being undertaken at a programmatic level. Consequently, appropriate future project-level analysis under NEPA ~~compliance~~ will be completed for the KBRA in the future as project-specific proposals are developed.

For purposes of this analysis, the KBRA, a connected action, is viewed as a whole program even though some of its component parts are currently being implemented (those without a ~~federal~~Federal nexus or not subject to environmental review) or could be implemented on an individual basis without dam removal. One of the reasons why the KBRA is treated as a whole for purposes of this ~~analysis under NEPA~~ EIS/EIR is that the individual activities under the KBRA will be implemented, through adaptive management and in close coordination with committees comprised of stakeholders, in a manner that seeks to attain synergy and optimize benefits through a coordinated, holistic approach to restoration and water management. Implementing those KBRA activities that are not connected to facilities removal on an individual basis without the benefit of adaptive management and stakeholder input will likely not ~~provide the same level of optimization~~optimize benefits.

Consequently, for purposes of NEPA, in the EIS for alternatives where dams are not removed, the KBRA, as currently signed by the parties, would not be implemented. This is not a judgment about whether any particular measure in the KBRA will be implemented in the absence of dam removal. Rather, it is an assumption that in the absence of dam removal, the KBRA will not include all of the components present in their current form. This means that this document does not make decisions about implementing any specific program, plan, commitment, or activity under the KBRA if dams are not removed. Federal decisions on specific measures in the KBRA, including any necessary additional environmental review, will be made in a separate process. This document will be used to ~~make~~inform a decision related only to dam removal ~~but in~~. In doing so, NEPA requires that we properly scope the ~~alternative and impacts analysis.~~
EIS to include a discussion of connected actions. Further NEPA Section 40 CFR 1508.25 recognizes the interrelationship of scope to other statements and encourages tiering EISs, focusing on issues as they are ripe for decision.

2.4.3.10.2 CEQA ~~-~~-Specific Analysis

~~For purposes of~~ CDFG, as Lead Agency under CEQA, is also analyzing relevant parts of the KBRA ~~analysis are~~in a programmatic fashion, as described in Section 15168 of the CEQA Guidelines. This decision was made because many of ~~its~~KBRA's component elements have not

[7] We acknowledge, however, that the KBRA could also be analyzed as a cumulative or similar action under 40 CFR 1508.25(a)(2) and (3). We note that all three definitions (connected action, cumulative actions, and similar actions) are within the section that provides parameters for the "scope" of the action, which determines both the range of alternatives and the impacts to be considered in an EIS. Ultimately, however, we believe the important point is not the labeling but the analysis and whether the decision (in this case whether to remove four dams) is informed by a~~n~~ EIS that is proper in scope.

been specified to a degree where the associated impacts would be reasonably foreseeable for purposes of this environmental analysis. The parties recognize that future project-specific analysis may be required for various components of the KBRA as they become more clearly defined and **if an affirmative public** when a public entity, as defined by CEQA Guidelines Section 15379, identifies a discretionary approval **is identified.** pursuant to CEQA Guidelines Section 15378, which would obligate subsequent review. A program-level document is appropriate when a project consists of a series of smaller projects or phases that may be implemented separately. Under the programmatic EIR approach, future projects or phases may require additional, project-specific environmental analysis. It should also be noted that this EIR makes certain assumptions about the foreseeable effects of KBRA based on existing information, including, among other things, how the fishery and water resources programs may be designed and implemented. **The lead agency understands**CDFG recognizes that subsequent environmental analysis **during permitting of dam removal** may be required by any California public entity **in California** with an approval or permitting obligation if the circumstances specified by CEQA Guidelines **section** Section 15162(a) are triggered.

Importantly, ~~California~~ CDFG could have analyzed the associated impacts of the KBRA relative to the KHSA in the indirect and cumulative impacts analysis portion of the KHSA EIR as it is not affirmatively approving or carrying out any one aspect of the KBRA that would be subject to environmental review. ~~California~~ CDFG recognizes it is not "approving" any discretionary portion of the KBRA that could alter the physical environment and that by signing the KBRA it has already executed and committed to the agreement itself. Thus, similarly to the EIS, there are no alternatives that consider what a new or revised KBRA might look ~~like~~ in the event dams are not removed. Rather, to avoid confusion, duplication, and wasted resources, ~~California~~CDFG has determined that the concurrent and connected nature of the KBRA to the KHSA warrants a clear understanding of its potentially significant impacts and that the approach of programmatic analysis is equally, if not more, sufficient for providing that information to decision-makers.

Thus, out of an abundance of caution, and to ensure full transparency, ~~California~~CDFG has agreed to consider significance determinations for ~~those portions of the KBRA~~the KBRA in a programmatic fashion. Recognizing that elements of the Proposed Action would occur in California and Oregon, CDFG collaborated with DOI, with input from the State of Oregon, to make a reasonable, good faith effort in disclosing all significant environmental effects of the Proposed Action. Absent certain circumstances, CEQA does not apply to any project or portion thereof located ~~within California consistent with CEQA Guideline section 21080(b)(14) of the~~ outside of California which will be subject to environmental review pursuant to NEPA. (Public Resources Code~~, and~~ § 21080(b)(14); CEQA Guidelines ~~Section~~ § 15277 ~~in a programmatic fashion. However, it too~~). CDFG considers the ~~proposed actions~~Proposed Actions by California to be implementation of the KHSA and thus has crafted alternatives only for dam removal itself, assuming that absent full or partial facilities removal the relevant elements of the KBRA will no longer be ascertainable. ~~The lead agency~~CDFG recognizes that in the event subsequent analysis is deemed appropriate, it will be required to consider any feasible alternatives, mitigation measures, and any other elements required by CEQA as the basis for any approval of such KBRA project or phase in accordance with existing law.

2.4.3.10.3 Implementation

Non-~~federal~~Federal parties who have signed the KBRA include states, tribes, counties, irrigators, and other organizations (Table 2-~~14~~15). Prior to the enactment of ~~federal~~Federal authorizing legislation, ~~federal~~Federal agencies are not parties to the KBRA. However, DOI, NOAA Fisheries Service, and the United States Department of Agriculture have each expressed their intent to take actions consistent with the KBRA to the extent that such actions are consistent with the agency's existing legal authorities and appropriations available for such purposes. These ~~federal~~Federal agencies have each sent separate letters to the non-~~federal~~Federal parties expressing this intent.

Upon the enactment of authorizing legislation, NOAA Fisheries Service, United States Forest Service (USFS), Bureau of Indian Affairs, Bureau of Land Management, Reclamation, and the USFWS would become parties to the KBRA. Additional appropriations would likely be necessary for these agencies to fully implement their responsibilities under the agreement.

Table 2-~~14.~~15. Non-Federal Parties to the KBRA

Karuk Tribe	Malin Irrigation District
Klamath Tribes	Midland District Improvement Company
Yurok Tribe	Pioneer District Improvement Company
California Department of Fish and Game	Plevna District Improvement Company
California Natural Resources Agency	Reames Golf and Country Club
Oregon Department of Environmental Quality	Shasta View Irrigation District
Oregon Department of Fish and Wildlife	Sunnyside Irrigation District
Oregon Water Resources Department	Tulelake Irrigation District
Humboldt County, California	Van Brimmer Ditch Company
Klamath County, Oregon	Randolph and Jane Walthall 1995 Trust
Ady District Improvement Company	Westside Improvement District #4
Collins Products, LLC	Winema Hunting Lodge, Inc.
Enterprise Irrigation District	Upper Klamath Water Users Association
Don Johnston & Son	American Rivers
Inter-County Properties Company	California Trout
Klamath Irrigation District	Institute for Fisheries Resources
Klamath Drainage District	Northern California/Nevada Council Federation of Fly Fishers
Klamath Basin Improvement District	Pacific Coast Federation of Fisherman's Associations
Klamath Water Users Association	Salmon River Restoration Council
Klamath Water and Power Agency	Trout Unlimited
Bradley S. Luscombe	

The "interim period" is the time between the signing of the KBRA and full implementation of the limits on water diversions to Reclamation's Klamath Project. The events that must occur to allow the full implementation of water diversion limits include the removal of the Four Facilities under the KHSA as well as other conditions listed in KBRA Sections 15.3.4 and 15.3.1.A.

While the water diversions to Reclamation's Klamath Project users are not enforceable during the interim period, water diversions would conform to the limits described below in the Diversion Limitations section as closely as possible. Until the On-Project Plan is fully implemented, it might not be possible for water to be managed consistent with the diversion limitations in all years because there are an insufficient number and amount of water measuring devices and control structures.

Programs or activities that are scheduled to occur prior to the enactment of authorizing legislation would be conducted under existing authorities (see on-going activities in ~~Table~~ Table 2-~~15~~16). However, implementation of most interim period activities would be dependent on appropriate authorizing legislation through Congress.

Table 2-~~15.~~16. Summary of KBRA Programs

~~Program[1]~~	~~On-Going Activities~~	~~Increased in Magnitude or Accelerated Schedule with KBRA~~		~~New Program initiated by KBRA~~
Program[1]	Location	Ongoing Activities	Increased in Magnitude or Accelerated Schedule with KBRA	New Program initiated by KBRA
Fisheries Programs:				
~~Fish Habitat Restoration Activities [2]~~	~~X~~	~~X~~		
~~Fisheries Restoration Phase I Plan~~		~~X~~		~~X~~
~~Fisheries Restoration Phase II Plan~~				~~X~~
~~Fisheries Reintroduction Plan – Phase I, Oregon~~				~~X~~
~~Fisheries Reintroduction Plan – Phase II, Oregon~~				~~X~~
~~Fisheries Reintroduction Plan – California~~				~~X~~
~~Fisheries Monitoring Plan~~		~~X~~		
~~Additional Water Storage Projects:~~				
~~Williamson River Delta Project~~	~~X [3]~~	~~X~~		
~~Agency Lake and Barnes Ranches Project~~	~~X [3]~~	~~X~~		
~~Wood River Wetland Restoration Project~~				~~X~~
~~Future storage opportunities~~				~~X [4]~~
Fish Habitat Restoration Activities [2]	OR/CA	X	X	
Fisheries Restoration Phase I Plan	OR/CA		X	X
Fisheries Restoration Phase II Plan	OR/CA			X
Fisheries Reintroduction Plan – Phase I, Oregon	OR			X
Fisheries Reintroduction Plan – Phase II, Oregon	OR			X
Fisheries Reintroduction Plan – California	CA			X
Fisheries Monitoring Plan	OR/CA		X	
Additional Water Storage Projects:				
Williamson River Delta Project	OR	X[3]	X	
Agency Lake and Barnes Ranches Project	OR	X[3]	X	
Wood River Wetland Restoration Project	OR			X
Future storage opportunities	OR			X[4]
Water and Power Programs:				
~~Water Diversion Allocations for Reclamation's Klamath Project and National Wildlife Refuges (NWR)~~				~~X [5]~~
~~Groundwater Technical Investigations~~				~~X~~
~~On-Project Plan~~				~~X~~
~~Winter Shortage Plan~~				~~X~~
~~Water Use Retirement Program (WURP)~~				~~X~~
~~Off-Project Water Settlement (OPWAS)~~				~~X~~
~~Off-Project Reliance Program~~				~~X~~
~~Power for Water Management Program~~				~~X~~
~~Drought Plan~~				~~X~~
~~Emergency Response Plan~~				~~X~~
~~Climate Change Assessment~~	~~X [3]~~	~~X~~		

Table 2-~~15.~~16. Summary of KBRA Programs

~~Program[1]~~	~~On-Going Activities~~	~~Increased in Magnitude or Accelerated Schedule with KBRA~~		~~New Program initiated by KBRA~~
Program[1]	**Location**	**Ongoing Activities**	**Increased in Magnitude or Accelerated Schedule with KBRA**	**New Program initiated by KBRA**
~~Environmental Water Management~~				~~X~~
~~Interim Flow and Lake Level Program~~				~~X~~
Water Diversion Limitations and Allocations for Reclamation's Klamath Project and NWRs	OR/CA			X[5]
Groundwater Technical Investigations	OR/CA			X
On-Project Plan	OR/CA			X
Water Use Retirement Program (WURP)	OR			X
Off-Project Water Settlement (OPWAS)	OR			X
Off-Project Reliance Program	OR			X
Power for Water Management Program	OR/CA			X
Drought Plan	OR/CA			X
Emergency Response Plan	OR/CA			X
Climate Change Assessment	OR/CA	X[3]	X	
Environmental Water Management	OR/CA			X
Interim Flow and Lake Level Program	OR/CA			X
Regulatory Assurances Programs:				
~~Fish Entrainment Reduction~~				~~X~~
~~General Conservation Plan or Habitat Conservation Plan~~				~~X~~
Fish Entrainment Reduction	OR			X
General Conservation Plan or Habitat Conservation Plan	OR/CA			X
County and Tribal Programs:				
~~Klamath County Economic Development Plan~~				~~X~~
~~California Water Bond Legislation (Siskiyou County Economic Development Funding)~~				~~X~~
~~Tribal Programs Fisheries and Conservation Management~~				~~X~~
~~Tribal Programs Economic Revitalization~~				~~X~~
~~Mazama Forest Project~~				~~X~~
~~Klamath Tribes Interim Fishing Site~~				~~X~~
Klamath County Economic Development Plan	OR			X
California Water Bond Legislation (Siskiyou County Economic Development Funding)	CA			X
Tribal Programs Fisheries and Conservation Management	OR/CA			X
Tribal Programs Economic Revitalization	OR/CA			X
Mazama Forest Project	OR			X
Klamath Tribes Interim Fishing Site	CA			X

Notes
1. "Plans" include both the development of the plan and the implementation of the plan.
2. While on-going fish habitat restoration activities are not part of the Proposed Action because they are conducted under current authorities and funding levels, the scope of these activities would be increased in magnitude and accelerated through

Table 2-~~15.~~16. Summary of KBRA Programs

~~Program[1]~~	~~On-Going Activities~~	~~Increased in Magnitude or Accelerated Schedule with KBRA~~		~~New Program initiated by KBRA~~
Program[1]	**Location**	**Ongoing Activities**	**Increased in Magnitude or Accelerated Schedule with KBRA**	**New Program initiated by KBRA**

implementation of the KBRA.~~–~~ Habitat restoration under the Proposed Action would be guided by the Fisheries Restoration Plan to be developed under the KBRA.~~–~~

3. Action is considered part of the No Action/No Project Alternative.
4. Development of additional storage would occur with implementation of KBRA and associated funding.
5. During the ~~Interim Period~~interim period, water diversion limitations to Reclamation's Klamath Project users would conform to the limits described in the Diversion Limitations section as closely as possible.~~–~~ However, before full implementation of the On-Project Plan, it might not be possible to fully comply with the diversion limitations in all years.

With enactment of authorizing legislation there would be the potential for additional funding to enhance some of the ongoing programs. In Table 2-~~15~~16, these are shown as programs that would be increased in magnitude or would be accelerated in schedule with implementation of the KBRA in Table 2-~~15~~16. Most of the programs described in the KBRA would only occur with the enactment of ~~federal~~Federal authorizing legislation and approval of funding at both the ~~federal~~Federal and ~~state~~State levels.

The plans and programs described in the KBRA lead through a series of milestones that culminate in the formal relinquishment of claims for damages, permanent assurances related to tribal water rights, and limitations on water diversions to Reclamation's Klamath Project. Long-term implementation would occur after the full implementation of the water diversion limitations.

The KBRA does not supersede existing ~~federal~~Federal laws such as NEPA and ESA. Programs to be developed and implemented under the KBRA would still be subject to review and analysis and would need to comply with ~~federal~~local, state, and Federal statutory authorities.

The programs proposed by the KBRA and shown in Table 2-~~15~~16 are considered to be connected to the Proposed Action (except as noted). This list includes plans and programs that would only be implemented through enactment of authorizing legislation and ongoing programs that would be enhanced by additional funding resulting from authorizing legislation. The portion of ongoing actions that would be amplified following enactment of authorizing legislation are considered a part of the Proposed Action and the portion that would be implemented regardless is considered under the No Action/No Project Alternative as noted above in Section 2.3.2.

2.4.3.10.4 Fisheries Program

The Fisheries Program of the KBRA has three main goals:

A. Restore and maintain ecological functionality and connectivity to historic habitat.
B. Re-establish and maintain naturally sustainable and viable populations of fish to the full capacity of the restored habitats.
C. Provide for full participation in harvest opportunities.

To meet these goals, the parties to the KBRA agreed to prepare and implement fisheries restoration, reintroduction and monitoring plans and to provide additional sources of instream water to support fish.

Fisheries Restoration Plans

The Phase I Fisheries Restoration Plan is intended to establish restoration priorities and criteria for restoration project selection for the immediate future through 2020 (KBRA Section 10.1). The plan is to be prepared by basin Fish Managers who are defined in the KBRA as ~~federal, state~~Federal, State, or tribal agencies that have responsibility under applicable laws to manage one or more fish species or their habitat in the Klamath Basin. USFWS and NOAA Fisheries Service are to be the co-leads for administrative tasks related to the preparation of both the Phase I and Phase II Restoration Plans. Under the schedule anticipated in the KBRA, the Phase I Plan would be completed in March 2012.

The effectiveness of Phase I restoration activities would be monitored under the Fisheries Monitoring Plan. Monitoring results would be used in the development of the Phase II Restoration Plan to adjust the recommended mix of restoration activities, priorities, and/or project locations to more effectively restore aquatic habitats. The Phase II Fisheries Restoration Plan would establish long-term restoration priorities and an adaptive management process to maintain fish restoration through 2060. The Draft Phase II Restoration Plan is to be prepared within 7 years of the finalization of the Phase I plan, and a final plan is to be completed by March 31, 2022 (KBRA Section 10.2).

Implementation of the Phase I plan could include actions for restoration of existing fisheries in the upper basin, as well as actions necessary to prepare for reintroduction of anadromous fish upstream of Iron Gate Dam. Specific elements could include restoration and protection of riparian vegetation, water quality improvements, restoration of stream channel functions, measures to prevent excessive sediment inputs, remediation of fish passage blockages, and prevention of entrainment into diversions (KBRA Section 10.1.2). See Table 2-~~16~~17 for a geographic breakdown of when and where restoration activities would occur.

Restoration activities similar to the general classes of actions described in the KBRA currently occur throughout the basin as funding is available. It is also expected that ~~the~~ the Phase I Restoration Plan would build upon existing activities and identified restoration needs and that implementation would include the same types of ~~restoration~~ restoration activities that are currently conducted within the basin. Activities would ~~be~~

be prioritized under the Plan and additional funding that may become available under ~~the~~ the KBRA would allow greater improvements to be realized than would occur without the KBRA.

~~Restoration activities are being conducted downstream of Iron Gate Dam on the mainstem and tributaries as well as in the upper basin subject to funding availability. The same types of activities would be expected to be conducted under the KBRA fish restoration program and would include the following types of work:~~

- ~~Floodplain rehabilitation work includes activities to improve or restore connections between channels and floodplains to create and maintain off-channel habitat accessible to overwintering juvenile salmonids. Floodplain rehabilitation could include activities such as riparian planting and understory thinning, to facilitate the development of mature riparian stands that would provide shading and large and small wood to stream channels and floodplains; wetland restoration; and levee setback or dike removal to reconnect floodplain hydrology.~~
- ~~Large woody debris placement could include both mobile wood and complex structures and could be used to create off-channel habitat or provide cover in pools.~~
- ~~Correction of fish passage issues could include culvert upgrades or replacement to meet current fish passage standards and correction of other fish blockages to provide access to new or historic habitats.~~

Table 2-~~16.~~17. KBRA Fisheries Restoration Projects

KBRA Project	Anticipated Schedule
Preparation Phase I Restoration Plan	2012–2013
Preparation Phase II Restoration Plan	2018–2019
Williamson River Aquatic Habitat Restoration	2012–2021
Sprague River Aquatic Habitat Restoration	2012–2021
Wood River Aquatic Habitat Restoration	2012–2021
Williamson Sprague Wood Screening Diversion	2012–2014
Williamson and Sprague USFS Uplands	2012–2021
Upper Klamath Lake Aquatic Habitat Restoration	2012–2021
Screening of Upper Klamath Lake Pumps	2012–2014
Upper Klamath Lake Watershed USFS Uplands	2013–2016
Keno ~~Reservoir~~Impoundment/Lake Ewauna Water Quantity Studies and Remediation Actions	2012–2021
Keno ~~Reservoir~~Impoundment/Lake Ewauna Wetlands Restoration	2013–2017
Keno to Iron Gate Upland Private and Bureau of Land Management	2012–2021
Keno to Iron Gate Upland USFS (Goosenest)	2012–2021
Keno to Iron Gate Mainstem Restoration	2012–2021
Keno to Iron Gate Tributaries – Diversions and Riparian	2016–2018
Shasta River Aquatic Habitat Restoration	2012–2021
Shasta River USFS Uplands	2012–2021

Table 2-~~16.~~17. KBRA Fisheries Restoration Projects

KBRA Project	Anticipated Schedule
Scott River Aquatic Habitat Restoration	2012–2021
Scott River USFS Uplands	2012–2021
Scott River Private Uplands	2013–2019
Mid-Klamath River and Tributaries (Iron Gate to Weitchpec) Aquatic Habitat Restoration	2012–2021
Mid-Klamath Tributaries USFS Upland	2012–2021
Mid-Klamath Tributaries Private Upland	2012–2021
Lower Klamath River and Tributaries (Weitchpec to Mouth) Aquatic Habitat Restoration	2012–2021
Lower Klamath Private Uplands	2012–2021
Salmon River Aquatic Habitat Restoration	2013–2018
Salmon River USFS Upland	2012–2021

Source: KBRA Appendix C-2
Key:
USFS: United States Forest Service

Restoration activities are being conducted downstream from Iron Gate Dam on the mainstem and tributaries as well as in the upper basin subject to funding availability. The same types of activities would be expected to be conducted under the KBRA fish restoration program and would include the following types of work:

- Floodplain rehabilitation work includes activities to improve or restore connections between channels and floodplains to create and maintain off-channel habitat accessible to overwintering juvenile salmonids. Floodplain rehabilitation could include activities such as riparian planting and understory thinning, to facilitate the development of mature riparian stands that would provide shading and large and small wood to stream channels and floodplains; wetland restoration; and levee setback or dike removal to reconnect floodplain hydrology.
- Large woody debris placement could include both mobile wood and complex structures and could be used to create off-channel habitat or provide cover in pools.
- Correction of fish passage issues could include culvert upgrades or replacement to meet current fish passage standards and correction of other fish blockages to provide access to new or historic habitats.
- Cattle exclusion typically includes the construction of fencing to prevent cattle from trampling stream banks, which allows riparian vegetation to grow. Cattle exclusion is often conducted in conjunction with riparian planting. Cattle exclusion fencing would only be implemented in accordance with applicable ~~federal, state~~Federal, State and county regulation and guidance.
- Mechanical thinning and prescribed burning are used to mimic some of the functions and characteristics historically provided by a natural fire regime. Thinning and prescribed burning reduce the potential for more catastrophic fires and the erosion that often follows.
- Purchases of conservation easements and land from willing sellers allow for more direct land management for habitat enhancement purposes.
- Decommissioning of roads could reduce road densities in areas with a high potential for failure and could stabilize slopes. ~~Road~~Routine road operation and road failures can be a major source of chronic sediment inputs into stream systems.
- Gravel augmentation involves the direct placement of spawning-size gravel into the stream channel. Gravel augmentation could increase spawning habitat in systems by increasing the amount of area with suitable substrate. Currently, suitable spawning gravel substrate is limited due to capture of gravels behind dams or armoring of channel banks, or it could be covered with fines from sedimentation.
- Treatment of fine sediment sources could include a broad array of actions including management of stormwater runoff from roads and other developed areas, agricultural and forestry management practices, and other specific actions depending on the sources of fine sediments.
- Screening of diversion structures on the Williamson, Sprague and Wood Rivers and Upper Klamath Lake ~~(UKL)~~ pumps. (This activity is separate from the fish entrainment reduction activities proposed on Reclamation's Klamath Project facilities as described under the Regulatory Assurances Program.)
- Above ~~UKL~~Upper Klamath Lake, activities may include restoration easements and grassbanks that facilitate habitat improvement and landowner economic stability.

2.4.3.10.5 Fisheries Reintroduction Plans

Under the KBRA, the states of California and Oregon would each prepare separate Fisheries Reintroduction ~~plans~~Plans that identify the facilities and actions that would be necessary to start reintroduction of anadromous fish upstream of Iron Gate Dam (KBRA Section 11). The Phase I reintroduction plans would be prepared if there is an Affirmative Determination and each ~~state~~State concurs with that Determination. Reintroduction activities specifically exclude the Trinity River watershed upstream of the confluence with the Klamath River; Lost River and its tributaries; and Tule Lake ~~basin~~Basin.

The Oregon Phase I Reintroduction Plan, to be prepared by the ODFW and the Klamath Tribes, would identify the facilities and actions necessary to start reintroduction and would be adaptable in order to incorporate information gained from the monitoring program. ODFW, the Klamath Tribes, and other Fish Managers would be responsible for implementation of the Phase I Reintroduction Plan.

Phase I reintroduction upstream of Upper Klamath Lake may include active intervention and movement of ~~fish~~Chinook salmon into suitable habitats (KBRA Section 11.3). ~~This could include facilities for collection, transport, and acclimation of fish. Fish would be collected and transported over the Four Facilities prior to~~Following dam removal~~, and~~ seasonal trap and haul operations~~ would~~, primarily for fall-run Chinook salmon may occur ~~at~~around Keno Dam until water quality conditions ~~no longer required them~~are sufficiently improved. A variety of release and rearing strategies would be utilized to optimize success; however, the KBRA does not contain specifics on what those strategies might include.

The California Phase I Reintroduction Plan, to be developed by the ~~California Department of Fish and Game~~CDFG, would adopt a passive approach including development of reintroduction goals, monitoring protocols, habitat assessments, and strategies for adapting the plan as additional information is developed (KBRA Section 11.4). The Phase I Reintroduction Plan would also include development of guidelines for the use of a conservation hatchery at Iron Gate Dam or on Fall Creek to more quickly establish naturally producing populations in the wild if deemed necessary.

Once self-sustaining populations were established, Phase II Reintroduction Plans would be developed to integrate anadromous fisheries into each state's harvest management plans. Fisheries management, including the setting of harvest levels, would be in accordance with the goal of maintaining a sustainable fishery throughout the basin. A schedule for Phase II Reintroduction Plans cannot be established at this time as it is dependent on the success of the establishment of anadromous fisheries in the ~~upper~~Upper Klamath Basin.

See Table 2-~~17~~18 for the general classes of actions that could occur under the Fisheries Reintroduction program during the interim period.

Table 2-~~17.~~18. KBRA Fisheries Reintroduction Projects

KBRA Project	Anticipated Schedule
Reintroduction Plan	2012–2021
Collection Facility	2012–2021
Production Facility	2012–2021
Acclimation Facility	2012–2021
Transport	2015–2021
Monitoring and Evaluation	2012–2021
Hatchery Facilities (at Iron Gate Dam or Fall Creek)	2012–2021

Source: KBRA Appendix C-2

Fisheries Monitoring Plan

The Fisheries Monitoring Plan is intended to direct a cohesive effort to monitor the status and population trends of Chinook and coho salmon, steelhead trout, resident rainbow/redband trout, lamprey, suckers, bull trout, sturgeon, and eulachon (KBRA Section 12.2). Monitoring programs would also collect data on water quantity (e.g., instream flows and Upper Klamath Lake level elevations), water quality (e.g., temperature, nutrient loading, sediment, and algae), the effectiveness of restoration activities, and factors that may limit recovery of fish populations (KBRA Section 12.2).

The Monitoring Plan, to be prepared by the Fish Managers, is scheduled in the KBRA to be completed by March 2012. The results of the monitoring program are to be reviewed in 2020 and 2030 at a minimum. Adjustments in proposed restoration activities would be made on the basis of the results of the monitoring program.

Table 2-~~18~~19 lists the general classes of actions that may occur under the Fisheries Monitoring program.

Additional Water for Fish

Many of the components of the KBRA are intended to result in additional instream flows and to retain water in Upper Klamath Lake in order to support fisheries restoration. Most of these actions are intended to benefit both anadromous and sucker populations regardless of the effects of dam removal. A cornerstone of the KBRA is the agreement to limit diversions to Reclamation's Klamath Project in exchange for certain assurances among the parties in the Oregon water rights adjudication process and with respect to the exercise of certain tribal water rights.

Table 2-~~18.~~19. KBRA Fisheries Monitoring Projects

KBRA Project	Anticipated Schedule
Adult Salmonids	2013 start
Juvenile Salmonids	2013 start
Genetics Otololith	2013 start
Hatchery Tagging	2013 start
Disease	2013 start
Green Sturgeon	2013 start
Lamprey	2013 start
Geomorphology	2013 start
Habitat Monitoring	2013 start
Water Quality	2013 start
Upper Klamath Lake Bloom Dynamics	2014 start
Upper Klamath Lake Water Quality/Phytoplankton/Zooplankton	2012–2021
Upper Klamath Lake Internal Load/Bloom Dynamics	2014 start
Upper Klamath Lake External Nutrient Loading	2012–2021
Upper Klamath Lake Analysis of Long-term Data Sets	2014 and 2019 only
Upper Klamath Lake Listed Suckers	2012–2021
Tributaries Water Quality/Nutrients/Sediment	2012–2021
Tributaries Geomorphology/Riparian Vegetation	2012–2021
Tributaries Physical Habitat	2012–2021
Tributaries Listed Suckers	2013 start
Keno ~~Reservoir~~Impoundment/Lake Ewauna Water Quality/Algae/Nutrients	2012–2021
Keno ~~Reservoir~~Impoundment/Lake Ewauna to Tributaries: Meteorology (Weather Stations)	2012–2021
Remote Sensing Acquisition and Analysis	2013, 2016, and 2019 only

Source: KBRA Appendix C-2

~~**Additional Water for Fish**~~

~~Many of the components of the KBRA are intended to result in additional instream flows and to retain water in Upper Klamath Lake in order to support fisheries restoration. Most of these actions are intended to benefit both anadromous and sucker populations regardless of the effects of dam removal. A cornerstone of the KBRA is the agreement to limit diversions to Reclamation's Klamath Project in exchange for certain assurances among the parties in the Oregon water rights adjudication process and with respect to the exercise of certain tribal water rights~~

Most of the programs that provide additional water for fish are organized under the Water Programs section of the KBRA and are described in greater detail below. These programs include the following:

- Limit on diversions to Reclamation's Klamath Project.
- Interim program of water lease and purchase to reduce diversions from the Klamath River and from tributaries upstream of Upper Klamath Lake.
- Voluntary Water Use Retirement Program (WURP) in ~~upper basin~~ Upper Klamath Basin to add up to 30,000 acre-feet of instream water per year to the Upper Klamath Basin including Wood River, Sprague River, Sycan River (except Sycan Marsh), and Williamson River.
- Increased water storage and conservation through specific projects including the following:
  - Breach levees on Williamson River Delta (Completed) - added 28,000 acre-feet of storage.
  - Reconnect Barnes and Agency Lake Ranches to Agency Lake (under study) - would ~~add~~shift 63,700 acre-feet of active (pumped) storage to passive storage.
  - The Wood River Wetlands would add 16,000 acre-feet of storage (under study).
- Monitor groundwater use to ensure that ~~river flows and~~ specified springs or the river are not adversely affected (KBRA Sec. 15.2.4. E.ii, p. 76).
- Assess effects of climate change for adaptive management of water resources.
- Provide at least an additional 10,000 acre-feet of storage in the Upper Klamath Basin to allow increased diversions in some years, to mitigate effects of drought, and/or to further fish restoration goals.

Additional Water Storage Projects

Section 18 of the KBRA includes three restoration projects intended to increase the amount of water storage in the Upper Klamath Basin. Full implementation of the KBRA is linked to the completion of specific milestones in these projects.

Wood River Wetland Restoration Project

Bureau of Land Management presently manages the Wood River Wetlands for the purpose of restoring wetlands adjacent to Agency Lake. Under the KBRA, Bureau of Land Management would conduct a study, with input from other KBRA parties, to consider options for managing the Wood River Wetland area that would include operating it as a pumped storage within existing dikes or fully reconnecting the area to Agency Lake by breaching the dikes (KBRA Section 18.2.3). The intent is to provide additional water storage for a total of 16,000 acre-feet of potential water storage capacity between elevations 4,143.3 and 4,136.0 feet. Once the study is completed and a proposed action selected, the appropriate level of NEPA analysis and associated Endangered Species Act (ESA) consultation would need to be conducted. The anticipated schedule for the Wood River Wetland Restoration Project is 2013–2015 (KBRA Appendix C-2). Full implementation of the diversion limitations and associated assurances under the KBRA is linked to completion of the study, NEPA analysis, and ESA compliance and to funding for implementation of the selected alternative.

Agency Lake Ranch and Barnes Ranch Project

In 2007, the Agency Lake/Barnes Ranches were transferred to USFWS to be managed as part of the Upper Klamath ~~National Wildlife Refuge (~~NWR~~)~~. Under the KBRA, USFWS would conduct a study with input from other KBRA parties, to consider options for managing the Agency Lake/Barnes Ranches area to enhance water management flexibility in providing

benefits for water storage, fish, wildlife, and wetland habitats (KBRA Section 18.2.2). Potential options would include continuing to operate the area as a pumped storage facility or breaching lakeshore levees and reconnecting the land to Agency Lake. The restoration of diked and drained portions of the ranches could add 63,770 acre-feet of potential storage capacity to Upper Klamath Lake between elevations 4,143.3 and 4,136.0 feet. Once the study is completed and a proposed action is selected, the appropriate level of NEPA analysis and associated ESA compliance would need to be conducted. The anticipated schedule for the Agency Lake/Barnes Ranches Project is between 2013 and 2015 (KBRA Appendix C-2). Full implementation of the diversion limitations and associated assurances under the KBRA is linked to completion of the study, NEPA analysis, and ESA compliance and to funding for implementation of the selected alternative.

Additional Water Storage

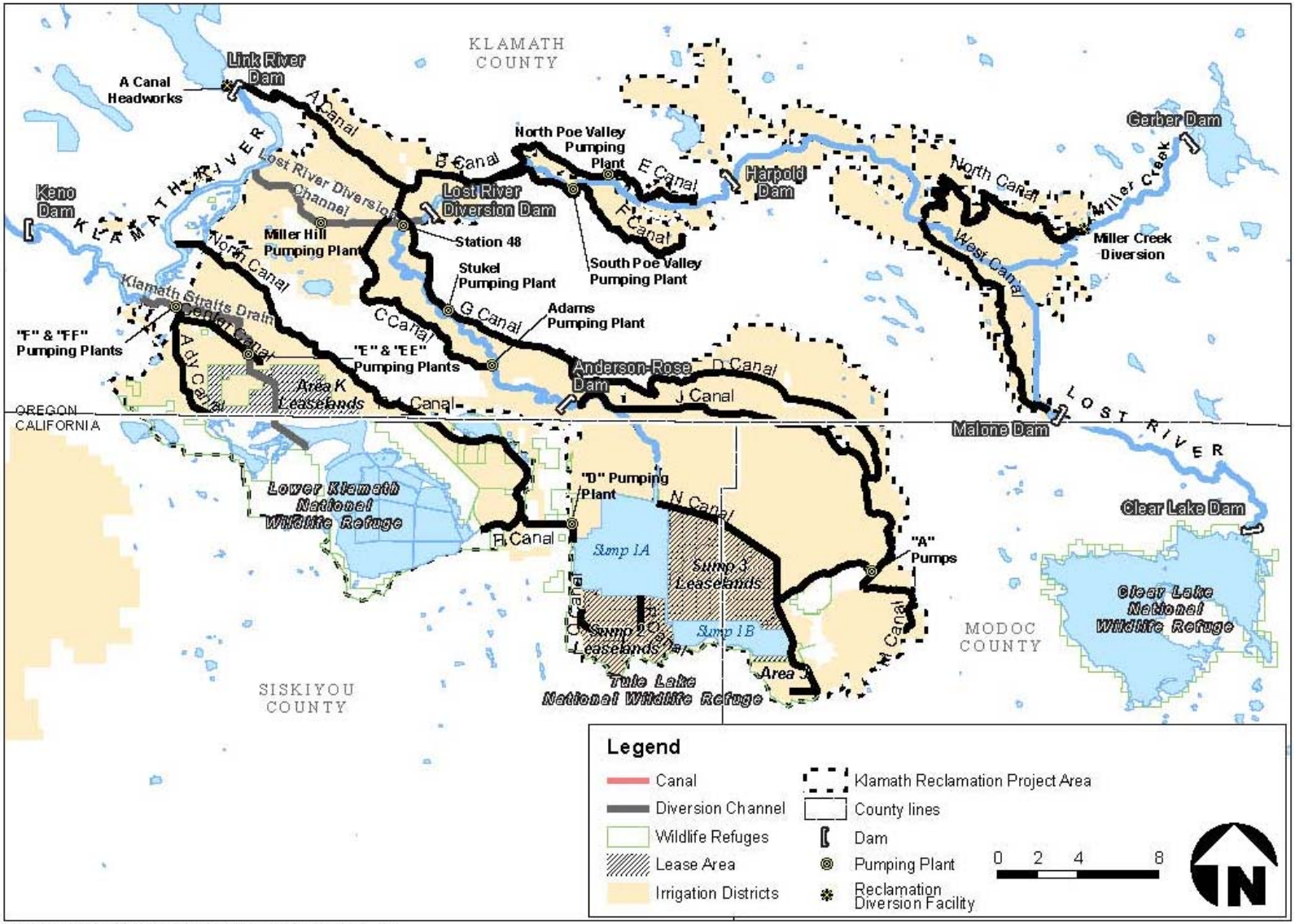
The KBRA includes provisions for further investigation and acquisition of at least an additional 10,000 acre-feet of storage (KBRA Section 18.3 and 15.1.1). This additional storage capacity would be in addition to the instream water and Upper Klamath Lake water storage benefits expected from the WURP and the water storage projects described above. Any project identified in the future that could provide this additional storage may need to comply with separate NEPA evaluations prior to implementation. The first 10,000 acre-feet of additional storage capacity is one of the identified milestones that would allow for increased diversion to Reclamation's Klamath Project users during the irrigation season in some years (KBRA Section 15.1.1).

Water and Power Programs

The Water and Power Programs in the KBRA address water supply reliability and power affordability for on- and off-Project agricultural users, and for moving water through the area of Reclamation's Klamath Project (Figure 2-13). These plans are intended to help all water users in the basin to be better prepared for reasonably foreseeable events and unexpected conditions.

Plans and programs to be developed and implemented under the Water and Power Program of the KBRA are described in the following sections and include:

- On-Project Plan
- Winter Shortage Plan
- WURP
- Off-Project Water Settlement
- Off-Project Reliance Program Plan
- Power for Water Management Plan
- Drought Plan
- Emergency Response Plan
- Climate Change Evaluation
- Interim Flow and Lake Level Protection Plan
- Environmental Water Program



~~Figure 2-13. On-Project Area~~

On-Project Water Management

Diversion Limitations

The proposed limitations on diversions to Reclamation's Klamath Project are described in Section 15 and Appendix E-1 of the KBRA. The diversion limitations would result in the availability of irrigation water to be approximately 100,000 acre-feet less than the current demand in the driest years to protect mainstem flows (Klamath Settlement Parties 2010). Implementation of the diversion limitations would include assurances of increased reliability of diversions.

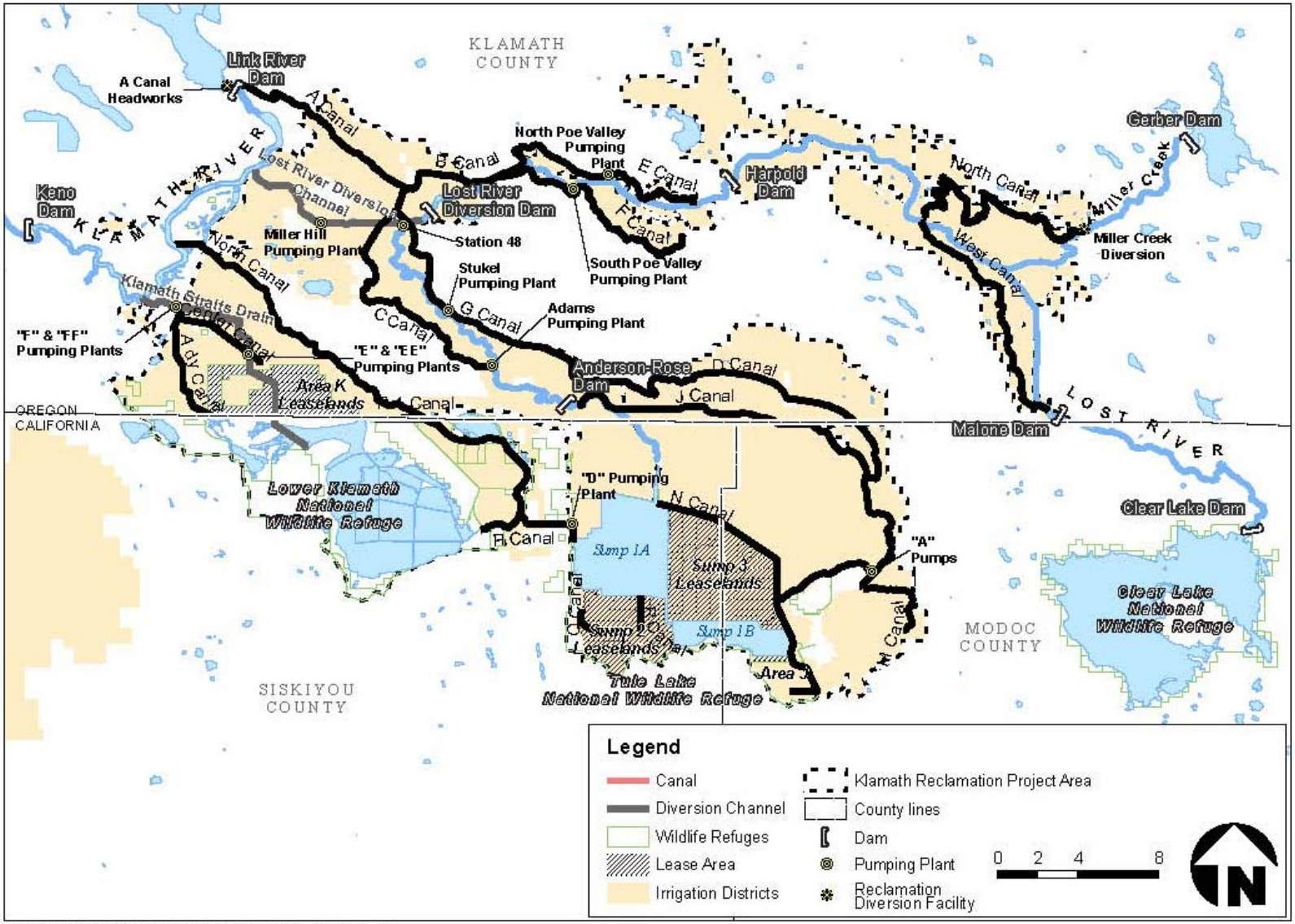


Figure 2-13. On-Project Area.

The amount of water that can be diverted to on-Project users, including the Lower Klamath NWR and Tule Lake NWR, varies by season and by water year forecast (whether a year is forecast to be wet or dry) (Table 2-~~19~~20). The forecast to be used to set diversion limits each year is the Natural Resources Conservation Service 50 percent exceedence forecast for net inflow to Upper Klamath Lake. The 50 percent exceedence forecast is a prediction that there is a 50 percent chance that the actual stream flow will exceed the forecast value (and a 50 percent chance that flows will be less than the forecast value). Although Reclamation's Klamath Project diverts water from a variety of sources, the Upper Klamath Lake forecast would be used to set the diversion limits each Spring and would generally characterize whether a particular year is expected to be wet or dry.

Reclamation's Klamath Project would follow these limitations as much as practicable during the interim period before full implementation of the On-Project Plan. The On-Project Plan would identify what measures might be needed to fully implement the diversion limitations, such as conservation easements or efficiency measures. However, until the On-Project Plan is fully implemented, it might not be possible for water managers to comply completely with the diversion limitations in all years. Full implementation of the On-Project Plan is defined as completion of any measures necessary to allow full implementation of the diversion limitations.

Table 2-~~19.~~20. Reclamation's Klamath Project Diversion Limitations per KBRA Appendix E-1

Season	Forecast (acre-feet)[1]	Diversion Limits (acre-feet)
Phase I[2]		
March–October		
	287,000 or less	378,000 (which includes a 48,000 Refuge Allocation (RA))
	287,000 to 569,000	378,000 to 420,640 (which includes 48,000 to 55,640 for the RA)[3]
	More than 569,000	445,000 (which includes a 60,000 RA)
November–February	N/A	80,000 (which includes a 35,000 RA)
Phase II[2]		
March–October	287,000 or less	388,000 (which includes a 48,000 RA)
	287,000 to 569,000	388,000 to 430,640 (which includes 48,000 to 55,640 for the RA)[4]
	More than 569,000	445,000 (which includes a 60,000 RA)
November–February	N/A	80,000 (which includes a 35,000 RA)

Notes

1. "Forecast" means the March 1st Natural Resources Conservation Service 50~~%~~ percent exceedence forecast (meaning there is a 50~~%~~ percent chance that flow will exceed the forecast amount) for net inflow to Upper Klamath Lake during the period of April 1 to September 30.
2. Phase I of the diversion limits represent the baseline agreement. Phase II allows additional diversions up to 10,000 acre-feet under certain circumstances and would apply after i) the physical removal of the dams and a free-flowing condition and volitional fish passage has been restored; or ii) 10,000 acre-feet of new storage has been developed in the upper basin; or iii) determination after February 1, 2020 that the increase is appropriate.
3. The Phase I allowable diversion in thousands of acre-feet is calculated by the formula 378+{42.64 x [(Forecast – 287) / 282]} and the refuge allocation is calculated by the formula 48 + {7.64 x [(Forecast – 287) / 282]}.
4. The Phase II allowable diversion in thousands of acre-feet is calculated by the formula 388+{42.64 x [(Forecast – 287) / 282]} and the refuge allocation is calculated by the formula 48 + {7.64 x [(Forecast – 287) / 282]}.

~~Reclamation's Klamath Project would follow these limitations as much as practicable during the interim period before full implementation of the On-Project Plan. The On-Project Plan would identify what measures might be needed to fully implement the diversion limitations, such as conservation easements or efficiency measures. However, until the On-Project Plan is fully implemented, it might not be possible for water managers to comply completely with the diversion limitations in all years. Full implementation of the On-Project Plan is defined as completion of any measures necessary to allow full implementation of the diversion limitations.~~

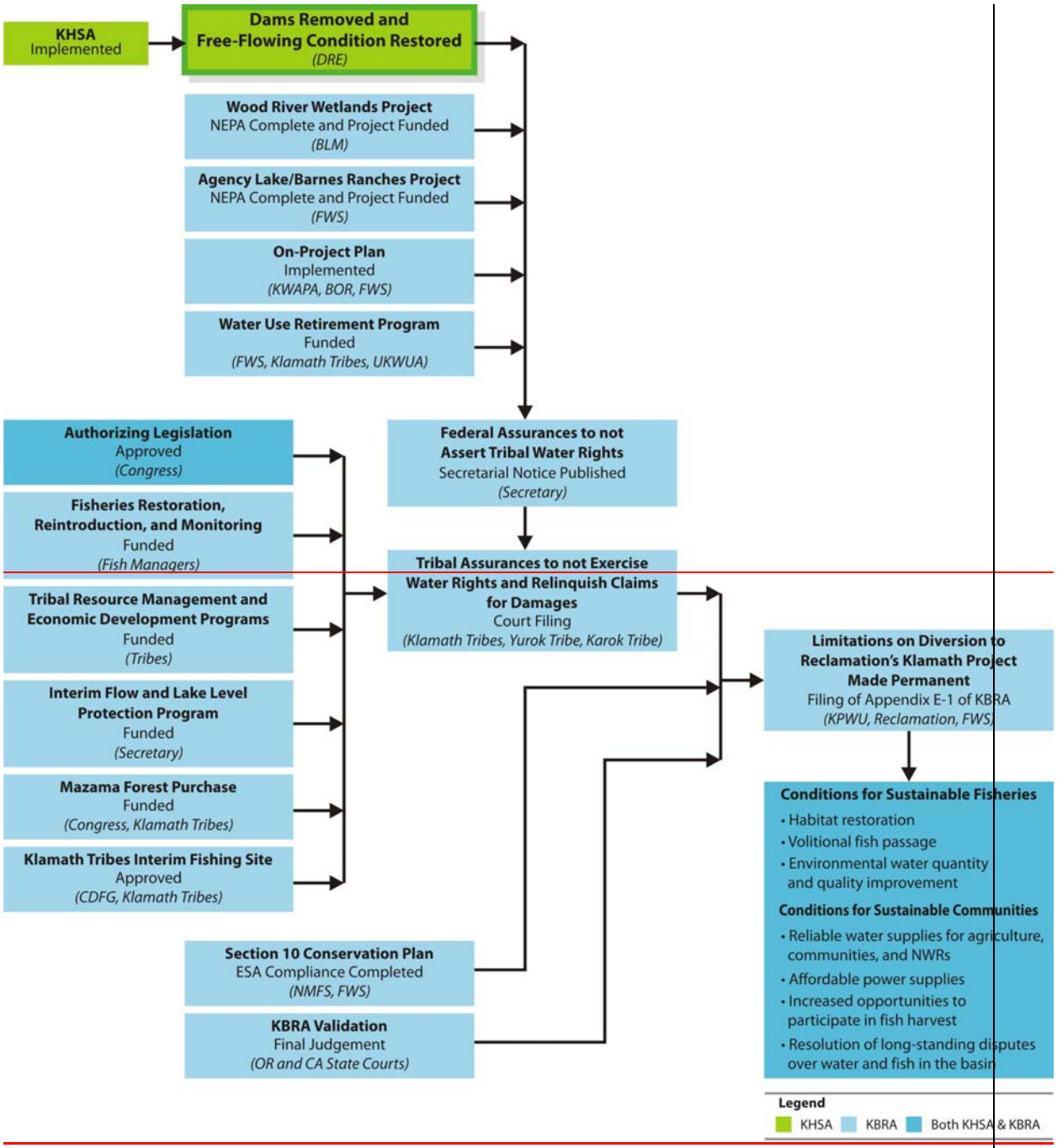
The diversion limitations would not be binding on the parties to the KBRA until Appendix E-1 is filed in an appropriate forum. Appendix E-1 is currently formatted as a filing in the Oregon Water Resources Department (OWRD) water rights adjudication process; however, it is anticipated that that adjudication process will be completed before the Appendix is filed. In that case, the appendix would be reformatted for filing with the most appropriate forum and context, which likely would include a filing with OWRD as it concerns matters of water rights. Prior to filing, the appendix would be signed by the Department of the Interior, Reclamation and USFWS, and irrigation districts within the Klamath Project. Figure 2-14 shows the key KBRA milestones towards full implementation of diversion limits.

Additional On-Project Water Management Provisions

The KBRA contains additional provisions regarding management of water and facilities on Reclamation's Klamath Project. These provisions include direction on a) developing a plan for how water would be allocated and delivered to the Lower Klamath NWR; b~~)~~) management of lease lands at the Lower Klamath NWR and Tule Lake NWR; c) the use of groundwater and a prohibition on adverse impacts to certain springs; d) payment schedule for D Pumping Plant costs; and e) management of Keno and Link River Dams.

Refuge Allocation and Management

The refuge allocation would be the amount of water that Lower Klamath NWR and Tule Lake NWR would receive from Reclamation's Klamath Project facilities as described in the KBRA and is shown in Table 2-~~19~~20 (while the refuges receive some water from other sources, the amounts are minimal compared to water from Reclamation's Klamath Project facilities). The Refuge Allocation includes water for a) Lower Klamath NWR wetlands; b) Lower Klamath NWR cooperative farming lands; c) refilling of the Tule Lake NWR sumps after intentional draining; d) refuge-approved walking wetlands on lease lands, cooperative farm lands, or lands within Reclamation's Klamath Project but outside of the Klamath Basin National Wildlife Refuge System; and e) certain conveyance losses.



~~**Figure 2-14. Key Milestones before Diversion Limits are Implemented**~~

The parties to the KBRA are to develop agreements on the parameters of delivery of water to the refuges including schedules, volumes by time of year and points of diversion, and a system to determine whether water has "passed through" the refuge without being consumed. Agreement on the general parameters of delivery of the Refuge Allocation ~~would~~was to be completed by 2011.

An anticipated schedule for specific projects under this element is identified in ~~Appendix~~ Appendix C-2 of the KBRA including~~:~~

- ~~Operation and maintenance of North and P Canals in 2014~~

~~Walking~~ walking wetland construction 2013–2021.

- ~~Big Pond Dike construction in 2014~~

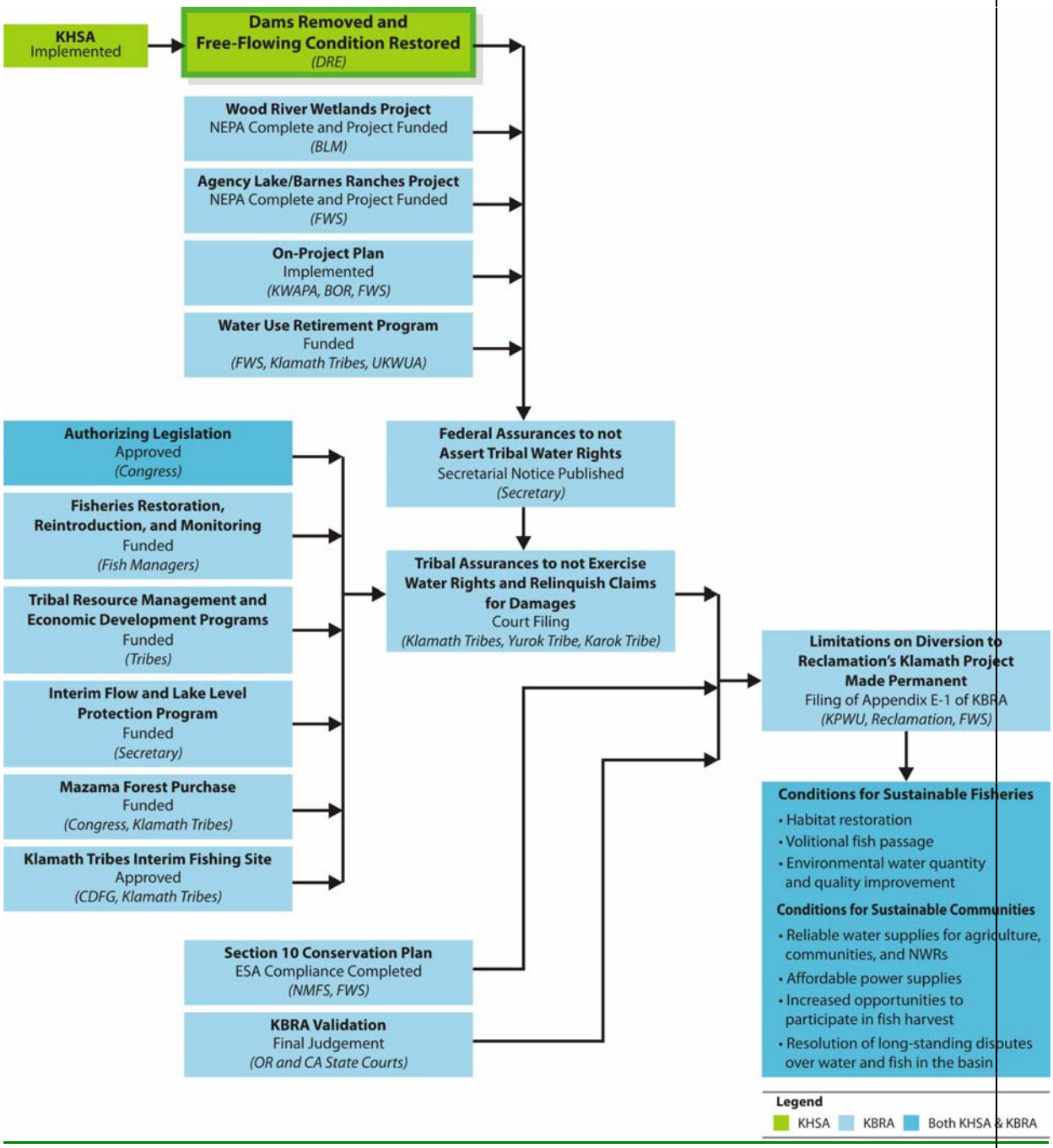


Figure 2-14. Key Milestones before Diversion Limits are Implemented.

Groundwater Management

The KBRA includes provisions for groundwater studies to evaluate potential effects of groundwater pumping and to provide baseline information needed to meet an objective of "no adverse impact" on specified springs in the basin. An adverse effect on springs is defined in the KBRA as a 6 percent reduction in flow and the year 2000 is used as a baseline. If future studies show that a 6 percent reduction or greater does not affect fisheries, then groundwater withdrawals may be increased. The results of the groundwater studies and ongoing monitoring of the effects of groundwater use would be included in the On-Project Plan (KBRA Section 15.2.4).

The anticipated schedule for the groundwater technical studies is between 2012 and 2014 (KBRA Appendix C-2). United States Geological Survey and OWRD would be the Lead Agencies to conduct groundwater technical investigations. The scope of these studies is described in Appendix E-2 of the KBRA. If investigations or monitoring identify an adverse impact, the parties to the KBRA will work together to modify the On-Project Plan and/or remedy the impact (KBRA Section 15.2.4.B.v). A fund for remedying adverse impacts due to groundwater use is identified in KBRA Appendix C-2.

On-Project Plan

The On-Project Plan is intended to set the framework for implementation of the diversion limits to Reclamation's Klamath Project (KBRA Section 15.2). The On-Project Plan would align supply and demand for water users within Reclamation's Klamath Project and is to include the specific objective that groundwater pumping would not adversely affect springs within the basin.

The On-Project Plan would include details on appropriate responses in the event of summer or winter shortages. The KBRA specifies how and under what circumstances a deficit would be shared among on-Project users and the Lower Klamath NWR and Tule Lake NWR in the event of a summer shortage of water available for diversion. A plan for management of winter shortages is to be developed. The On-Project Plan would reference the Winter Shortage Plan, the Drought Plan, the Emergency Response Plan, and other plans to be developed as appropriate.

Full implementation of the On-Project Plan is to occur no later than March 1, 2022. To implement the On-Project Plan, managers may need to take a variety of actions including acquisition or negotiation of conservation easements; forbearance agreements; land acquisitions; efficiency measures; conservation measures, development of groundwater sources; or creation of additional storage. The anticipated schedule to develop and implement the On-Project Plan is between 2012 and 2021 (KBRA Appendix C-2).

Winter Shortage Plan

In the event that there is insufficient water available for diversion to Reclamation's Klamath Project during the winter months (November through February) a plan would be developed to identify how shortages would be shared between the Reclamation's Klamath Project water users including the Lower Klamath NWR and Tule Lake NWR. This plan ~~is~~was intended to be completed by 2011 (KBRA Section 15.1.2.F).

Emergency Response Plan

An Emergency Response Plan would be developed to prepare water managers for potential failure of Reclamation's Klamath Project facilities or dikes on Upper Klamath Lake or Lake Ewauna that affects the storage and delivery of water needed to implement the commitments under the KBRA (KBRA Section 19.3). The emergency response plan is to include: a) a process to prepare for potential emergencies; b) funding sources to respond to emergencies; c) the priority of funding emergency responses; d) potential emergency response measures, including emergency NEPA review, as necessary; and e) a process to implement emergency responses. The Emergency Response Plan is intended to be completed in 2011 and implemented as needed.

Water Use Retirement Program

The voluntary WURP is intended to permanently increase the flow of water into Upper Klamath Lake by 30,000 acre-feet per year to support restoration of fish populations (KBRA Section 16.2.2). In exchange for this benefit to the Upper Klamath Lake fisheries, the Klamath Tribes would be willing to settle certain water rights claims with water users in the ~~upper basin~~Upper Klamath Basin.

The WURP is intended to be part of the Off-Project Water Settlement (OPWAS, see below), but may also be implemented independently by the Upper Basin Team. It is expected that the WURP will take up to 10 years to be fully implemented and implementation would start with the completion of the OPWAS in 2012. The anticipated schedule for implementation of the WURP is between 2012 and 2016 (KBRA ~~Appendix~~ Appendix C-2).

The WURP may be implemented through a variety of measures including retirement of water rights, forbearance agreements, short-term water leasing, split season irrigation, upland management techniques, water efficiency measures, dry land cropping, and natural storage improvements such as wetlands or improved riparian areas.

The OWRD would determine when the required 30,000 acre-feet of water is permanently assigned to Upper Klamath Lake. The additional storage that would be provided by the Williamson River Delta, Wood River Wetlands, and Agency Lake/Barnes Ranches projects would not apply towards successful implementation of the WURP.

Off-Project Water Management

Off-Project Water Settlement (OPWAS)
The OPWAS is intended to provide a forum for resolving long-standing water disputes between the Upper Klamath Water Users Association, Klamath Tribes, and the Bureau of Indian Affairs (KBRA Section 16) in the Off-Project Area. The Off-Project Area includes the Wood River, Sprague River, Sycan River, and Williamson River sub-basins (Figure 2-15). The intent is to negotiate a settlement that resolves the off-Project irrigators' contests to claims in Tribal Cases under the Klamath Basin water rights adjudication process. In the event that not all such contests are resolved through this process, then the intent is to provide reciprocal assurances for maintenance of instream

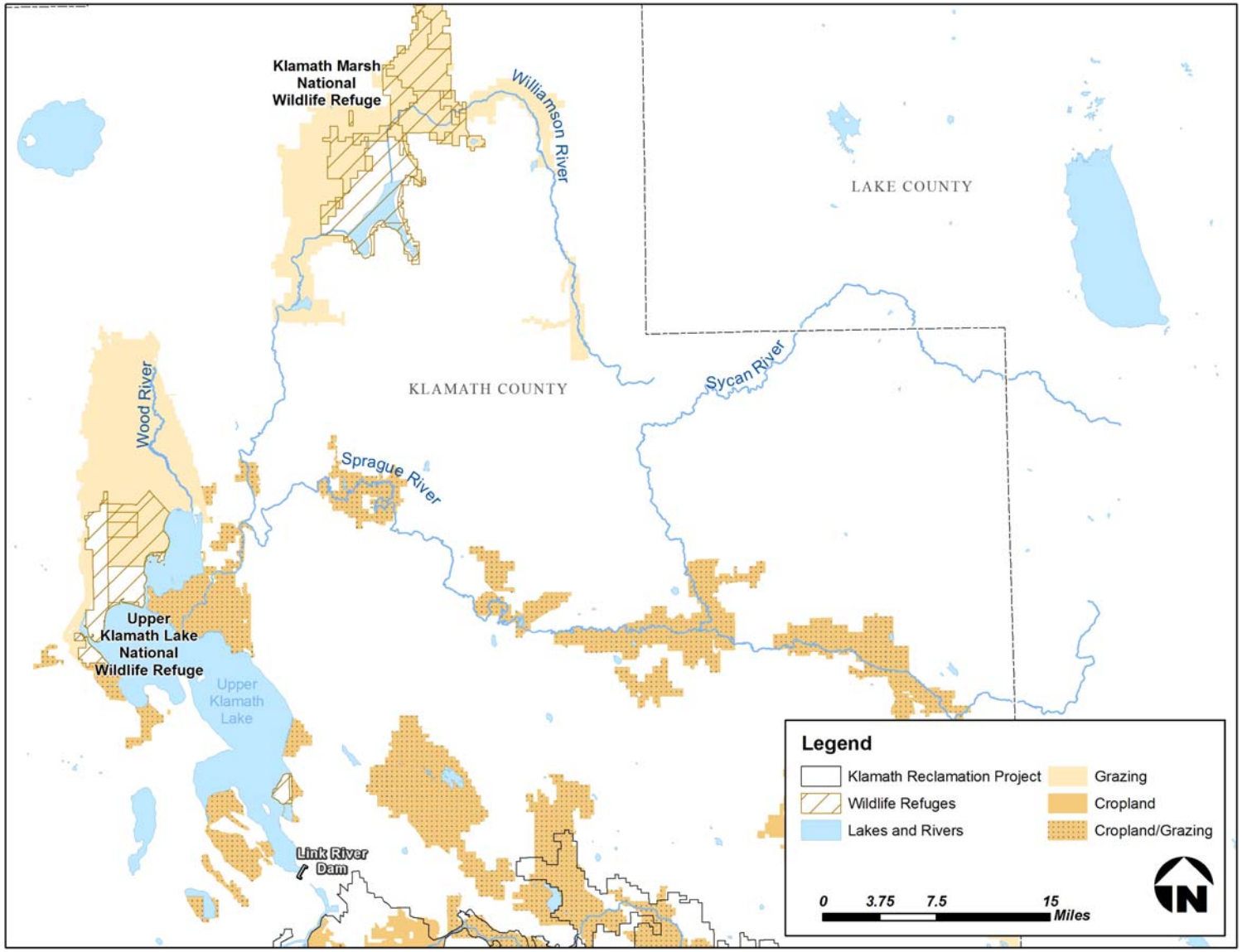


Figure 2-15. Off Project Irrigation Area.

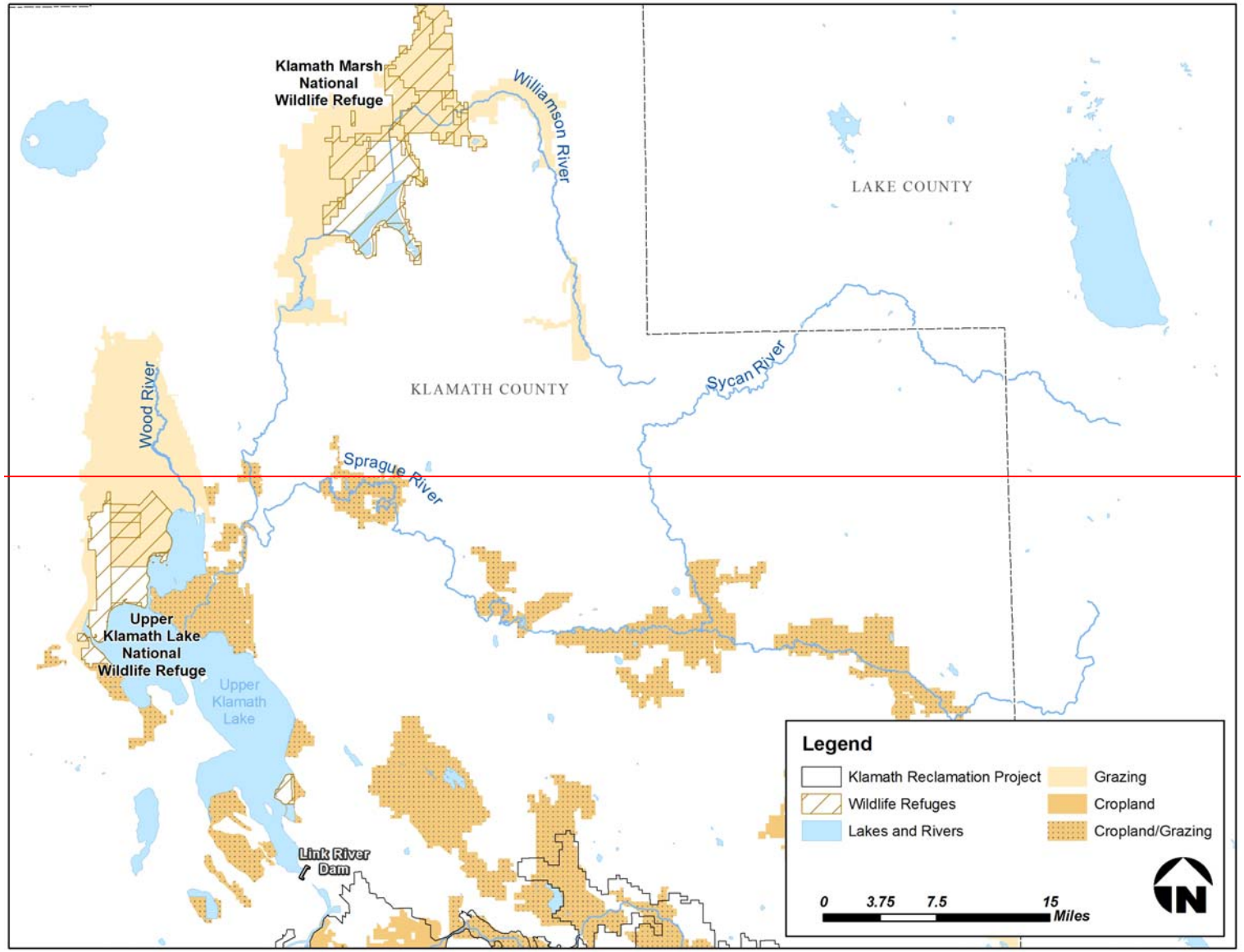
flows and reliable irrigation water deliveries to the Off-Project Area. Under the KBRA, the OPWAS would include the WURP. The anticipated schedule for development and implementation of the OPWAS is between 2012 and 2021 (KBRA Appendix C-2).

Off-Project Reliance Program

The Off-Project Reliance Program is intended to avoid or mitigate the immediate effects of unexpected circumstances affecting water availability downstream ~~of~~from Upper Klamath Lake that could affect the amount of water available for irrigation in the Off-Project Area (KBRA Section 19.5). Due to the way that water rights are prioritized throughout the basin, circumstances that affect water availability for diversion to on-Project users could affect off-Project users upstream.

The program would be developed by the Upper Klamath Water Users Association with input and assistance from off-Project irrigators, Reclamation, and USFWS. The program is intended to be developed prior to the successful conclusion of the WURP but would not be implemented until a) 30,000 acre-feet of additional flow is added to Upper Klamath Lake through the WURP; b) the OWRD finds that additional instream flow has been added; and c) KBRA Appendix E-1 has become effective (i.e., the diversion limits to Reclamation's Klamath Project are fully implemented).

Actions that avoid the impacts of unexpected circumstances might include providing funding for water leasing to increase water availability for irrigation in the Upper Klamath Basin, or mitigating the economic impacts of lost agricultural production (KBRA Section 19.5). Because the Off-Project Reliance Program could not be implemented until the WURP was completed and Appendix E-1 was effective, it would not be likely to start until after 2021.



~~Figure 2-15. Off Project Irrigation Area~~

Power for Water Management Program

The Power for Water Management program is intended to deliver power to eligible users at a cost that is targeted at or below the average cost for similarly situated Reclamation irrigation and drainage projects in the surrounding area. The goals of the program include providing affordable electricity for (i) efficient use, distribution, and management of water within Reclamation's Klamath Project and the Klamath Basin NWR System, and facilitate the return of water to the Klamath River as part of the implementation and administration of the On-Project Plan; (ii~~)~~) implementation of the WURP and OPWAS; (iii) meeting the objectives of the Fisheries Restoration Program; and (iv) providing power cost security to assist in maintaining sustainable agricultural communities in the Upper Klamath Basin (KBRA Section 17.1).

Under the KBRA, a power management entity would be established to deliver affordable power to eligible users. The program includes three components: the Interim Power Program, a Federal Power Program, and a Renewable Power Program. The Interim Power Program is intended to maintain the power cost target for eligible users while the other program elements are implemented (KBRA Section 17.5). The anticipated schedule is between 2012 and 2021 (KBRA Appendix C-2), although the specific implementation steps are yet to be identified by the power management entity.

The Federal Power Program is intended to obtain and provide for the transmission and delivery of ~~federal~~Federal preference power to eligible power users (KBRA Section 17.6). The parties to the KBRA would need to request and be granted an allocation of ~~federal~~Federal power before this element could be fully implemented.

The Renewable Power Program would increase the efficiency of power users both on- and off-Project and generate renewable energy in order to reduce power costs for eligible power users (KBRA Section 17.7). Implementation of the Renewable Power Program includes development of a financial and engineering plan to identify specific renewable energy resources and energy efficiency measures to be developed or invested in. The financial and engineering plan would specifically evaluate the potential for development of a biomass energy project (KBRA ~~Section~~ Section 17.7.2). The renewable energy plan is intended to be completed by 2012 (KBRA Appendix C-2).

Drought Plan

The Drought Plan is intended to provide a process to evaluate and adapt water resource management in the event of a drought or an extreme drought so as to avoid or minimize adverse effects. ~~It would identify~~The Plan identifies water and resource management actions such that no Klamath Basin interest shall bear an unreasonable portion of burdens imposed or the risk of loss or injury as a result of drought or extreme drought (KBRA Section 19.2). The Drought Plan ~~would define~~defines what conditions constitute a drought year. The water years 1992 and 1994 are defined as representing extreme drought conditions.

Full implementation of the KBRA would include the availability of drought relief funds to help offset the impacts of a drought on water users. Measures suggested in the KBRA

that might be taken in the event of a drought include conservation measures, the use of stored water developed for use on Reclamation's Klamath Project, water leasing, use of groundwater, exercise of water rights priorities, and reduction in the diversion to Reclamation's Klamath Project (KBRA Section 19.2). The Drought Plan ~~is intended~~has been drafted and submitted to ~~be completed in 2011~~the Department of the Interior pursuant to KBRA Section 19.2.3 and implementation would be ongoing as needed.

Climate Change

The KBRA provides for an assessment of how long-term climate change may affect fisheries and communities in the Klamath Basin (KBRA Section 19.4). The technical assessment of climate change is scheduled to occur in 2013~~ (KBRA Appendix C-2)~~. Depending on the results of the technical assessment, the parties may need to negotiate supplemental terms to the KBRA in order to achieve the goals of the agreement.

Environmental Water Management

Environmental water is the quantity and quality of instream water available to support fisheries and other aquatic resources. Section 20 of the KBRA lists the obligations of the parties to the KBRA to provide environmental water as described in various sections of the KBRA, including:

- Support dam removal under KHSA (KBRA Section 8).
- Limit diversions to Reclamation's Klamath Project (KBRA Section 15 and Appendix E-1).
- Retire water uses upstream of Upper Klamath Lake to produce additional instream flows and maintain lake levels through a voluntary WURP (KBRA Section 16.2.2).
- Develop additional water storage in the basin (KBRA Section 18).
- Develop and implement Fisheries Restoration Plans (KBRA Section 10).
- Develop and implement Fisheries Reintroduction Plans (KBRA Section11).
- Provide for real-time management of stored environmental water (KBRA ~~Section~~ Section 20.3).
- Implement an Interim Flow and Lake Level Protection Program (KBRA ~~Section~~ Section 20.4).
- Support instream water rights applications (KBRA Section 20.5).
- Support the development and implementation of TMDLs on the Klamath River and actions that protect water quality generally (KBRA Section 20.5.4).
- Oppose proposals for additional out-of-basin transfers of water (KBRA ~~Section~~ Section 20.5.4).

Environmental water may be stored and managed by means such as the operation of the Agency Lake/Barnes Ranches project. In order to determine whether to store water at any particular time, the parties would need to understand the real-time water budget of the basin. Implementation of real-time water management would occur through installation of tools such as water flow monitoring gauges and snowpack gauges (see Table 2-~~20~~21).

~~Under the KBRA, flows for environmental water and lake level management would be increased by at least 30,000 acre-feet through the voluntary WURP. To achieve environmental water goals during the interim period, an Interim Flow and Lake Level Protection Program is proposed in the KBRA (KBRA Section 20.4). This program would purchase or lease water rights from willing sellers to increase the amount of water in the Klamath River and Upper Klamath Lake until permanent instream water supply enhancements could be put into effect.~~

Table 2-~~20.~~21. KBRA Environmental Water Management Projects

KBRA Project	Anticipated Schedule
Real Time Water Management	2012–2021
Water Flow Monitoring and Gauges	2012–2021
Snowpack Gauges	2012–2021
Adaptive Management: Science and Analysis	2012–2021
Calibration and improvements to KLAMSIM or other modeling and predictions	2012–2021
Interim Flow and Lake Level Program	2012–2021

Source: KBRA Appendix C-2

Under the KBRA, flows for environmental water and lake level management would be increased by at least 30,000 acre-feet through the voluntary WURP. To achieve environmental water goals during the interim period, an Interim Flow and Lake Level Protection Program is proposed in the KBRA (KBRA Section 20.4). This program would purchase or lease water rights from willing sellers to increase the amount of water in the Klamath River and Upper Klamath Lake until permanent instream water supply enhancements could be put into effect.

Under the KBRA, the parties agree to withdraw any contests to the existing Instream Water Rights applications filed by ODFW or the Oregon State Parks and Recreation Department and to support any other instream water right claims. The KBRA also includes a provision that the parties would support the conversion of existing PacifiCorp water rights to instream uses when the hydroelectric dams are removed from service.

Water protection and improvement are key objectives of the KBRA. However, the KBRA does not include a separately defined water quality program. KBRA Section 20.5 on the protection of environmental water includes general statements about the importance of protecting water quality and the agreement that the parties to the KBRA would support the development and implementation of appropriate TMDLs (KBRA Section 20.5.4). However, this section does not include any specific actions or prerequisites for other actions.

Regulatory Assurances Program

The KBRA provides for reintroduction of salmon and other aquatic species in the Upper Klamath Basin, which continued to have potential regulatory or other legal consequences for land or water users upstream of the current site of Iron Gate Dam. Therefore, the KBRA includes a set of regulatory assurances to avoid or minimize new regulation or other legal or funding -burdens that might occur to land or water users upstream of Iron Gate Dam from introduction or reintroduction of aquatic species. The KBRA does not supersede existing laws or regulations nor does it modify existing laws or create exemptions. Plans and projects to be developed under the auspices of the KBRA would

still need to comply with laws and regulations in force when discretionary decisions are made on those projects and plans.

The KBRA includes a commitment from Reclamation, upon receipt of funding and in compliance with applicable law, to construct entrainment reduction facilities such as fish screens to prevent fish from entering diversion facilities on Reclamation's Klamath Project (KBRA Section 21.1.3). Entrainment would be specifically evaluated and addressed at a) Lost River diversion channel or associated diversion points; b) North Canal, c) ADY Canal; and d) other diversions from Reclamation or Reclamation contractor-owned facilities (Figure 2-13). The anticipated schedule for construction of these entrainment facilities would be between 2019 and 2020.

The parties to the KBRA have also agreed to coordinate with each other and communicate openly on a wide variety of issues in an effort to avoid surprises so that solutions can be sought without acrimony. The KBRA specifically mentions unforeseen circumstances and consequences of restoration and water delivery as situations that might require fresh coordination (KBRA Sections 21.1.4, 21.2, and 21.3).

Development of either a General Conservation Plan or a Habitat Conservation Plan is identified as a means to secure an incidental take permit under Section 10(a)(1)(B) of the Endangered Species Act. This would be one means to avoid or minimize regulatory burdens or costs -arising from the reintroduction of fish species to the ~~upper basin~~Upper Klamath Basin (KBRA Section 22). In that light, NOAA Fisheries Service and USFWS will lead the development of a General Conservation Plan or Plans for use by KBRA parties or others to apply for incidental take permits under the Endangered Species Act. While development of a conservation plan could begin as early as 2012, it would not be anticipated that a plan would be approved until the end of the interim period.

The KBRA identifies requirements related to incidental take authorizations under the California Endangered Species Act and provides for coordination between Federal and State agencies related to those authorizations. The California Department of Fish and Game may draft legislation regarding a limited authorization to incidentally take fully protected species that may be affected by implementation of the agreement (KBRA Section 24). The KBRA also contains a provision for consideration of any request that the Oregon Department of Environmental Quality perform a Use Attainability Analysis before proposing any new designated use due to the reintroduction of fish species (KBRA Section 25).

2.4.3.10.6 County and Tribal Programs

County Programs

The County Programs under the KBRA recognize that there may be impacts and opportunities for each of the counties within the Klamath Basin. Klamath County has agreed to develop a plan for economic development if funding is available (KBRA Section 27). Funding would potentially come from KBRA authorizations and from ~~state~~State business development programs. The California Water Bond funding legislation, scheduled for a vote in 2012, proposes funding for economic development

within Siskiyou County. The KHSA (Appendix G-1) describes this $20 million in economic development funds that would be provided to Siskiyou County as a part of the dam removal action in the event of an Affirmative Determination and a positive vote on the Water Bond Fund. Humboldt and Del Norte Counties are not included in this economic development fund. Funds remaining in the Water Bond fund after covering facilities removal, CEQA mitigation, and actions to secure the City of Yreka's water supply, may be used for fish restoration projects within Siskiyou, Humboldt, and Del Norte Counties.

Similarly there may be property tax revenue losses and gains from the various effects of the KBRA. Property tax revenue changes could occur due to reduced agricultural land values from a) a reduction in water deliveries and b) the surrender of significant water rights. The Klamath County Program within the KBRA includes a provision to compensate Klamath County for these potential revenue changes upon the availability of funding. The anticipated schedule for identification of potential property tax impacts and compensation payments is 2016 (KBRA Appendix C-2). County programs for Siskiyou, Humboldt, and Del Norte Counties do not include a provision for compensation for changes in property tax revenues that may result from the removal of the hydroelectric facilities.

Tribal Programs

The KBRA includes provisions for each of the affected signatory tribes (the Klamath Tribes, Karuk Tribe, and Yurok Tribe) to receive assistance in developing their capacity to participate in both fisheries management and conservation management activities within the basin (KBRA Sections 31 and 32). In addition, each signatory tribe would prepare an economic development plan and work towards implementing that program (KBRA Sections 31 and 33). Preparation of economic development plans is anticipated to occur in 2013.

The Klamath Tribes have been working with the Trust for Public Lands and have acquired an option to purchase the Mazama Forest in the ~~upper basin~~Upper Klamath Basin, once a part of the tribes' reservation lands. The parties to the KBRA agree to support the Tribes' efforts to secure funding and complete the purchase of this forestland (KBRA Section 33.2). Final acquisition of the Mazama Forest is anticipated to occur in 2012 or 2013. Complete funding to allow the Klamath Tribes to purchase the Mazama Forest is one of the key milestones towards the filing of KBRA Appendix E-1 and the full implementation of the diversion limits to Reclamation's Klamath Project.

Under Section 34 of the KBRA, the Klamath Tribes have petitioned the California Fish and Game Commission to establish an interim fishing site in the reach of the Klamath River between Iron Gate Dam and the Interstate 5 Bridge. The grant of this petition is one of the key milestones toward implementation of the KBRA.

2.4.4 Alternative 3: Partial Facilities Removal of Four Dams

The primary purpose of removing dams on the Klamath River is to restore volitional fish passage and free-flowing river conditions at each dam site, in order to advance restoration of anadromous fish populations. The Partial Facilities Removal of Four Dams Alternative would achieve these goals by partially removing the Four Facilities. The Partial Facilities Removal of Four Dams Alternative satisfies the KHSA and includes the same IMs as in the Proposed Action, implementation of the KBRA, transfer of Keno Dam to DOI, and decommissioning of PacifiCorp's East Side/West Side facilities. The ongoing resource management activities, TMDLs, biological opinions, and other regulatory conditions described under the No Action/No Project Alternative would also occur under this alternative. Inflows to Upper Klamath Lake and outflows from Keno Dam are assumed to be the same under the Partial Facilities Removal of Four Dams Alternative as described above for the Proposed Action. Flows through the Hydroelectric Reach and downstream from the Iron Gate Gauge would also be the same as those in the Proposed Action (see Figure 2-8).

The Partial Facilities Removal of Four Dams Alternative would include removal of enough of each dam to allow free-flowing river conditions and volitional fish passage at all times. Under this alternative, portions of each dam would remain in place, along with ancillary buildings and structures such as powerhouses, foundations, tunnels, and pipes. Some of these remaining features would likely require perpetual maintenance and security measures to prevent unauthorized entry. Maintenance activities would include periodic repair and replacement of fencing and repainting/recoating facilities. All tunnel openings would be sealed with reinforced concrete to eliminate trespass concerns. All oils, hydraulic fluids, and other potential contaminants found in powerhouses and machinery would be removed prior to final decommissioning and securing of buildings. Table 2-~~21~~22 provides a summary of facilities that would be removed or retained under the Partial Facilities Removal of Four Dams Alternative.

Table 2-~~21.~~22. Summary of Features to be Removed or Retained with Alternative 3[1,2]

Feature	J.C. Boyle	Copco 1	Copco 2	Iron Gate
Embankment/earth fill dam	Remove		Retain	Remove
Concrete dam structure	Remove	Remove	Remove	
Concrete wingwalls			Retain Right Wall	
Reservoir power intake structure	Retain	Retain	Retain	Remove
Spillway	Remove	Remove	Remove	Retain
Spillway control gates	Remove	Remove	Remove	
Concrete fish ladder	Remove			Remove
Concrete flume headgate structure	Retain			
Concrete canal intake screen	Retain			
Concrete flume	Remove Walls			
Concrete canal spillway	Remove			

Tunnel intake structure	Remove	Retain	Retain	Remove
Tunnel portals	Plug	Plug	Plug	Plug
Steel pipeline & supports	Retain			
Steel surge tank	Remove			
Wood-stave penstock			Remove	
Penstocks, supports, anchors	Remove	Retain	Retain	Remove
Powerhouse building		Retain	Retain	Retain
Powerhouse gantry crane	Remove			
Powerhouse concrete slab/structure	Retain	Retain	Retain	Retain
Powerhouse hazardous materials	Remove	Remove	Remove	Remove
Tailrace flume walls	Retain			
Tailrace channel	Fill	Fill	Fill	Fill
Switchyard	Remove	Remove	Retain	Remove
Warehouse & support buildings	Remove		Retain	
Fish Hatchery				Retain

Notes

1. Grayed-out cells indicate features that are not present at existing dam facilities and would therefore not need to be removed or retained.
2. Features indicated as retained under the Partial Facilities Removal of ~~Dour~~Four Dams Alternative are features that would be removed as part of the Proposed Action/Full Facilities Removal of Four Dams Alternative.

2.4.4.1 Deconstruction Actions

Deconstruction techniques for the Partial Facilities Removal of Four Dams Alternative are the same as for the Proposed Action, with no specialized means or methods necessary. Partial facilities removal would ~~be completed during a 1-year period, and dam removal at each site would require~~use the same equipment ~~as~~and be on a similar schedule to the Proposed Action. The following sections describe the scope of work and features for partial removal of each dam under this alternative.

2.4.4.1.1 J.C. Boyle

Partial facilities removal would require the complete removal of the embankment section, gated concrete spillway section, and concrete cutoff wall to the bedrock foundation. The DRE would also do the following:

- Remove the lower portion of the fish ladder to prevent potential fish stranding during peak flow events.
- Remove the abutment wall and upper portion of the fish ladder, because they could become unstable after the removal of the embankment and spillway sections.
- Recoat the 14-foot-diameter steel pipeline and supports to encapsulate potential heavy metals.
- Remove concrete walls for the water conveyance canal to allow drainage and animal migration, and prevent collapse due to rockfall.
- Remove the 78-foot-tall steel surge tank and the 150-ton gantry crane to prevent a potential future stability problem during a large seismic event.
- Remove the penstocks to avoid long-term maintenance issues related to the steel, which likely has coatings containing heavy metals.
- Plug the downstream tunnel portal with concrete to avoid unauthorized entry.
- Remove the switchyard and warehouse building.
- Fence and seal the powerhouse

Under the Partial Facilities Removal of Four Dams Alternative, the DRE would not remove the water intake structure, left abutment concrete gravity section, concrete headgate structure, intake screen, steel pipeline and supports, tailrace walls, and powerhouse concrete slab and structure, as shown in Figure 2-16. The DRE ~~would not~~may partially fill and stabilize the headcut downstream ~~of~~ from the forebay overflow discharge canal (as in the Proposed Action~~) because it would require a large quantity of material that would not be available; partial~~). Partial removal would not produce as much concrete rubble as full removal would; therefore, the amount of fill would be dependent on the quantity of material available.

The DRE would leave the mechanical and electrical equipment in place with all power connections to the outside removed; however, it would remove any oil in the turbine governor and hydraulic control systems, transformers, oil storage tanks, or other equipment. The DRE would also remove other mechanical and electrical equipment containing potentially hazardous materials.

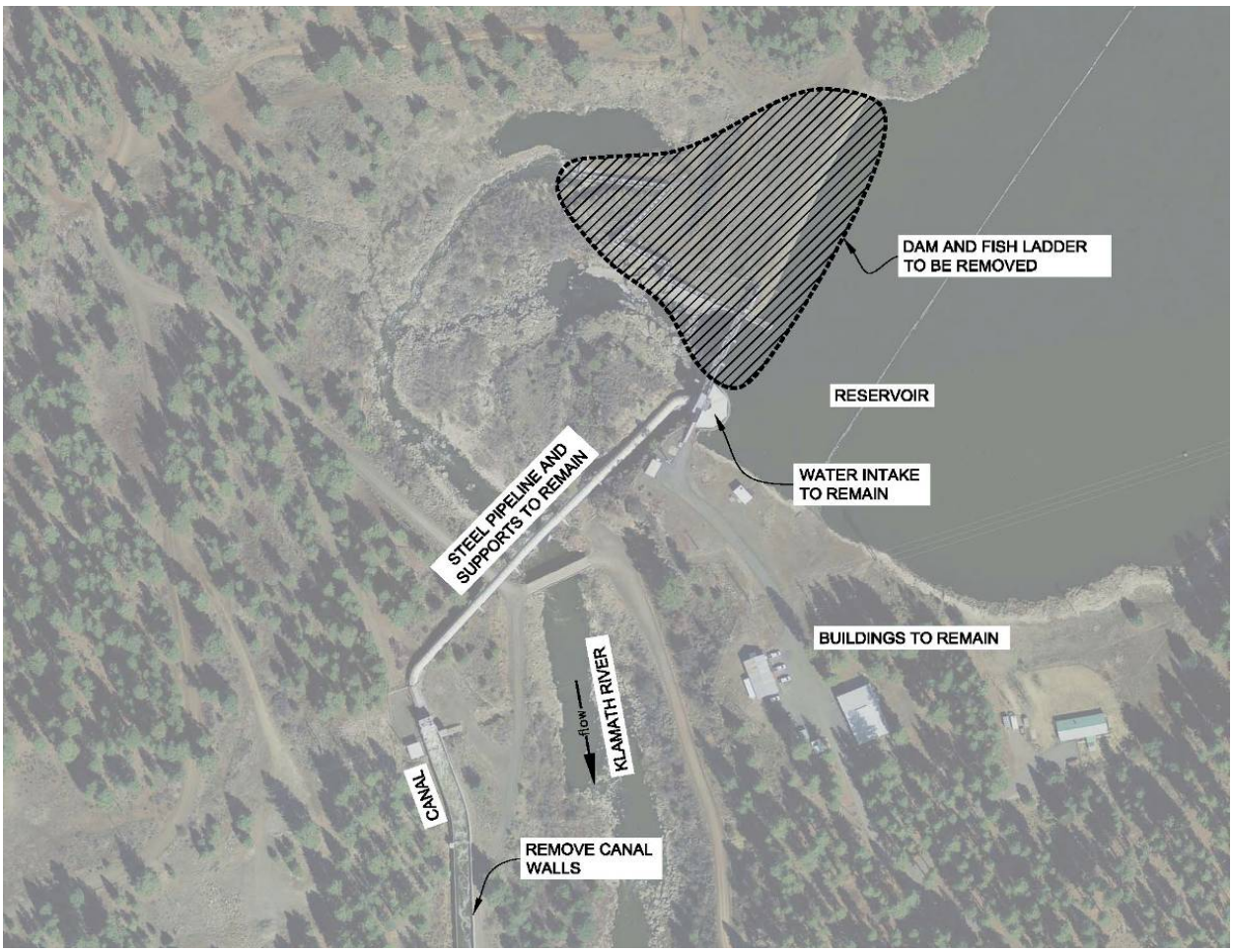


Figure 2-16. View of J.C. Boyle Dam showing portion of dam and fish ladder to be removed for the Partial Facilities Removal Alternative

2.4.4.1.2 Copco 1 Dam and Powerhouse

To create a free-flowing condition and volitional fish passage through the Copco 1 site, the DRE would:

- Remove the concrete gravity arch dam and associated facilities (spillway gates, bridge deck, and piers) between the left abutment rock and the concrete intake structure on the right abutment to 5 feet below the existing streambed level at the dam.
- ~~Remove the two concrete gate houses on the right abutment intake structure if necessary to provide workspace for a large crane.~~

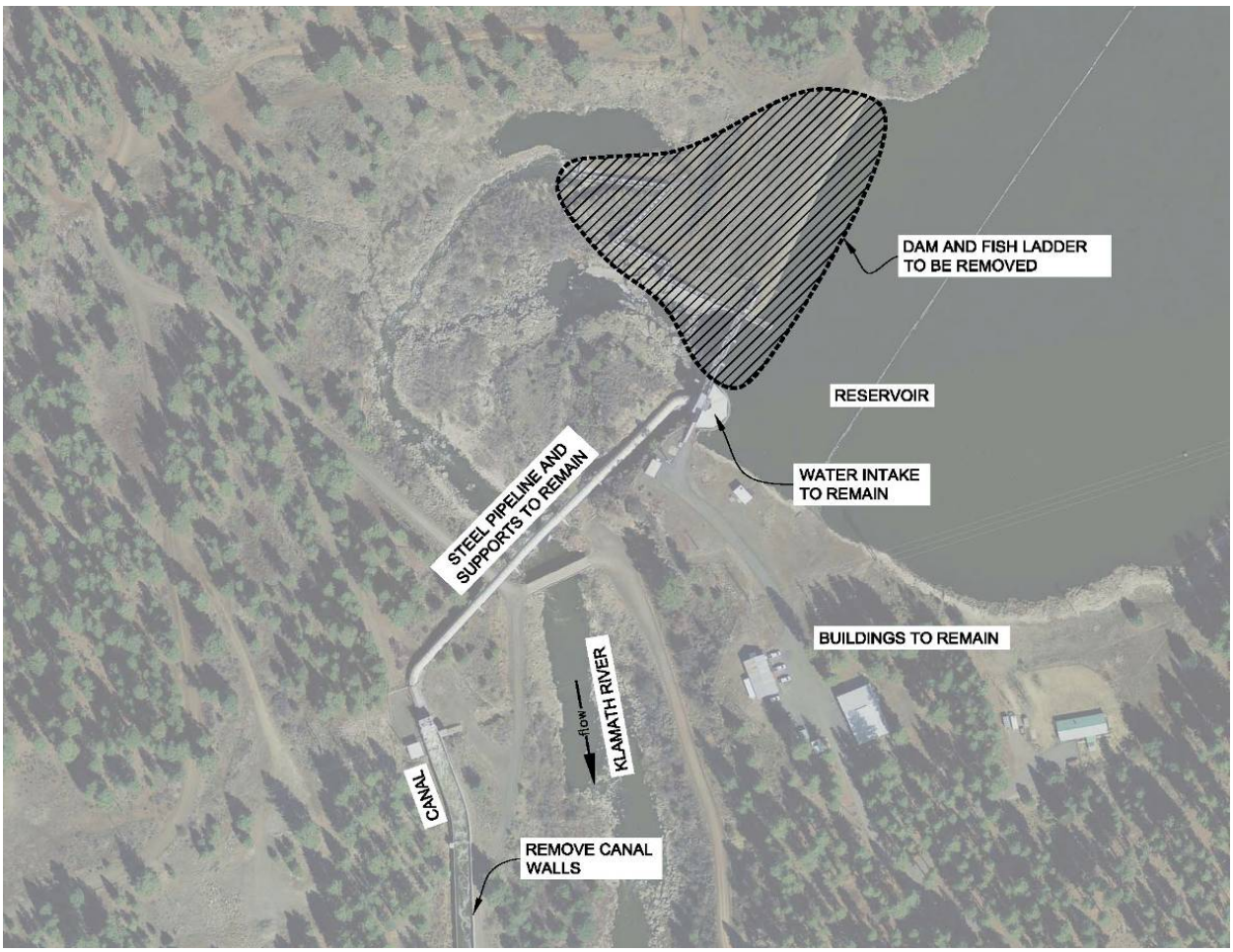


Figure 2-16. View of J.C. Boyle Dam showing portion of dam and fish ladder to be removed for the Partial Facilities Removal Alternative.

- Seal the downstream end of the intake tunnel portal with concrete to avoid unauthorized entry.
- Remove unused transmission lines, poles, and the switchyard.
- Seal and fence the powerhouse.

Under the Partial Facilities Removal of Four Dams Alternative, the DRE would not remove the power generation water intake structure, penstocks, and powerhouse (~~Figure~~ Figure 2-17). Retention of these structures would require long-term maintenance, including the preservation of any items with coatings containing heavy metals. The DRE would handle mechanical and electrical equipment and equipment containing potentially hazardous materials in the same manner as for the J.C. Boyle Dam removal under this alternative.

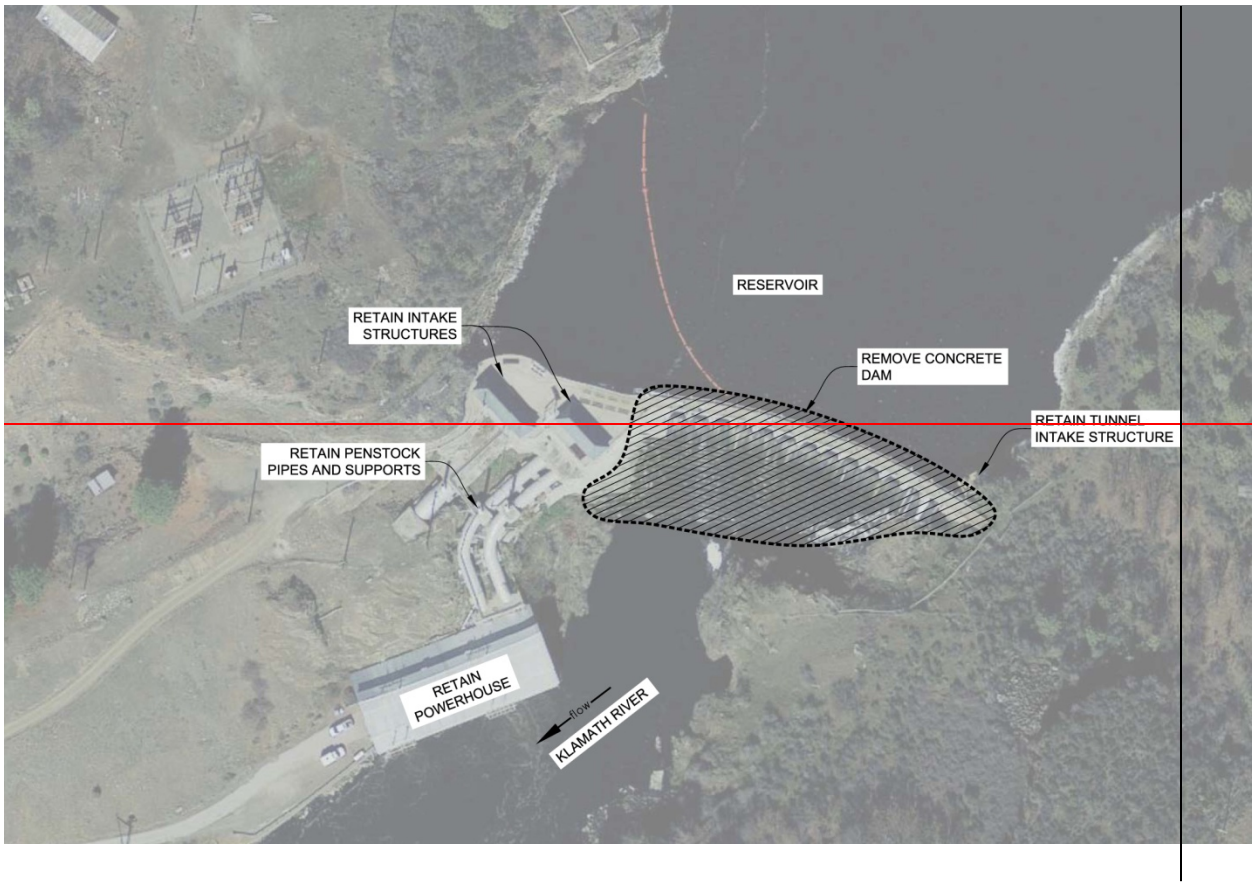


Figure 2-17. Copco 1 showing portion of dam to be removed for the Partial Facilities Removal Alternative

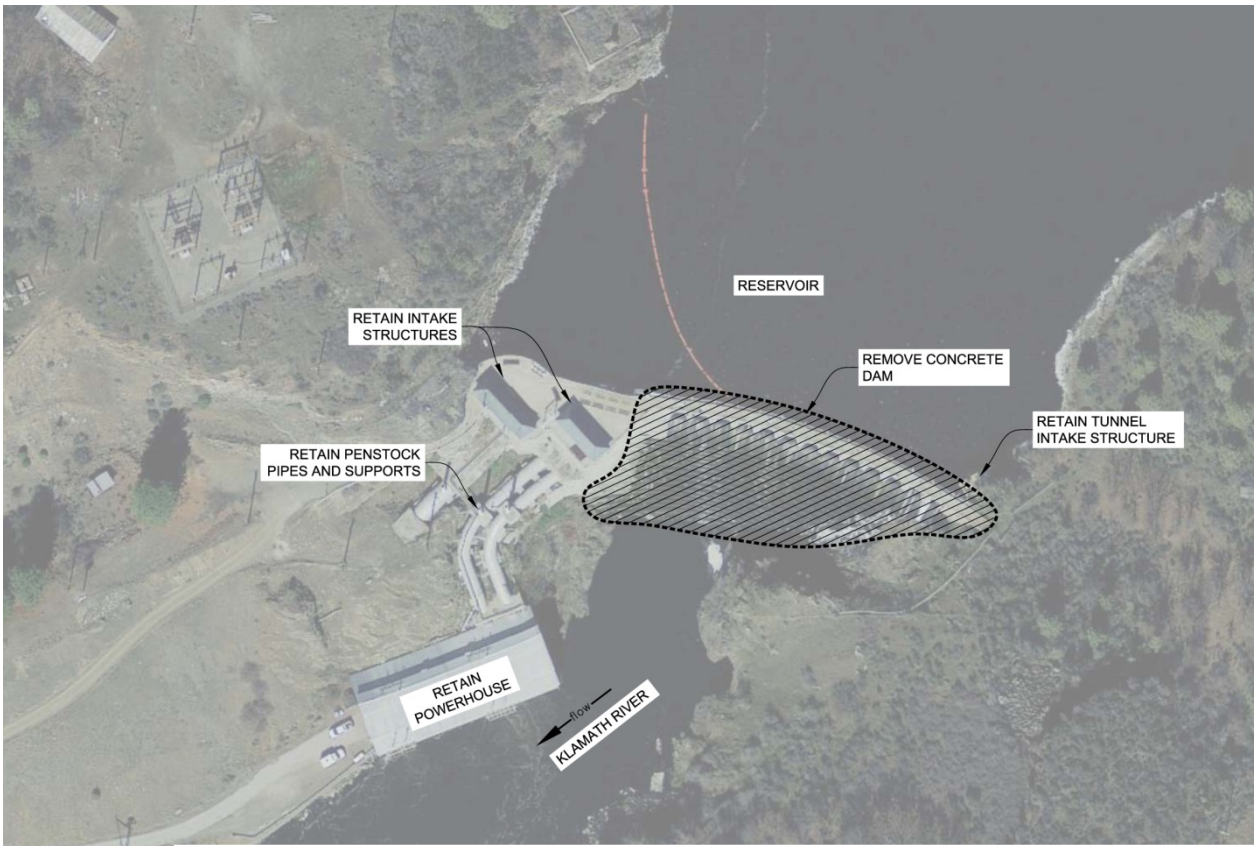


Figure 2-17. Copco 1 showing portion of dam to be removed for the Partial Facilities Removal Alternative.

2.4.4.1.3 Copco 2 Dam and Powerhouse

To create a free-flowing condition and volitional fish passage through the Copco 2 site, the DRE would take the following actions:

- Remove the concrete gated spillway structure and concrete end sill between the existing sidewalls (see Figure 2-18) as well as associated facilities (spillway gates, bridge deck, and piers).
- Remove wood-stave penstock.
- Remove equipment on the right abutment embankment section to facilitate construction access to the gated spillway.
- Seal and fence powerhouse.

Under the Partial Facilities Removal of Four Dams Alternative, the embankment section on river right, intake structure on river left, conveyance system to the powerhouse, and powerhouse would remain in place. A small portion of the downstream basin apron slab would remain intact for structural stability of the right sidewall, provided that a potential fish barrier would not result.

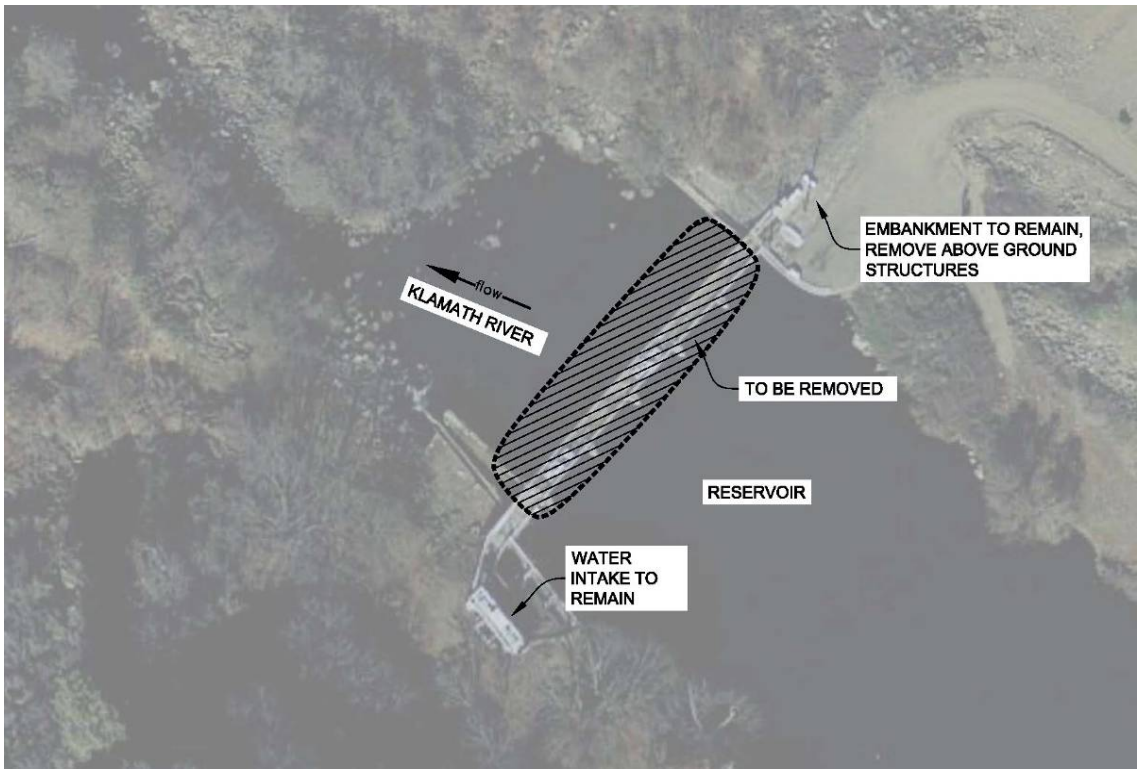


Figure 2-18. Copco 2 dam showing portion of dam to be removed for the Partial Facilities Removal Alternative.

The DRE would handle mechanical and electrical equipment and equipment containing potentially hazardous materials in the same manner as for the J.C. Boyle and Copco 1 Dam removals under this alternative.

2.4.4.1.4 Iron Gate Dam and Powerhouse

Theoretically, the DRE could notch Iron Gate Dam instead of removing the full dam. The river channel would need a 100-foot opening to accommodate fish passage at high flows. Figure 2-19 shows Iron Gate Dam with a 100-foot-wide notch at the base of the dam with potential stable side slopes to the top of the dam. This figure illustrates that notching the dam would remove nearly the entire dam and would create the need to protect the newly exposed inner core of the dam for stability. The amount of effort required to notch the dam is comparable to removing the entire earthfill embankment. Likewise, the stabilization costs of the remaining structure would be comparable to the costs to remove the minor amount of remaining material. Therefore, under this alternative, the DRE would remove the entire embankment dam, concrete water intakes, water supply pipes, and fish facilities at the base of the dam, with methods and equipment requirements as described for the Proposed Action.

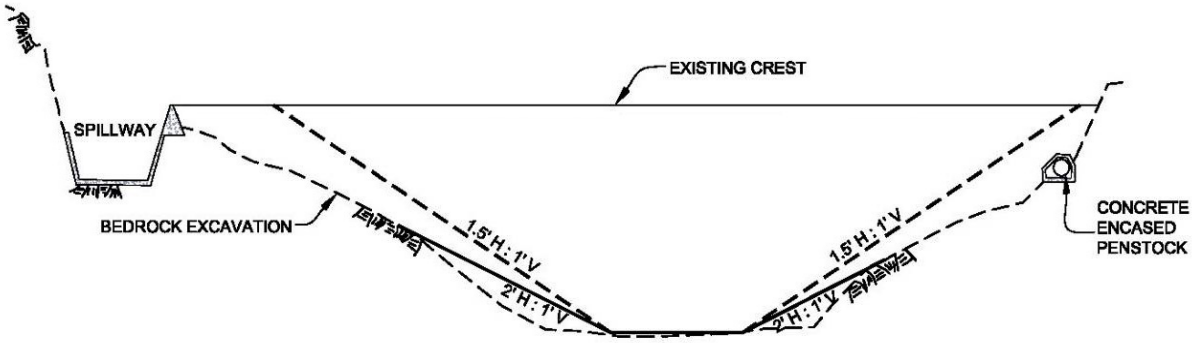
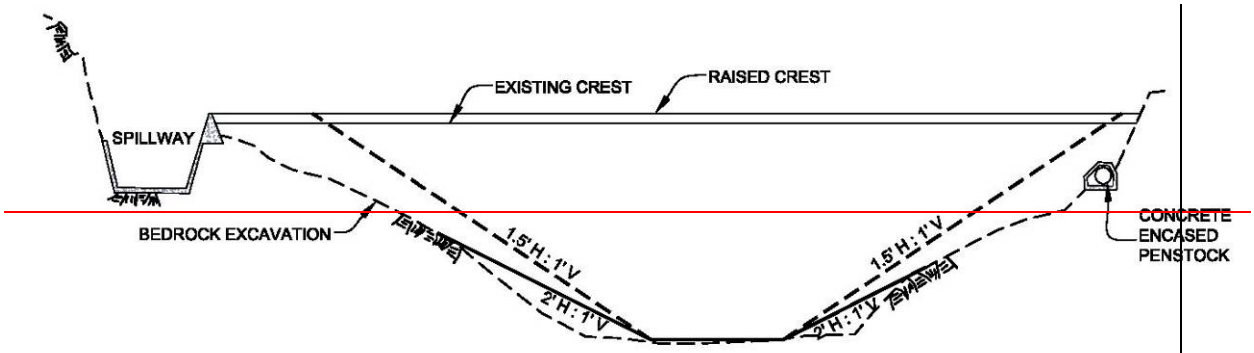


Figure 2-19. Section view of Iron Gate Dam showing 100-foot-wide bottom notch with different potential side slopes.



~~**Figure 2-19. Section view of Iron Gate Dam showing 100-foot-wide bottom notch with different potential side slopes**~~

Facilities that would remain include the existing concrete spillway and powerhouse (Figure 2-20). The DRE would fill the spillway and chute with material removed from the dam embankment. The DRE would seal all tunnels at the upstream and downstream openings using reinforced concrete plugs to prevent unauthorized entry.

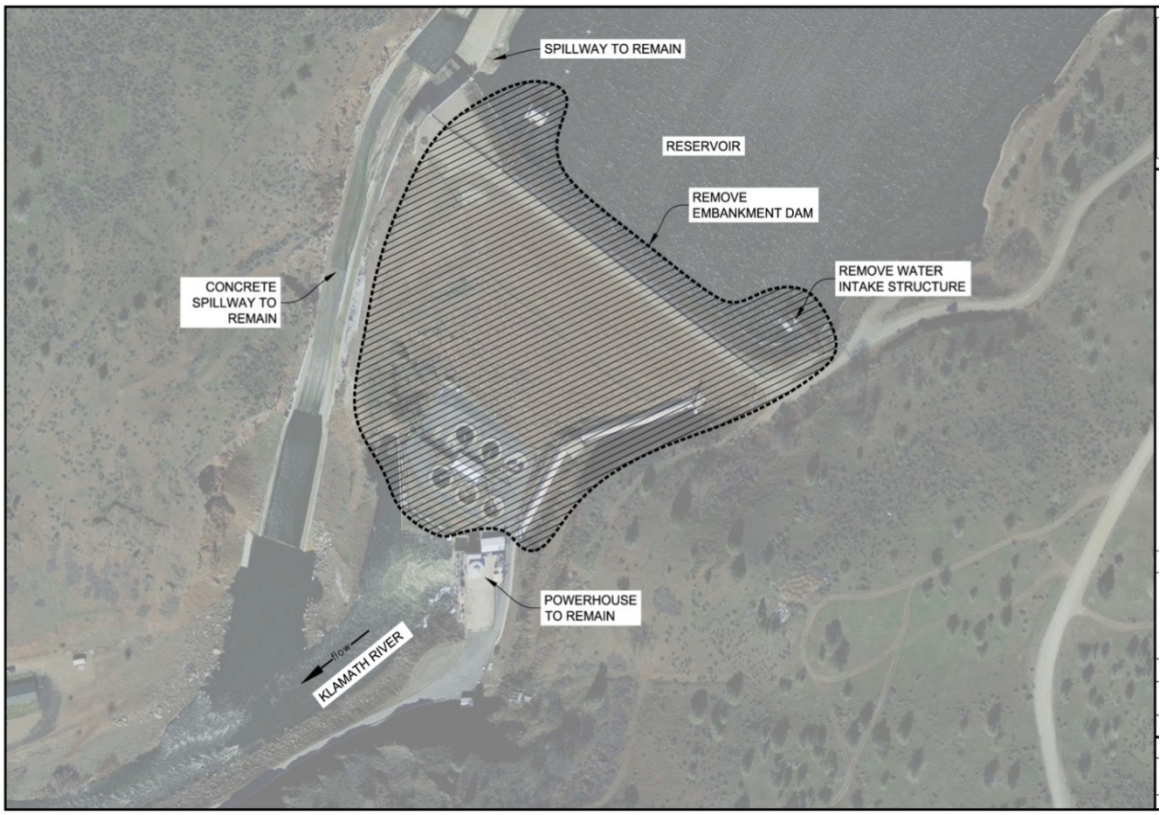


Figure 2-20. Iron Gate dam showing portion of dam to be removed for the Partial Facilities Removal Alternative.

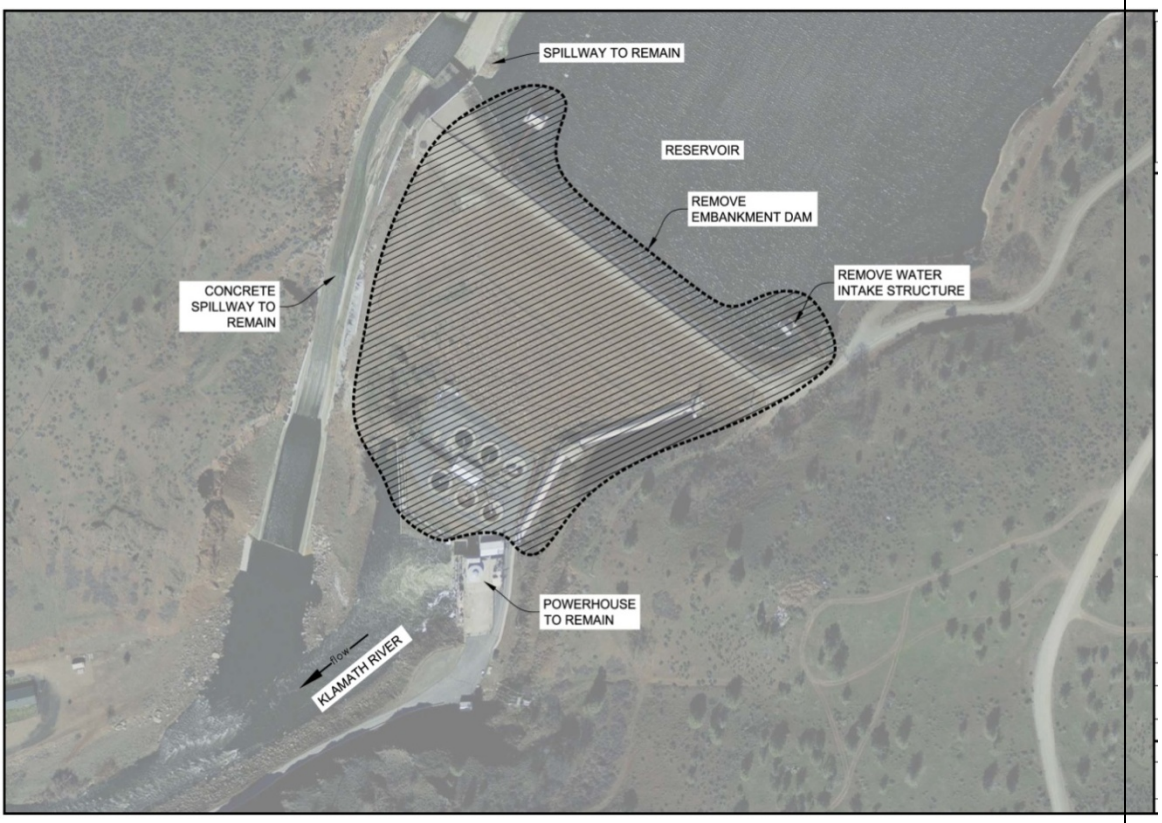


Figure 2-20. Iron Gate dam showing portion of dam to be removed for the Partial Facilities Removal Alternative

The Iron Gate Fish Hatchery downstream ~~of~~ from the dam would remain in place. The KHSA requires PacifiCorp to secure an alternate water source to replace the existing water supply pipe from Iron Gate Dam.

Retention of the Iron Gate powerhouse would require the structure to be sealed and fenced. The DRE would handle mechanical and electrical equipment and equipment containing potentially hazardous materials in the same manner as for the other dam removals under this alternative.

2.4.4.2 Schedule

The Partial Facilities Removal of Four Dams Alternative would follow a schedule similar to that of the Proposed Action. Figure 2-21 provides a schedule that is consistent with the schedule in Section 2.3.2 for Full Facilities Removal. The staging and methods would remain the same; however, the DRE would only remove portions of the dam and facilities. This alternative's schedule includes time to secure retained facilities by removing hazardous materials and installing fences and similar security features to

prevent unwanted entry. Therefore, it is not likely that this alternative would result in a substantially shorter project schedule than the Proposed Action.

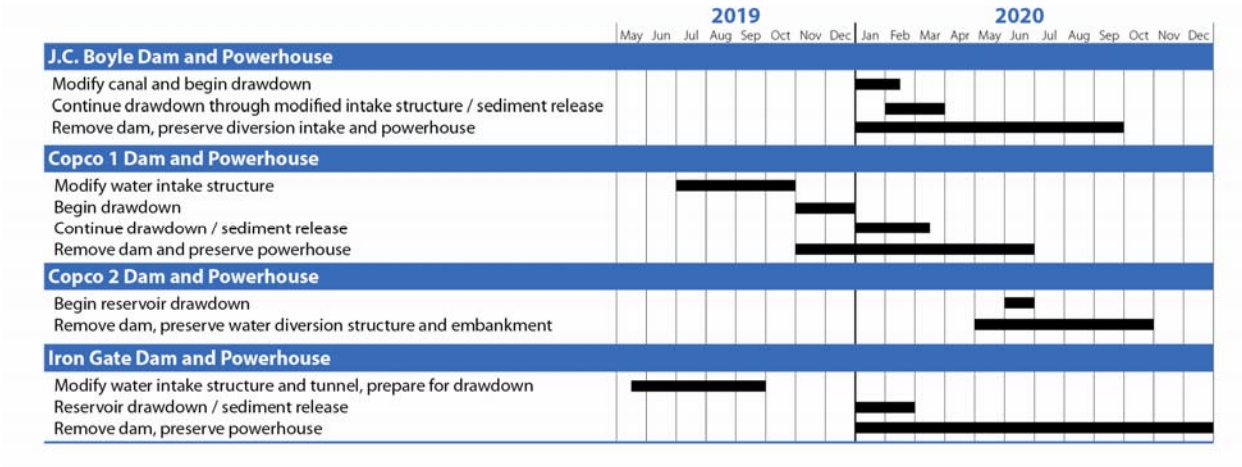


Figure 2-21. Anticipated Schedule for Partial Facilities Removal.

2.4.4.3 Workforce

Table 2-~~22~~23 shows the estimated workforce necessary for deconstruction at each facility. The crews for the removals at Copco 1 and 2 Dams could move between the projects as necessary to perform critical path work, to reduce overall workforce numbers, depending on how the contract is released for the projects.

Table 2-~~22~~23. Estimated Construction Workforce for Partial Removal at each Facility

Facility	Estimated Average Construction Workforce	Duration	Estimated Peak Workforce	Peak Period
J.C. Boyle	20 to 30 people	10 months	40–45	Jul 2020–Sep 2020
Copco 1	25 to 35 people	12 months	50–55	Nov 2019–Apr 2020
Copco 2	20 to 30 people	7 months	35–40	May 2020–Aug 2020
Iron Gate	30 to 40 people	18 months	75–80	Jun 2020–Sep 2020

2.4.4.4 Environmental Measures

The Partial Facilities Removal of Four Dams Alternative would incorporate standard measures to reduce environmental effects. These measures would be the same as those included in the Proposed Action (see Section 2.4.3).

2.4.4.5 Reservoir Restoration

The Partial Facilities Removal of Four Dams Alternative would include the same reservoir restoration actions described above for the Proposed Action. The restoration actions would include bank stabilization, revegetation, and decommissioning and or modification to existing recreation facilities surrounding the reservoir. Securing facilities left in place following partial facilities removal is not considered a component of this reservoir restoration action and would be completed as described above for this alternative.

2.4.4.6 Recreation Facilities

Changes to the recreation facilities surrounding the existing reservoirs would be the same as those in the Proposed Action (see Table 2-~~13~~14).

2.4.4.7 Keno Transfer

The Partial Facilities Removal of Four Dams Alternative would include the transfer of Keno Dam as a connected action in the same fashion as for the Proposed Action. The description of the transfer presented in Section 2.4.3.7 characterizes how the transfer would be executed under the Partial Facilities Removal of Four Dams Alternative.

2.4.4.8 East ~~Side/West Side Facility Decommissioning~~ and Westside Facilities – Programmatic Measure

The Partial Facilities Removal of Four Dams Alternative would include decommissioning the East Side and ~~West Side~~Westside Facilities in the same fashion as the Proposed Action. The description of the facility decommissioning presented in Section 2.4.3.~~2.~~8 characterizes how decommissioning would be completed under the Partial Facilities Removal of Four Dams Alternative.

2.4.4.9 City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The Partial Facilities Removal of Four Dams Alternative would include the relocation of the Yreka Water Supply Pipeline in the same fashion as the Proposed Action. The description of the relocation presented in 2.4.3.9 characterizes how the relocation would be completed under the Partial Facilities Removal of Four Dams Alternative.

2.4.4.10 KBRA – Programmatic Measures

The Partial Facilities Removal Alternative would include implementation of the KBRA in the same fashion as the Proposed Action. The description of the KBRA presented in Section 2.4.~~2.8~~3.10 characterizes the plans, programs, and actions that would be pursued under the Partial Facilities Removal of Four Dams Alternative.

2.4.5 Alternative 4: Fish Passage at Four Dams

Alternative 4 would provide upstream and downstream fish passage at the Four Facilities. The Fish Passage at Four Dams Alternative would not satisfy the KHSA; consequently, the KBRA would not be implemented (although ongoing restoration activities in the No Action/No Project Alternative may continue). For the purposes of this analysis, alternatives that would not result in full implementation of the KHSA do not include the KBRA as a connected action to the alternative. Additionally, the transfer of Keno Dam to DOI would not move forward as a connected action.

The description of Alternative 4 uses information from the *United States Department of the* ~~*Interior*~~*Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082)* (DOI 2007) and from the *National Marine Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis* ~~*Pursuant to Section 18 and Section 33 of the Federal Power Act*~~ *for the Klamath Hydroelectric Project (FERC Project No. 2082)* (~~DOI and~~ NOAA Fisheries Service 2007~~) and from the *Modified Terms and Conditions and Prescriptions for Fishways filed pursuant to Sections 4(e) and 18 of the Federal Power Act* (DOI/BLM 2007~~). These fishway prescriptions and mandatory conditions were developed during the FERC relicensing process. Issues of Material Fact associated with the prescriptions and mandatory conditions were challenged; the resulting Administrative Law Judge decision found that ~~the Agencies met their~~PacifiCorp failed to meet its burden of proof on most factual issues in dispute. Attachment B of Appendix A includes the full list of prescriptions and mandatory conditions; ~~a key 4(e) condition requires at least 40 percent of J.C. Boyle inflow to be released into the Bypass Reach. Under this alternative, the J.C. Boyle Powerhouse would produce peaking power only one day a week to coincide with recreation releases. This alternative would generate less power than current production because of the change in peaking operations and the flow requirements for the J.C. Boyle Bypass Reach. Several~~several of the prescriptions include studies to determine if features are necessary (such as spillway and tailrace modification).

For the purposes of analysis in this EIS/EIR, however, Alternative ~~4~~4 has been developed with some assumptions regarding details and feature designs for purposes of this analysis that are not included or not yet determined for the fishway prescriptions and do not reflect any final decision by NOAA Fisheries Service or USFWS regarding any differences from the express text of the fishway prescriptions or how any decision may be made under the terms of the fishway prescriptions. Alternative 4 thus includes some specific fishway facility design and construction details beyond what are specifically required in the prescriptions and are based on designs of similar fishway facilities used at other hydroelectric facilities. For example, the prescriptions include spillway modification at Copco 1 Reservoir; Alternative 4 includes a fish screen at the power intake and a fish collection device to divert fish from the spillway. Prior to advancing to feasibility-level of design, the Hydropower Licensee must obtain concurrence from NOAA Fisheries Service and USFWS related to proposed modifications for each independent facility, or any major feature of a facility (DOI 2007; NOAA Fisheries Service 2007).

Flows within the Hydroelectric Reach would change compared to the No Action/No Project Alternative because of the ~~prescriptions~~ mandatory conditions related to releases from J.C. Boyle Dam and Powerplant. A key 4(e) condition requires at least 40 percent of J.C. Boyle inflow to be released into the Bypass Reach. Under this alternative, the J.C. Boyle Powerhouse would produce peaking power only one day a week to coincide with recreation releases. This alternative would generate less power than current production because of the change in peaking operations and the flow requirements for the J.C. Boyle Bypass Reach. Flows downstream from Iron Gate Dam, however, would be similar to those in the No Action/No Project Alternative (see Figure 2-7).

This alternative would be implemented through FERC licensure including 401 certifications to an entity that would operate the Four Facilities (the "Hydropower Licensee"). ~~The Hydropower Licensee would need to re-enter the FERC process to implement this alternative.~~ Inflows to Upper Klamath Lake, and outflows from Iron Gate Dam are assumed to be the same under the Fish Passage at Four Dams Alternative as described above for the No Action/No Project Alternative. The ongoing resource management activities, TMDLs, biological opinions, and other regulatory conditions described under the No Action/No Project Alternative would also occur under this alternative.

This section describes general information about the fish passage facilities that would be constructed, and the following sections discuss aspects unique to each facility. Typical upstream fish passage facilities at each dam would consist of pool and weir type fish ladders to provide the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead trout, Pacific lamprey, and redband trout. This type of fish ladder is generally constructed from reinforced concrete and occasionally uses metal or wood hardware for adjustable components. In order to meet the prescribed fish passage criteria (DOI ~~and~~2007; NOAA Fisheries Service 2007), the fish ladders would use 6-inch steps between each weir that would result in an overall structure slope of 4 and 6 percent. At a minimum, each ladder bay would measure 8 feet long by 6 feet wide by 5 feet deep to meet the minimum pool requirements (NOAA Fisheries Service 2008), which would drive the structure slope of 4 to 6 percent. The FERC Final EIS identified a 10 percent slope, but that slope would not meet current requirements for fish ladders. Figure 2-22 shows an example of a cast-in-place pool and weir fish ladder that is similar to that proposed for upstream fish passage at the Four Facilities under this alternative. Final design of these structures would likely exceed this minimum pool dimension by 50 to 100 percent in order to meet all regulatory criteria and minimize turbulence in the ladder bays. Table 2-~~23~~24 provides a minimum footprint for each upstream fish ladder.

Figure 2-22. Example of cast-in-place pool and weir fish ladder.

Table 2-~~23.~~24. Minimum Structure Footprint and Dimensions for Fish Ladders at Each Dam

Dam	Vertical Drop (~~ft)~~feet)	Min. Number of Pools	Min. Structure Length (~~ft)~~feet)	Min. Structure Footprint (sq~~. ft.)~~uare feet)
J.C. Boyle	61	122	1,089	8,712
Copco 1	124	249	2,241	17,928

Copco 2	22	44	396	3,168
Iron Gate	157	314	2,826	22,608

Vertical Drop Source: CH2M Hill 2003

The J.C. Boyle and Copco 2 fish ladders are well within typical pool and weir fish ladders being designed today to meet fish passage criteria for the vertical drop. The Copco 1 and Iron Gate fish ladders are substantially longer and have a bigger elevation differential; however, there are two successful examples in Oregon where bigger elevation differentials have been overcome with pool and weir fish ladders for upstream fish passage. The two examples are the Faraday/North Fork ladder on the Clackamas River (196 feet tall, 1.9 miles long) and the Pelton ladder on the Deschutes River (~~230~~ 230 feet tall, 2.8 miles long) (Ratliff et. al. 1999). The Pelton ladder was shut down in 1968 primarily due to downstream juvenile passage and not upstream passage.

~~Fish ladders would be designed to allow passage 90 percent of the time that migratory fish would be present in the project area. For the extreme high and low flows, or 10 percent of the time, hydraulic conditions might prevent the ladders from meeting fish passage criteria.~~ Fishway prescriptions require two downstream entrances and associated entrance pools for each fish ladder (DOI ~~and~~2007; NOAA Fisheries Service 2007). All fish ladders would require an auxiliary water supply (AWS) to ensure adequate attraction flows at the downstream and to draw fish into the fish ladder and moderate water temperatures. The AWS would consist of a pipeline or intake that draws water from the reservoir and releases it in the fish ladder and near the fishway entrance pools. To accommodate increased flows, the downstream bays of the fish ladder would be larger than upstream bays in the fish ladder.

Downstream fish passage facilities would vary at each dam. Generally, the facilities would include ~~V-~~fish screens ~~or floating surface bypass collectors (FSBC)~~ and collection facilities to screen the fish away from the intake structures for the power generation facilities and the spillways (if they are unsuitable for downstream passage). Table 2-~~24~~25 summarizes the fish passage facilities that would be required at each dam under this alternative.

Table 2-~~24.~~25. Fish Passage Improvements under the Fish Passage at Four Dams Alternative

Dam	Upstream Fish Passage	Spillway Modifications[1]	Tailrace Barrier[1]	Fish Screens & Bypass
J.C. Boyle	New fish ladder over dam with auxiliary water supply (AWS) for attraction	Spillway modification to provide smooth transition	Extend river bank and install cutoff screen	New ~~V-~~fish screen with ~~fish~~ bypass
Copco 1	New fish ladder over dam with AWS	~~Surface bypass collector~~Collection device	Extend river bank and install cutoff screen	New ~~V-~~fish screen with ~~fish~~ bypass
Copco 2	New fish ladder over dam	Spillway modification	Extend river bank and	New ~~V-~~fish

	with AWS	to provide smooth transition	install cutoff screen	screen with ~~fish~~ bypass
Iron Gate	New fish ladder over dam with AWS, observation and sorting station in fish ladder	Spillway modification to provide smooth transition		New ~~V-~~fish screen with ~~fish~~ bypass

Notes:

1. ~~The prescriptions require studies to determine the need for and design of spillway modifications and tailrace barriers.~~ For the purposes of analysis in this EIS/EIR, Alternative 4 includes some specific fishway facility design and construction details that are beyond those required in the prescriptions. The modified prescriptions provide that the applicant is allowed to perform site-specific studies to determine if spillway modifications and tailrace barriers are necessary at the developments where these are prescribed. However, the modified prescriptions provide that spillway modifications and tailrace barriers shall be constructed and operated unless and until USFWS and NOAA Fisheries Service determine based on any such site-specific studies that any prescribed spillway modifications or tailrace barriers are unnecessary.

2.4.5.1 Construction Details

Construction of fish ladders represents the bulk of the work under this alternative. The Hydropower Licensee would construct the ladders from reinforced concrete using construction methods typical for civil infrastructure work.

Table 2-~~25~~26 shows estimated quantities of concrete for each facility.

Table 2-~~25.~~26. Estimated Minimum Amount of Reinforced Concrete Necessary ~~For~~for Fish Ladder at Each Dam

Dam	Reinforced Concrete (yd^3)
J.C. Boyle	2,800
Copco 1	5,800
Copco 2	1,000
Iron Gate	7,000

The Hydropower Licensee would need to control water and isolate the work area from flowing water and aquatic organisms throughout the duration of construction. Control mechanisms would be installed prior to starting work for each dam removal. The Hydropower Licensee could control water in most areas using gravity diversions; however, pumps could be required to dewater isolated ponding. Dewatering would require electric, gasoline, or diesel powered pumps, along with flexible hosing to convey water. Pumps would discharge water away from the river into upland areas to prevent discharge of fine sediments to waterways.

The Hydropower Licensee would work in wet conditions in areas that cannot be dried. For in-water work, the Hydropower Licensee would use physical barriers of a type and in a manner similar to that used under the dam removal alternatives.

The following sections provide a detailed description of necessary fish passage facilities for each dam under the Fish Passage at Four Dams Alternative.

2.4.5.1.1 J.C. Boyle Fish Passage Facilities[8]

The J.C. Boyle site has the best access for construction equipment and staging for construction. Equipment and materials could be brought into the site on existing gravel access roads and temporary access roads where necessary.

Upstream Passage

J.C. Boyle Dam has an existing pool and weir concrete fish ladder on the north side of the spillway, but it does not meet current design criteria and must be replaced because of its configuration and poor structural condition. The Fish Passage at Four Dams Alternative would include removal of the existing fish ladder structure and construction of a new pool, weir, and reinforced concrete fish ladder on the north side of the dam spillway, at or near the same location as the existing fish ladder (see Figure 2-23).

[8] Feature design has been provided in this EIS/EIR to support effects analysis. If the Klamath Hydroelectric Project is relicensed, the licensee would be required to obtain concurrence from USFWS and NOAA Fisheries Service regarding fishway design and construction plans for each facility prior to advancing to feasibility-level of design (NOAA Fisheries Service 2007; DOI 2007).

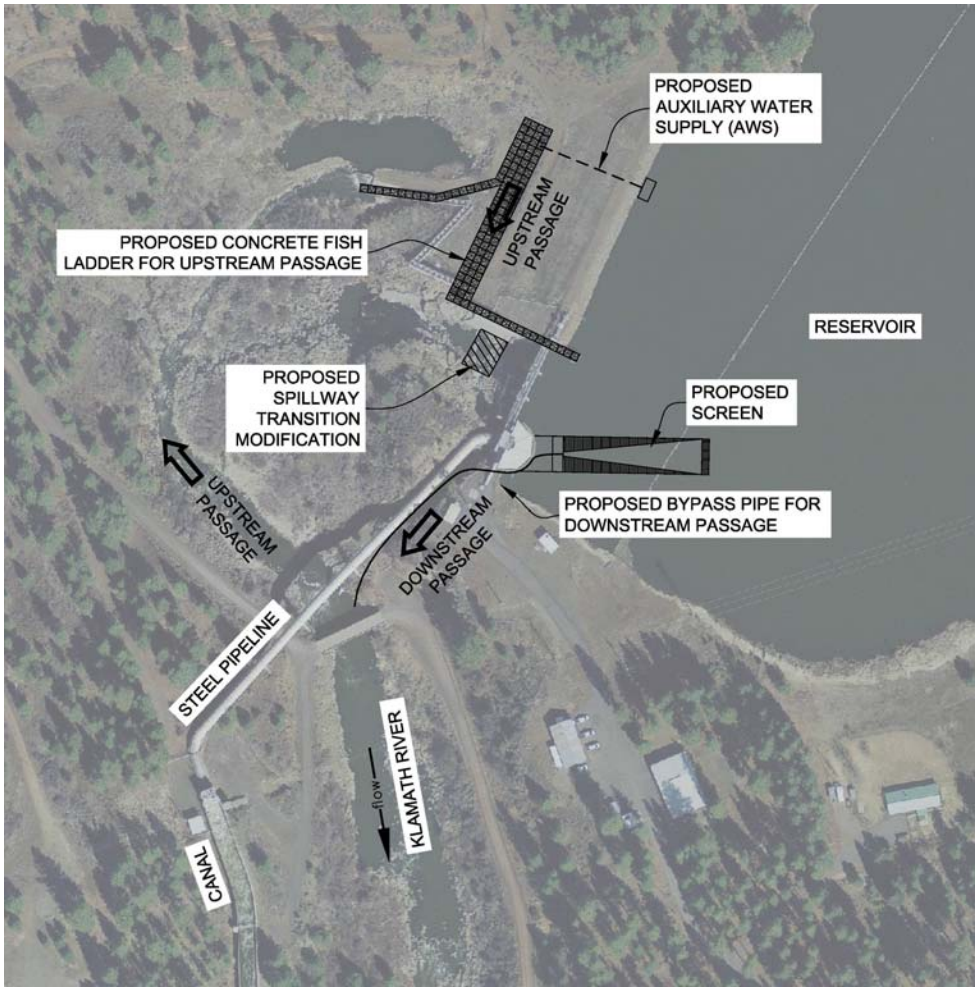
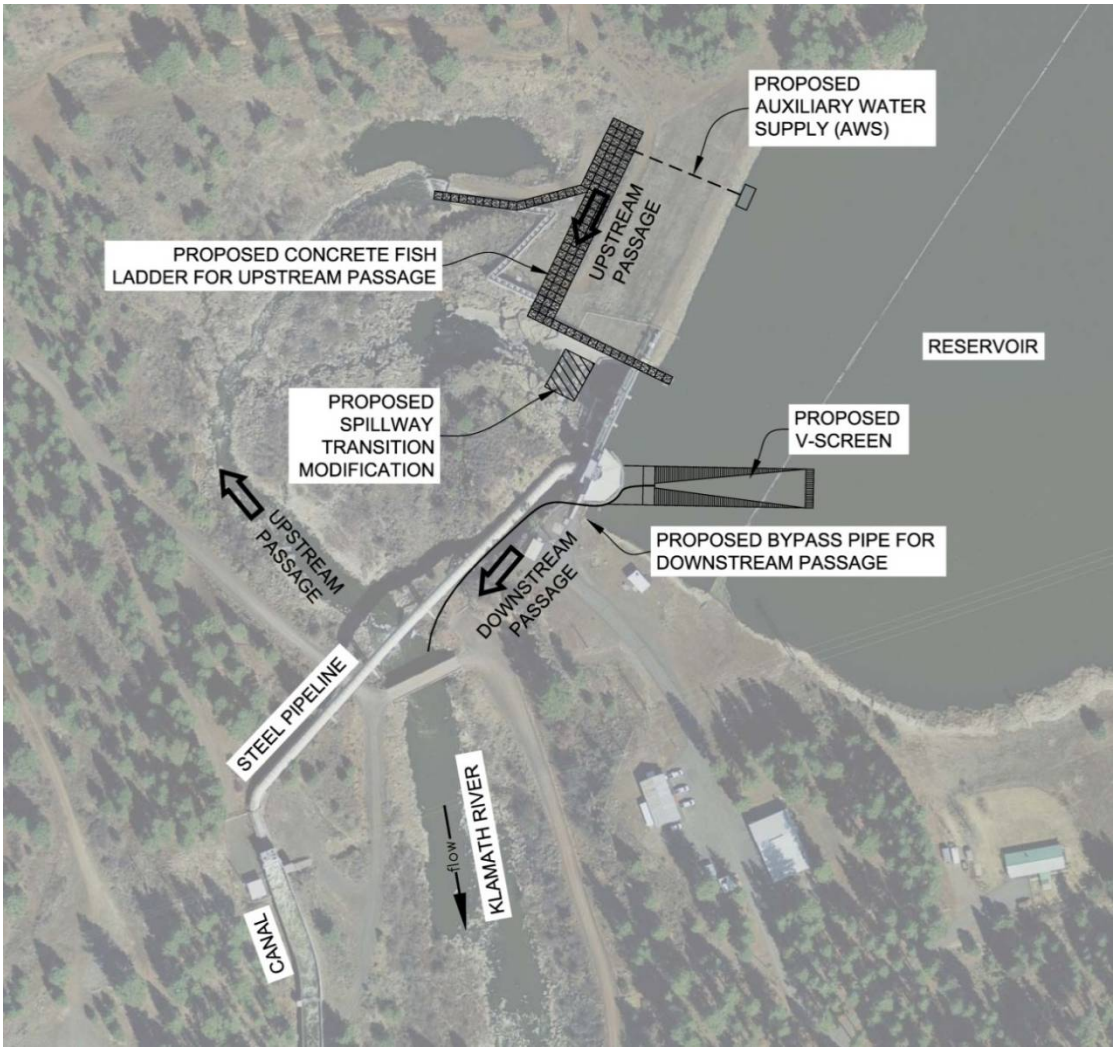


Figure 2-23. Conceptual Layout of J.C. Boyle Fish Passage Facilities.

The overall difference in water levels from the downstream river to J.C. Boyle Reservoir ranges from 55 to 61 feet, depending on reservoir pool elevation. The new fish passage facilities would have multiple openings into the reservoir to accommodate the reservoir pool fluctuation while maintaining continual upstream passage. The new ladder would have two entrances to accommodate low flow and high flow conditions.

An AWS would be necessary for temperature and attraction flow mitigation. The AWS would draw water from the reservoir through a screened inlet and variable height intake structure to provide water temperature control. The AWS would pipe water into the fish ladder at two locations.



~~**Figure 2-23. Conceptual Layout of J.C. Boyle Fish Passage Facilities**~~

Construction of these facilities would begin with demolition and removal of the ~~existing~~ existing fish ladder using mechanical means (such as hydraulic shears or hoe-ram). ~~The~~ The Hydropower Licensee would then install the new reinforced concrete fish ladder ~~by~~ by constructing concrete forms, laying the reinforcement, and pouring concrete. ~~The~~ The Hydropower Licensee would construct a cofferdam around the area where the ~~fish~~ fish ladder enters the reservoir to allow construction in dry conditions.

Downstream Fish Passage – Water Intake

The existing water intake has a design flow of 3,000 cfs, which requires a minimum fish screen of 7,500 square feet based on an approach velocity of 0.4 feet per second (ft/s). The Fish Passage at Four Dams Alternative would include a conventional ~~V-~~fish screen at the J.C. Boyle water intake. The ~~V-~~fish screen would terminate in a 36 inch diameter fish bypass pipe (approximately 40 cfs) that would run from the water intake to a bypass

facility for recording downstream migrating fish and then continuing on to a controlled outfall in the river downstream ~~of~~from the dam. The ~~V-~~fish screen would be stainless steel and the fish return pipe would be standard steel with concrete and steel support structures along the length of the pipe.

The ~~V-~~fish screen would be fabricated offsite and installed by a crew of skilled workers using light equipment. This phase of construction would require extensive dewatering and work isolation effort in order to provide a dry or partially isolated work area. Dewatering could require reservoir water level manipulation or construction of coffer barriers with pumps to dewater the work area around the water intakes.

Downstream Fish Passage – Spillway

Radial gates regulate discharge over the J.C. Boyle Dam's concrete spillway section that terminates in an abrupt drop onto bedrock. Modifications to the spillway would likely include removing the drop at the downstream end of the spillway by building a cast-in-place concrete transition and minor channel modifications. This design would likely reduce fish mortality on the rock outcrop below the spillway and provide a smooth transition for downstream passage. Construction would involve a small amount of demolition and concrete placement; methods would be similar to the work on the new fish ladder.

Tailrace Barrier

The power generation turbines at J.C. Boyle Powerhouse are several miles downstream from the dam with a large outlet bay, or tailrace area, that flows into the Klamath River (see Figure 2-2). This tailrace has the potential for false attraction waters and needs a barrier. The Fish Passage at Four Dams Alternative would include extension of the bank of the Klamath River and installation of a stainless steel, wedge-wire cutoff screen.

2.4.5.1.2 Copco 1 Fish Passage Facilities[9]

The Copco 1 Dam site has difficult site access because of steep canyon terrain. The Fish Passage at Four Dams Alternative would include construction of temporary roads for site access and other special provisions to move materials, such as a tower crane or aerial tramway.

Upstream Passage

Fish Passage at Four Dams Alternative would include a new pool and weir fish ladder on the right side of Copco 1 Dam for upstream fish passage. The fish ladder would have an AWS plumbed into it at two locations to moderate water temperatures, flow in the fishway, and attraction flows at the downstream end of the fishway. The downstream entrance of the fish ladder would have two entrances for low water and high water conditions, as shown in Figure 2-24. The upstream end of the fish ladder that enters the reservoir area would also have multiple openings to accommodate water level fluctuations. Construction would require installation of the cast-in place concrete ladder and isolation of the area where the ladder connects to the reservoir.

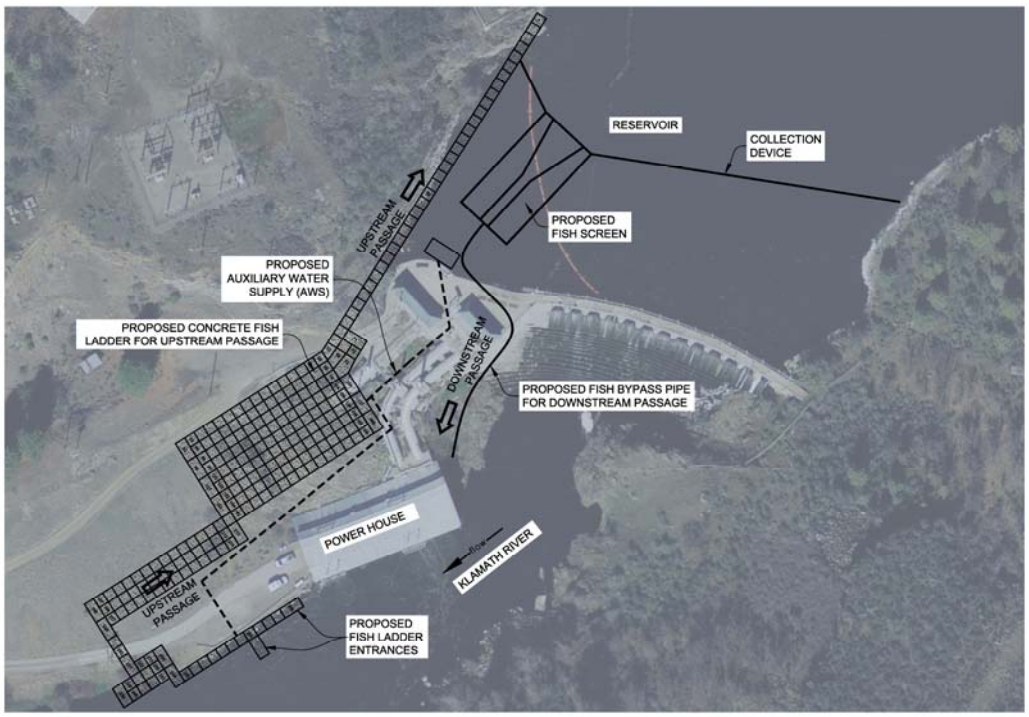


Figure 2-24. Copco 1 Fish Ladder Configuration, Fish Screen, and Collection Device.

[9] Feature design has been provided in this EIS/EIR to support effects analysis. If the Klamath Hydroelectric Project is relicensed, the licensee would be required to obtain concurrence from USFWS and NOAA Fisheries Service regarding fishway design and construction plans for each facility prior to advancing to feasibility-level of design (NOAA Fisheries Service 2007; DOI 2007).

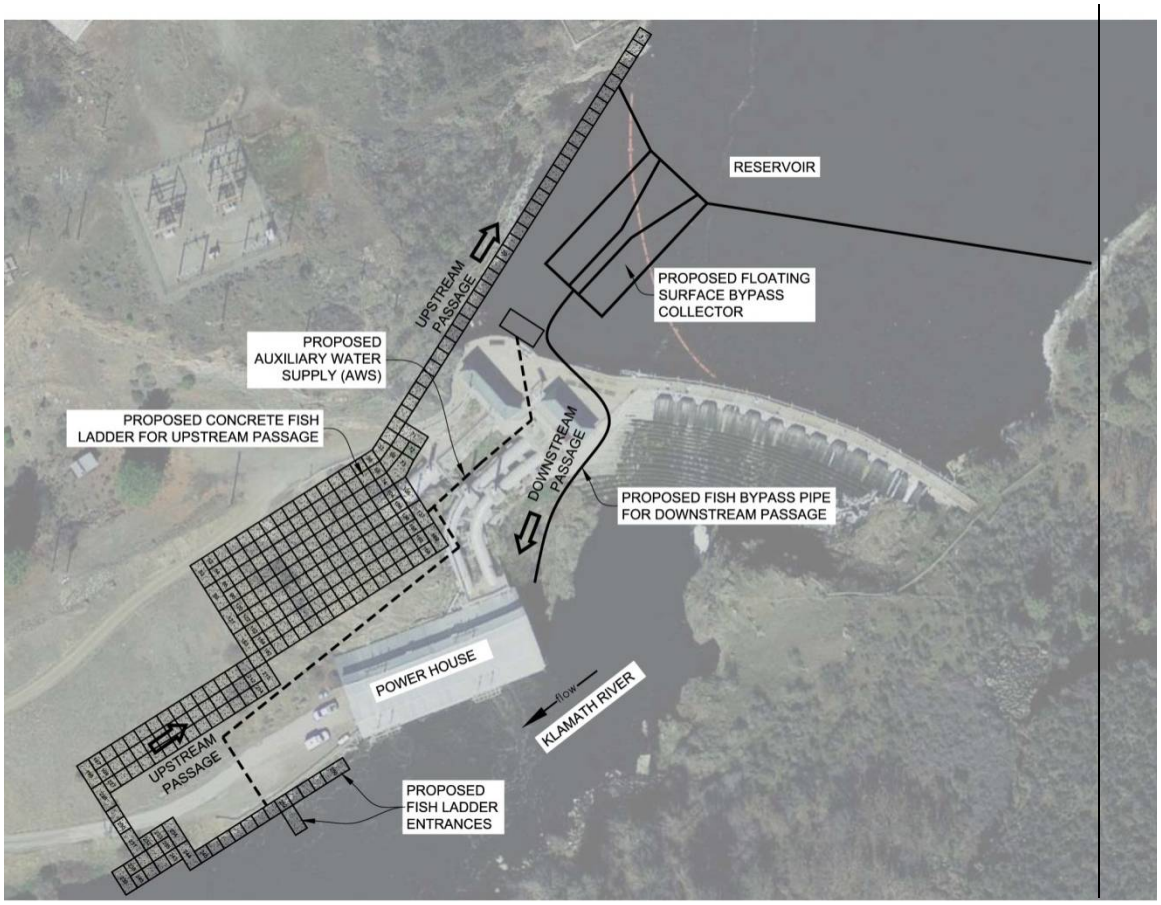


Figure 2-24. Copco 1 Fish Ladder Configuration and Floating Surface Bypass Collector

Downstream Fish Passage

The existing facilities at Copco 1 Dam are not conducive to downstream fish passage because the juvenile salmonids travelling downstream would flow through the intake to the power generation facility or over the dam spillway during high flows. The Fish Passage at Four Dams Alternative would include a ~~V-~~fish screen as the primary measure to ensure safe downstream passage (DOI ~~and~~2007; NOAA Fisheries Service 2007).

Depending on the frequency of spill, ~~an FSBC~~a collection facility may also be necessary to prevent fish from moving toward the spillway area. For the purposes of this analysis, the Fish Passage at Four Dams Alternative includes construction of ~~an FSBC~~a collection facility that is integrated with the ~~V-~~fish screen for Copco 1 Reservoir~~ with full-depth nets~~. The ~~FSBC~~collection facility would ~~be placed on the reservoir surface to~~ protect the entire spillway area. The ~~FSBC~~collection device would be fabricated off-site and shipped to the site using standard flatbed trucks. The Hydropower Licensee would assemble the pieces on-site~~ to create the larger body of the FSBC~~. Once the structure was assembled, it would be ~~floated into~~ put in place near the water intake area and secured. ~~Reservoir guide nets would facilitate fish passage through the bypass collector.~~

The ~~FSBC~~ fish screen would be a steel structure using a typical ~~V-~~fish screen configuration~~ similar to Upper Baker Dam in Washington (see Figure 2-25)~~. The existing power generation water intake has a design flow of 3,200 cfs, which requires a minimum fish screen of 8,000 square feet based on an approach velocity of 0.4 ft/s. The ~~main FSBC~~fish screen would be at the intake structure on the right side of the dam. The ~~FSBC~~fish screen would be anchored to the existing rock and concrete dam structure to ensure stability. The ~~FSBC~~screen would direct fish to an approximately 36 inch diameter bypass pipe with a capacity of more than 60 cfs.

~~**Figure 2-25. Example of Floating Surface Bypass Collector in Upper Baker Dam, Washington**~~

Tailrace Barrier

The Copco 1 Powerhouse tailrace configuration is similar to the Iron Gate facility~~, which would not include~~. For the purposes of analysis, this analysis of Alternative 4 includes a tailrace barrier~~ based on observed conditions and past performance. Prescriptions include a study to determine if a tailrace barrier is necessary. Because of its similarities with Iron Gate, Alternative 4 does not include a tailrace barrier because the study is likely to find that it would not be necessary.~~.[10]

2.4.5.1.3 Copco 2 Fish Passage Facilities[11]

The Copco 2 site has difficult access because of the narrow canyon and relatively steep road access into the site. The existing access road would require upgrades such as gravel surfacing and grading.

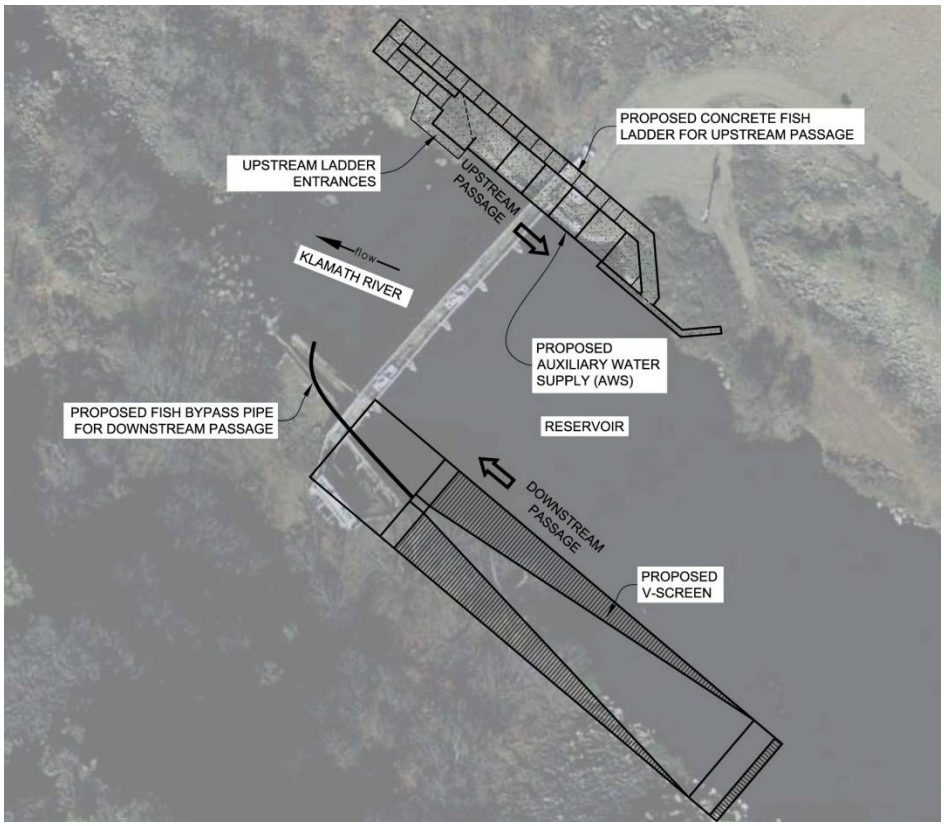
Upstream Fish Passage

[10] The modified prescriptions provide that the applicant is allowed to perform site-specific studies to determine if spillway modifications and tailrace barriers are necessary at the developments where these are prescribed. However, the modified prescriptions provide that spillway modifications and tailrace barriers shall be constructed and operated unless and until USFWS and NOAA Fisheries Service determine based on any such site-specific studies that any prescribed spillway modifications or tailrace barriers are unnecessary.

[11] Feature design has been provided in this EIS/EIR to support effects analysis. If the Klamath Hydroelectric Project is relicensed, the licensee would be required to obtain concurrence from USFWS and NOAA Fisheries Service regarding fishway design and construction plans for each facility prior to advancing to feasibility-level of design (NOAA Fisheries Service 2007; DOI 2007).

The Fish Passage at Four Dams Alternative includes a concrete pool and weir fish ladder with 6-inch drops to provide volitional fish passage at Copco 2 Dam. The overall difference in water levels from the downstream river to Copco 2 Reservoir is about 20 to 25 feet, depending on reservoir pool elevations. The new fish passage facilities would accommodate the reservoir pool fluctuation while maintaining continual upstream passage. Construction would require installation of the cast-in place concrete ladder and isolation of the area where the ladder connects to the reservoir.

The pool and weir fish ladder would be on the right side of the concrete spillway structure in the earth embankment. An AWS would be necessary for temperature and attraction flow mitigation. The AWS would draw water from the reservoir through a screened inlet. Figure 2-~~26~~25 shows a conceptual layout for a fish ladder at Copco 2 Dam.



~~Figure 2-26. Copco 2 Fish Ladder and V-screen, along the left side of the river, for~~

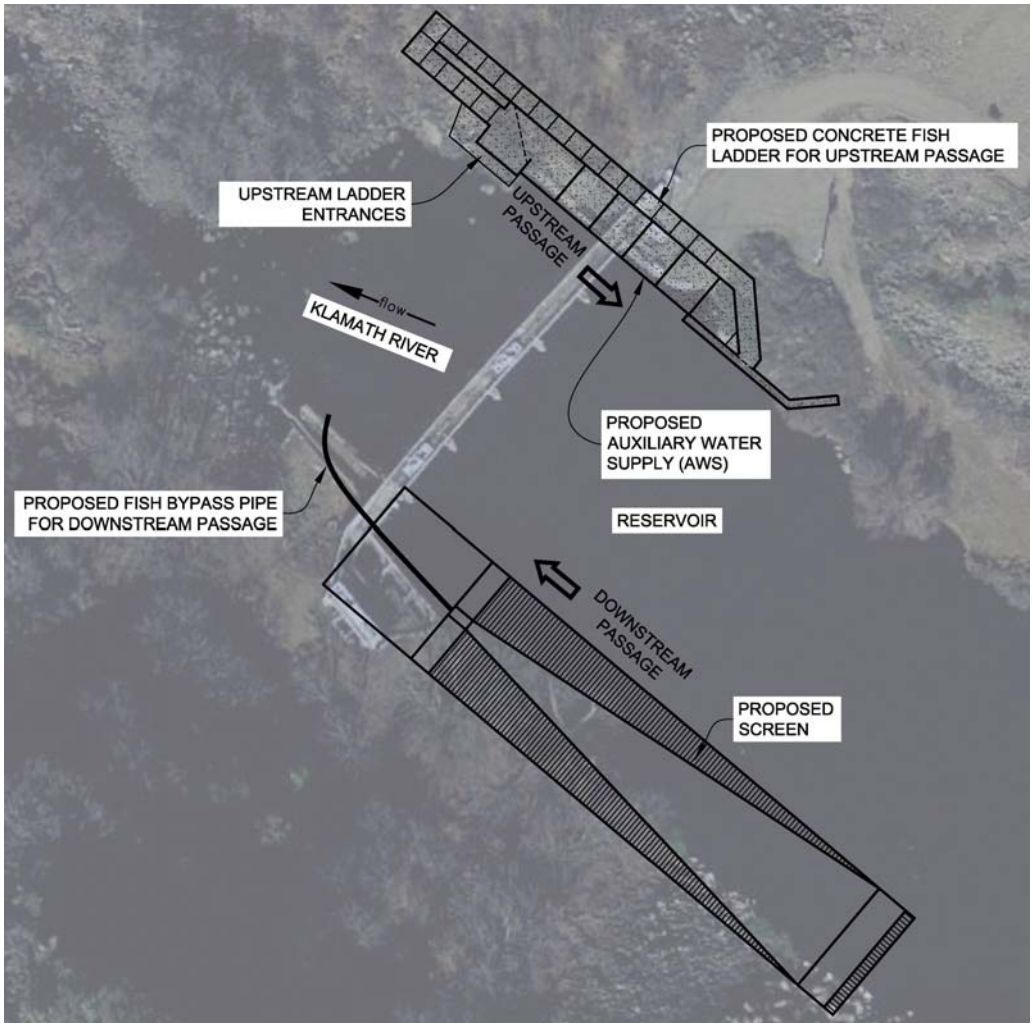


Figure 2-25. Copco 2 Fish Ladder and Fish Screen, along the left side of the river, for power water diversion.

~~power water diversion~~

In addition to the fish ladder, a transverse bedrock sill approximately 0.5 miles upstream of the Copco 2 Powerhouse in the Bypass Reach could create a fish passage barrier. A new FERC license would likely increase flows in the Bypass Reach and this barrier would not likely exist. As part of the license renewal process, a study would determine

whether corrective measures would be needed at this barrier to provide fish passage~~.~~.[12] According to the mandatory prescriptions, sufficient flow would need to be released into the Bypass Reach to attract upstream-migrating fish into the fishway entrance pools and ensure that flows are sufficient to attract fish at the point of confluence between the Bypass Reach and the downstream powerhouse discharges. The prescriptions do not specify a flow rate in the Bypass Reach, but modeling the recommendations indicates that minimum flows would be approximately 438 cfs.

Downstream Fish Passage – Water Intake

The existing power generation water intake at Copco 2 Dam is on the left side of the concrete spillway structure. The water diversion capacity is 3,200 cfs, which would require a minimum 8,000 square feet of screen. A conventional ~~V-~~fish screen for the water intake would minimize the length of the screen. The ~~V-~~fish screen would terminate in an approximately 36-inch fish bypass pipe that would flow over the dam and into the downstream river area. As with the ~~V-~~fish screen for the J.C. Boyle Development, the ~~V-~~screen would be fabricated off-site and installation would require dewatering and isolation to provide a dry or partially isolated work area.

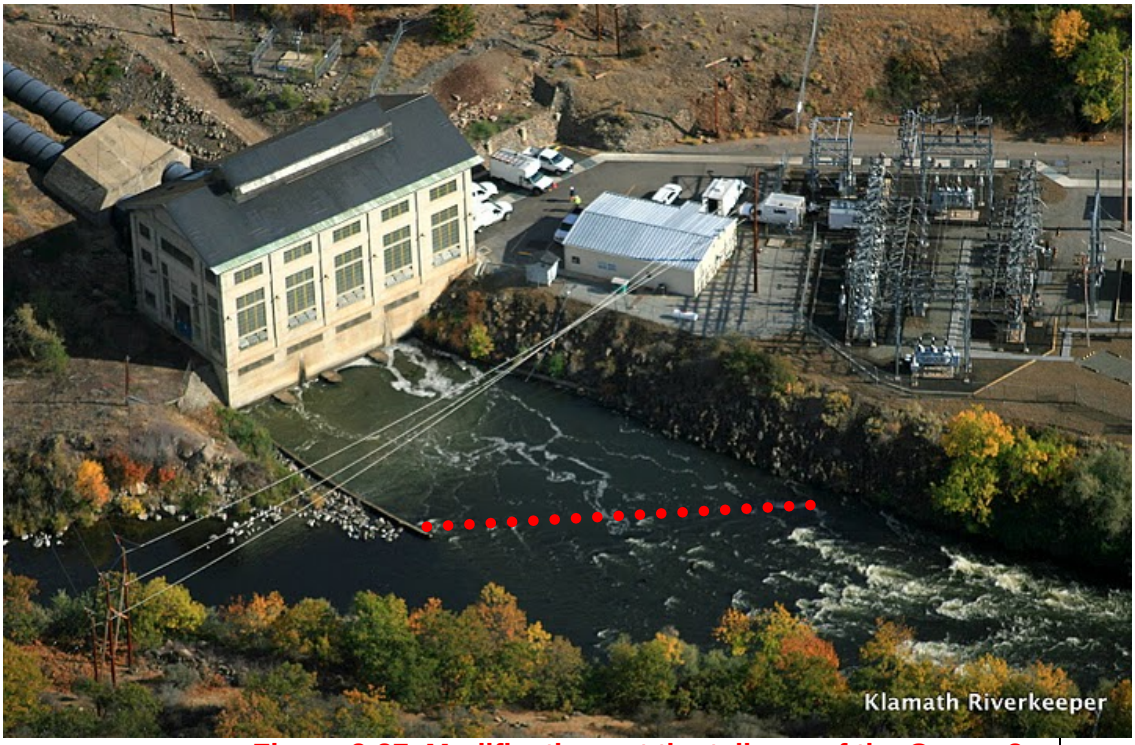
Downstream Fish Passage – Spillway

The Copco 2 spillway is controlled with radial gates that regulate discharge over the concrete spillway section. The existing elevation difference between the spillway crest and water level on the downstream side of the dam is approximately 13 feet. Modifications to the concrete apron and spillway would minimize or eliminate rapid changes in direction and abrupt velocity changes at the spillway apron for downstream moving fish. A transitional ramp would be installed at the midpoint of the spillway to transition flows smoothly into the water conditions downstream from the concrete apron. The transitional ramp would be formed using cast-in-place concrete similar to the existing spillway construction.

Tailrace Barrier

The power generation turbines for Copco 2 are ~~several~~ 1.4 miles downstream from the dam with a large tailrace area that flows back into the Klamath River. The water flowing out through this tailrace has the potential to attract fish to a false pathway. ~~Prescriptions require a tailrace barrier unless studies prove otherwise (DOI and NOAA Fisheries Service 2007);~~ Alternative 4 includes a tailrace barrier ~~because the orientation and nature of the tailrace area indicate that a barrier would likely be necessary. The Fish Passage at Four Dams Alternative includes~~ extending the bank line of the Klamath River and installing a cutoff screen to prevent fish from straying into the tailrace area (see Figure 2-~~27~~26).

[12] The prescriptions require modifications to the bedrock sill unless the licensee demonstrates through an evaluation approved by USFWS and NOAA Fisheries Service that indicates that it will not be a "barrier to fish passage under normal operating flows specified for the Copco 2 bypassed reach in the new license" (USFWS 2007; NOAA Fisheries Service 2007).



~~**Figure 2-27. Modifications at the tailrace of the Copco 2 Powerplant would extend the bank and install a tailrace barrier screen (red dots)**~~
~~(Source: Klamath Riverkeeper)~~

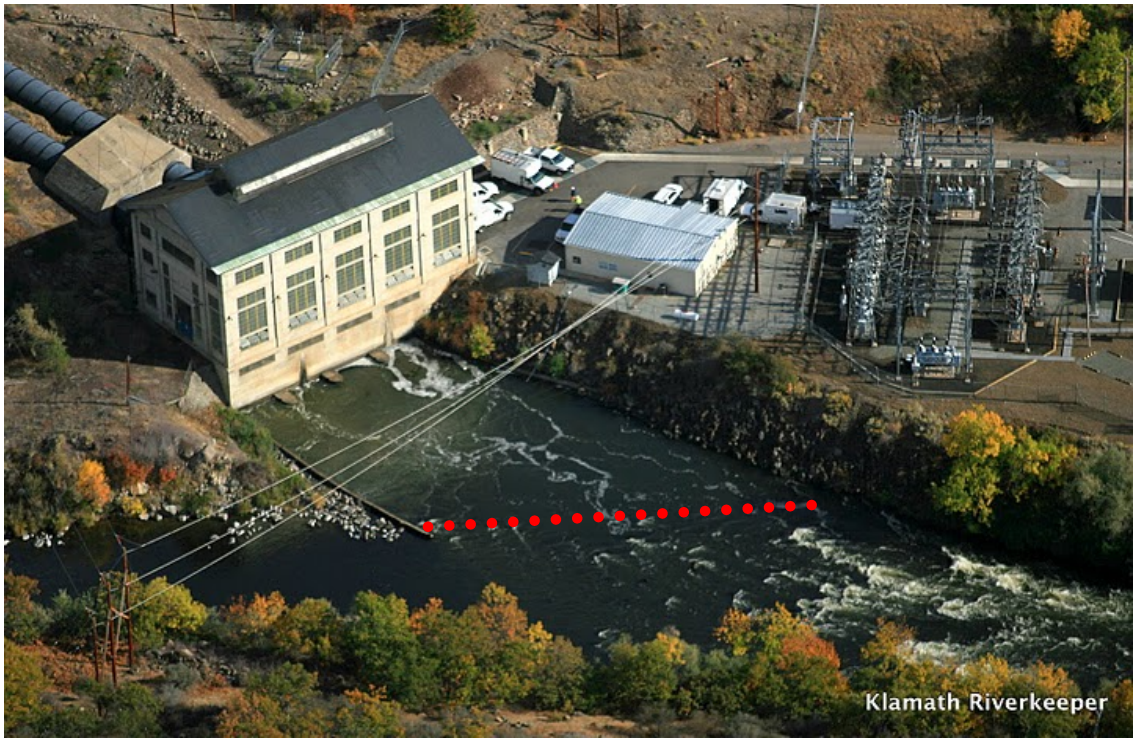


Figure 2-26. Modifications at the tailrace of the Copco 2 Powerplant would extend the bank and install a tailrace barrier screen (red dots).
(Source: Klamath Riverkeeper)

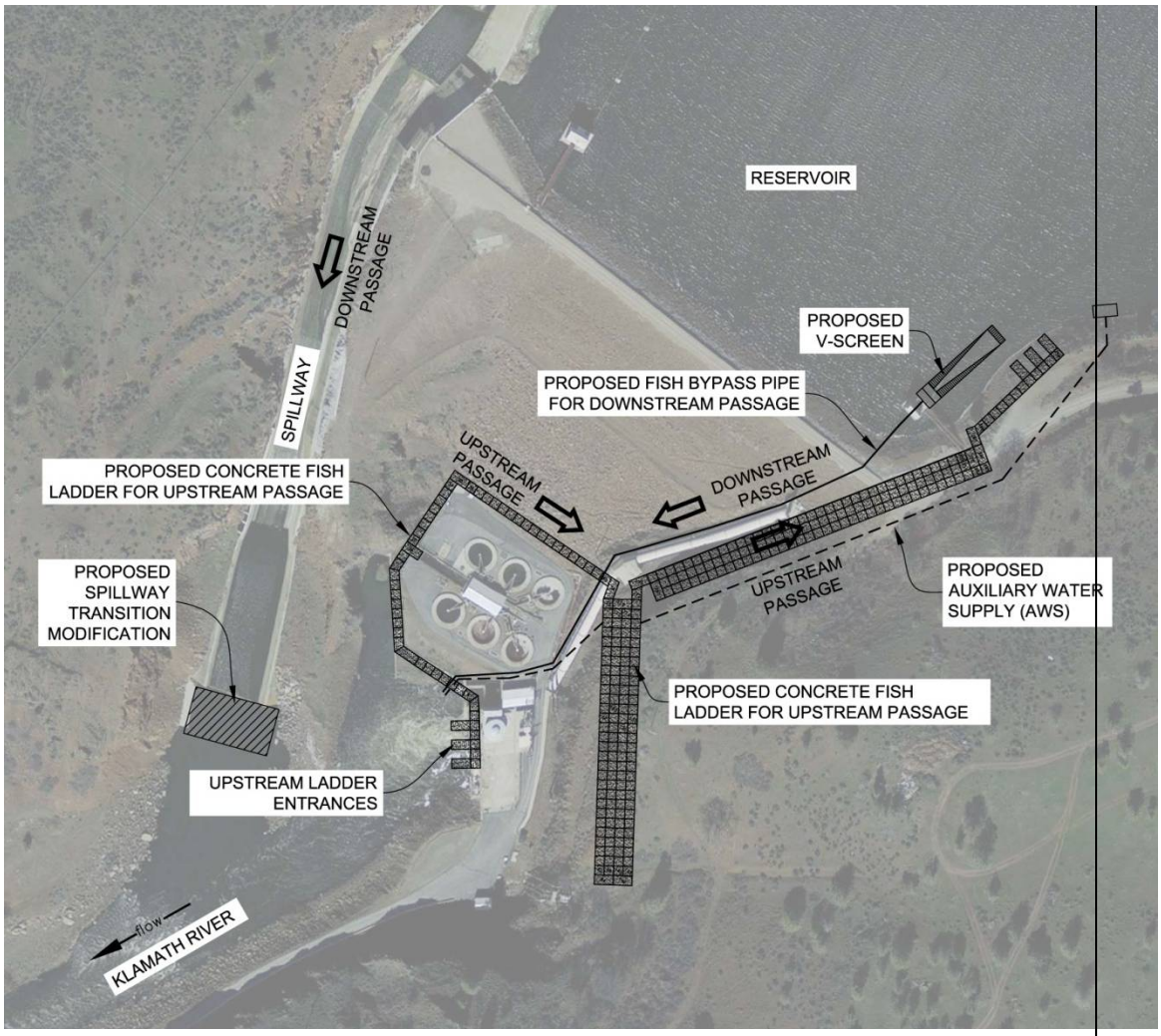
2.4.5.1.4 Iron Gate Dam Fish Passage Facilities[13]

The Iron Gate Development has difficult site access because of steep canyon terrain. It would require construction of temporary roads for site access and a tower crane or aerial tramway to move construction materials.

Upstream Fish Passage

The Fish Passage at Four Dams Alternative would include installation of a fish ladder on the left side of Iron Gate Dam near the existing penstock pipe, as shown in Figure 2-~~28~~27. The fish ladder would have two entrances with entrance pools at the downstream end of the fish ladder. An AWS would feed water into the fish ladder at two locations to help with attraction flows and water temperatures. Multiple openings would be necessary where the fish ladder connects to the reservoir to allow for water level fluctuation. Construction would require installation of the cast-in place concrete ladder and isolation of the area where the ladder connects to the reservoir.

[13] Feature design has been provided in this EIS/EIR to support effects analysis. If the Klamath Hydroelectric Project is relicensed, the licensee would be required to obtain concurrence from USFWS and NOAA Fisheries Service regarding fishway design and construction plans for each facility prior to advancing to feasibility-level of design (NOAA Fisheries Service 2007; DOI 2007).



~~Figure 2-28. Conceptual fish passage facilities layout for Iron Gate Dam showing fish ladder, water intake screen, and spillway transition modifications~~

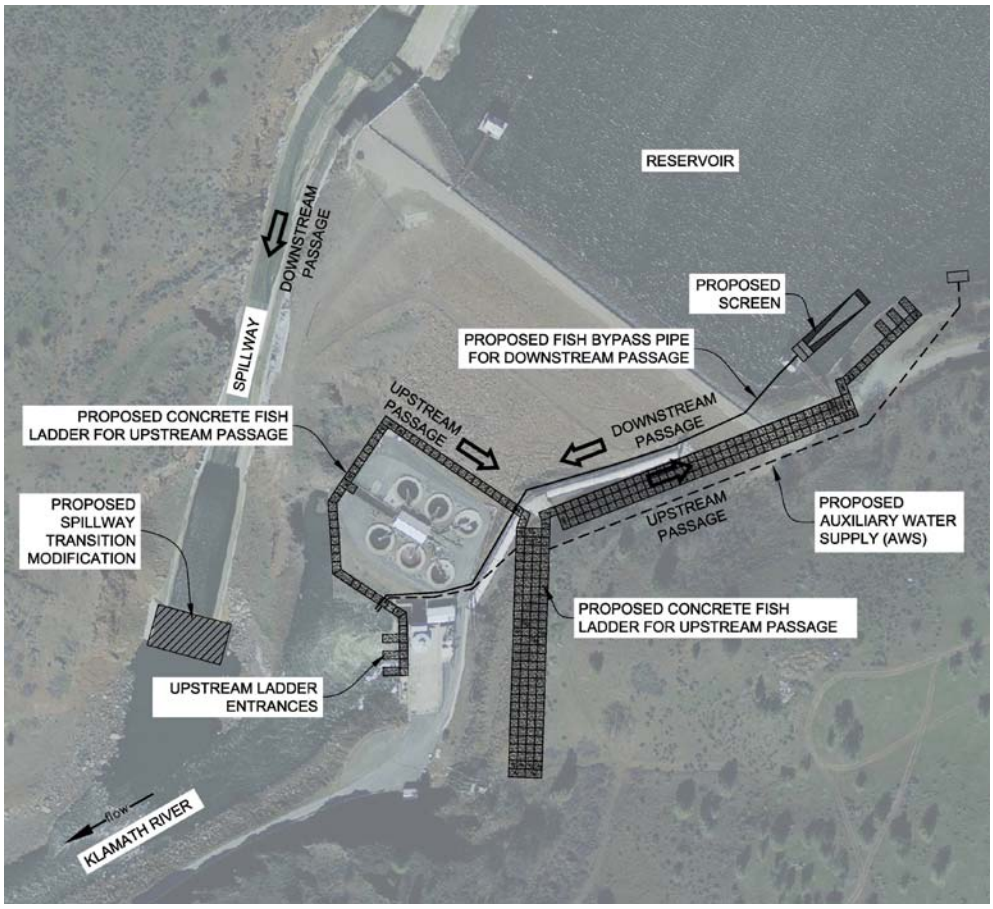


Figure 2-27. Conceptual fish passage facilities layout for Iron Gate Dam showing fish ladder, water intake screen, and spillway transition modifications.

Downstream Fish Passage – Water Intake

The existing power generation water intake structure at Iron Gate Dam is on the left side of the embankment dam. The water intake design flow is 1,735 cfs and would require a minimum fish screen of 4,340 square feet based on an approach velocity of 0.4 ft/s. A conventional ~~V-~~fish screen would be the best option for screening the water intake to address the substantial size of the screen. The ~~V-~~fish screen would terminate in a 36-inch-diameter fish bypass pipe (approximately 40 cfs) that would run from the water intake to a fish bypass facility for identification of downstream migrating juveniles and then continue downstream to the river below the dam. The ~~V-~~fish screen would be stainless steel and the fish return pipe would be standard steel with concrete and steel support structures along the length of the pipe. As with the ~~V-~~fish screen for the J.C. Boyle facility, the ~~V-~~fish screen would be fabricated off-site and installation would require dewatering and isolation to provide a dry or partially isolated work area.

Downstream Fish Passage – Spillway

The Iron Gate spillway is an unregulated, free overflow from the reservoir area. Likely modifications to the spillway would include building a smoother transition at the downstream end using cast-in-place concrete to form an ogee-type drop structure that would connect the downstream river levels to the free flowing spill conditions. This modification would reduce fish mortality on the rock outcrop below the spillway. In addition, the Hydropower Licensee would use concrete to fill the area just upstream of the free outfall at the downstream end of the spillway to make a consistent hydraulic transition and reduce potential harm during downstream passage of primarily juvenile fish.[14]

2.4.5.2 Schedule

The schedule would likely follow the schedule prescribed in the FERC relicensing process. The prescriptions include a schedule for implementation and recommend that downstream facilities be installed prior to upstream passage facilities (DOI and 2007; NOAA Fisheries 2007). Table 2-2627 shows the schedule for implementation (including design, permitting, and construction) of the fish passage facilities at each dam, based on these constraints.

Table 2-26.27. Timetable for Implementation of Fish Passage Improvements at each Dam from Date of FERC License Renewal

Dam	Upstream Fish Passage	Spillway Modifications	Tailrace Barrier	Screens & Bypass
J.C. Boyle	4 years	4 years	4 years	4 years
Copco 1	6 years	6 years	N/A8 years	6 years
Copco 2	6 years	6 years	8 years	6 years
Iron Gate	5 years	5 years	N/A	5 years

Key:
N/A: Not Applicable

[14] The modified prescriptions provide that the applicant is allowed to perform site-specific studies to determine if spillway modifications and tailrace barriers are necessary at the developments where these are prescribed. However, the modified prescriptions provide that spillway modifications and tailrace barriers shall be constructed and operated unless and until USFWS and NOAA Fisheries Service determine based on any such site-specific studies that any prescribed spillway modifications or tailrace barriers are unnecessary.

2.4.5.3 Workforce

Table 2-~~27~~28 shows the estimated workforce necessary for construction at each facility. Each facility would also have 5 to 10 on-site construction administrative personnel (e.g., inspectors, field engineers) for the duration of the project.

Table 2-~~27~~28. Estimated Average Construction Workforce for Fish Passage at Four Dams

Facility	Estimated Construction Workforce	Duration
J.C. Boyle	10 to 20 people	4-6 months
Copco 1	15 to 25 people	9 months
Copco 2	10 to 20 people	4-6 months
Iron Gate	15 to 30 people	12 months

2.4.5.4 Environmental Measures

The Fish Passage at Four Dams Alternative would incorporate standard measures to reduce environmental effects. These measures would be the same as those included in the Proposed Action (see Section 2.4.3).

2.4.5.5 Trap and Haul around Keno Impoundment – Programmatic Measure

NOAA Fisheries Service and DOI prescriptions include a measure to trap and haul fall-run Chinook salmon upstream and downstream around Keno Impoundment. The prescriptions call for seasonal trap and haul operations from June 15 to November 15 when water quality conditions are not suitable for fish (dissolved oxygen concentration less than ~~20~~ 6 mg/l or temperature above 20 degrees Celsius) (DOI ~~and~~2007; NOAA Fisheries Service 2007). Upstream operations would include construction of a collection and handling facility downstream ~~of~~ from Keno Dam; these fish would be released upstream of Link River Dam. Downstream operations would include construction of a collection and handling facility at or adjacent to Link River Dam that would ~~also~~ collect downstream migrating fish ~~from the East Side and West Side canals~~. These fish would be released downstream from Keno Dam. The exact details of the collection facilities, haul routes, or necessary road improvements are not yet defined; therefore, this measure is analyzed in this EIS/EIR at a programmatic level.

2.4.6 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative consists of the full removal of Iron Gate and Copco 1 facilities and installation of upstream and downstream fish passage facilities at both the J.C. Boyle and Copco 2 Dams. On Copco 2 and J.C. Boyle Dams, ladders would be less complex to construct

and provide volitional fish passage because of dam height and reservoir length. Iron Gate and Copco 1 Dams also provide less power; therefore, removal would have less effect on power generation. Removing Iron Gate and Copco 1 Reservoirs, the two largest impoundments in the Hydroelectric Reach, would also address water quality problems driven by reservoir size, such as increased water temperature, low dissolved oxygen, and toxic algal blooms in the summer and fall.

In order to meet current criteria for volitional fish passage, J.C. Boyle and Copco 2 Dams would require new upstream and downstream fish passage facilities. The fish passage facilities at J.C. Boyle and Copco 2 Dams would be the same as in the Fish Passage at Four Dams Alternative; Section 2.4.~~1~~ 5 describes these facilities in detail. Similar to the Fish Passage at Four Dams Alternative, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would incorporate most of the prescriptions from the FERC relicensing process related to fish passage at J.C. Boyle and Copco 2 Dams (see Attachment B of Appendix A for a list of prescriptions). Alternative 5 would not incorporate the prescriptions related to peaking power at J.C. Boyle and recreation releases. In Alternative 5, Copco 2 Dam would be the only dam remaining downstream from J.C. Boyle Dam. Copco 2 Reservoir is very small, and does not have adequate capacity to reregulate flows associated with peaking operations so that they are suitable for fish downstream. Therefore, Alternative 5 would not include peaking operations or recreation releases on any days at J.C. Boyle Dam.

Alternative 5 flows would be driven by releases from J.C. Boyle Dam because of the lack of downstream reregulation. The prescriptions would require 40 percent of J.C. Boyle releases to enter the Bypass Reach; therefore, these flows would be greater than the No Action/No Project Alternative. Flows at the Iron Gate Gauge would be generally similar to the No Action/No Project Alternative to maintain suitable flows for fish, although they may experience small variations because Iron Gate and Copco 1 Dams would not be in place to control flow patterns.

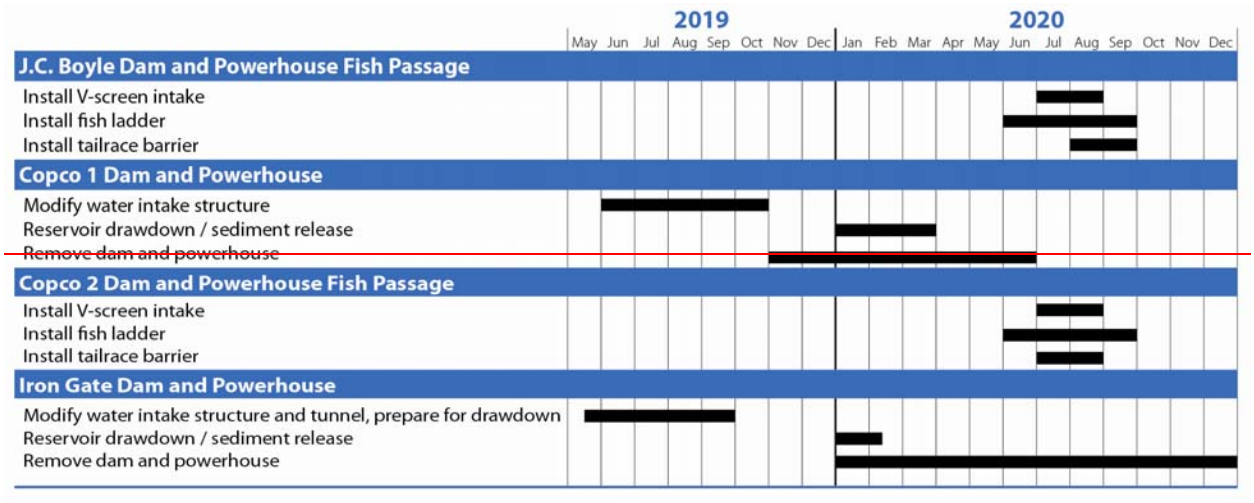
Removal of Iron Gate and Copco 1 Dams would be the same as in the Proposed Action; Section 2.4.3 describes the removal plans in more detail. Inflows to Upper Klamath Lake, and outflows from Copco 2 Dam and fish ladder and the Copco 2 Powerhouse are assumed to be nearly the same under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative as described above for the No Action/No Project Alternative.

A Hydropower Licensee would implement this alternative through licensure by FERC and would be responsible for its long term operation and maintenance. ~~The Hydropower Licensee would need to re-enter the FERC process to implement this alternative.~~ Implementation of the KBRA is not included in the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative. The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would not satisfy the KHSA; consequently, the KBRA would not be implemented (although ongoing restoration activities in the No Action/No Project Alternative may continue). For the purposes of this analysis, alternatives that would not result in full implementation of the KHSA do

not include the KBRA as a connected action to the alternative. Additionally, the transfer Keno Dam to DOI would not move forward as a connected action. The ongoing resource management activities, TMDLs, biological opinions, and other regulatory conditions described under the No Action/No Project Alternative would also occur under this alternative.

2.4.6.1 Schedule

This alternative would follow a schedule similar to that of the Proposed Action, because two of the dams are being removed and fish passage would be necessary as soon as possible after dam removal. Similar to Alternative 4, downstream fishways at each site would be completed before upstream fishways. Figure 2-~~29~~28 shows the schedule for construction of the fish passage facilities at two dams and for removal of the remaining two dams, based on these constraints.



~~**Figure 2-29. Anticipated schedule for Fish Passage at J.C. Boyle and Copco 2 Dams with Removal of Copco 1 and Iron Gate Dams**~~

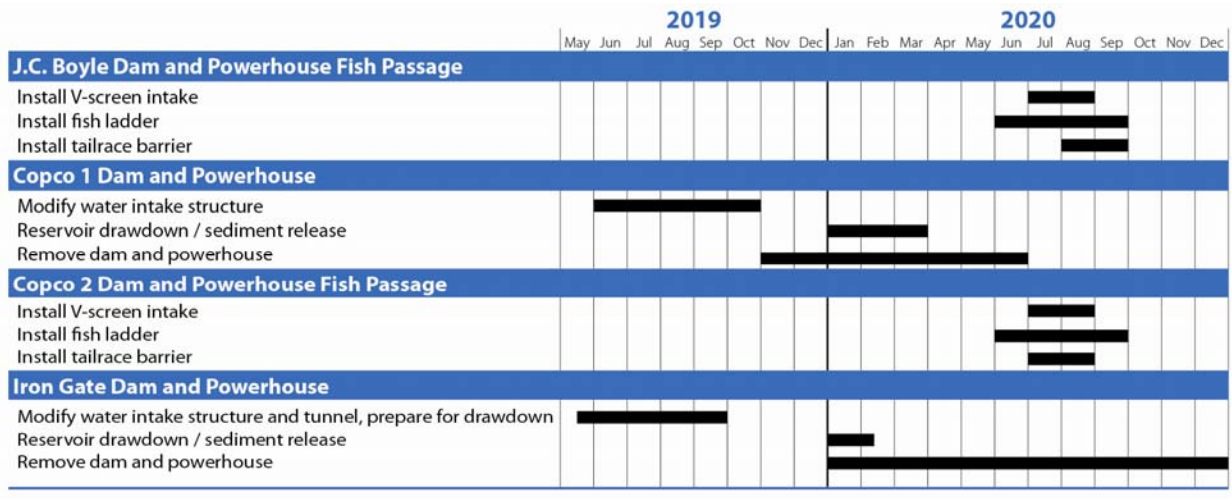


Figure 2-28. Anticipated schedule for Fish Passage at J.C. Boyle and Copco 2 Dams with Removal of Copco 1 and Iron Gate Dams.

2.4.6.2 Workforce

Table 2-~~28~~29 shows the estimated workforce necessary for each facility under this alternative. In addition to the average construction workforce, there would be 5 to 10 on-site construction management staff (e.g., inspectors, field engineers) at each site for the duration of the project. The deconstruction efforts at Copco 1 and Iron Gate Dams would constitute the bulk of the efforts in this alternative.

Table 2-~~28~~29. Estimated Construction Workforce for Full Removal of Iron Gate and Copco 1 Dams with Fish Passage at Copco 2 and J.C. Boyle Dams

Facility	Estimated Average Construction Workforce	Duration	Estimated Peak Workforce	Peak Period
J.C. Boyle	10 to 15 people	4 to 6 months	15–20	Jul 2020–Sep 2020
Copco 1	30 to 35 people	12 months	50–55	Nov 2019–Apr 2020
Copco 2	10 to 15 people	4 to 6 months	15–20	Jul 2020–Sep 2020
Iron Gate	35 to 40 people	18 months	75–80	Jun 2020–Sep 2020

2.4.6.3 Environmental Measures

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would incorporate standard measures to reduce environmental effects. These measures would be the same as those included in the Proposed Action (see Section 2.4.3).

2.4.6.4 Recreation Facilities

Recreation facilities near J.C. Boyle Reservoir would stay intact, and the Copco 2 area does not have any developed recreation facilities. Recreation facilities at Iron Gate and Copco 1 (see Table 2-2930) would be removed.

Table 2-2930. Recreation Facility ChangesFacilities under the Fish Passage at J.C. Boyle and Copco Copco 2, Remove Copco 1 and Iron Gate Alternative

Site Name	Existing Facilities	Facilities Following Dam Removal
Sites at J.C. Boyle Reservoir (Oregon)		
Pioneer Park	Two day-use areas with picnic tables, fire rings, and portable toilets	This site would remain, there would be no improvements or changes
Topsy Campground	Campground, day-use area, boat launch	This site would remain, there would be no improvements or changes
Sites at Copco 1 Reservoir (California)		
Mallard Cove	Day-use picnic area and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Copco Cove	Picnic area and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Sites at Iron Gate Reservoir (California)		
Fall Creek Trail	Day-use area and trail	This site would remain, there would be no improvements or changes
Jenny Creek	Day-use area and campground	This site would remain, there would be no improvements or changes
Wanaka Springs	Day-use area, campground, boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Camp Creek	Day-use area, campground, boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Juniper Point	Primitive campground and boat dock	All facilities would be removed. Parking area would be regraded, seeded, and planted
Mirror Cove	Campground and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Overlook Point	Day-use area	All facilities would be removed. Parking area would be regraded, seeded, and planted
Long Gulch	Picnic area and boat launch	All facilities would be removed. Parking area would be regraded, seeded, and planted
Dutch Creek	Day-use area	All facilities would be removed. Parking area would be regraded, seeded, and planted
Iron Gate Fish Hatchery Public Use Area	Day-use area and boat launch	This site would remain, there would be no improvements or changes

Source: O'Meara 2010Reclamation 2011

2.4.6.5 Trap and Haul around Keno Impoundment – Programmatic Measure

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include trap and haul measures to move fish around Keno Impoundment when

water quality is not suitable for fish. The measures would be the same as those described in the Fish Passage at Four Dams Alternative (see Section 2.4.5). The exact details of the collection facilities, haul routes, or necessary road improvements are not yet defined; therefore, this measure is analyzed in this EIS/EIR at a programmatic level.

2.4.6.6 City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include the relocation of the Yreka Water Supply Pipeline in the same fashion as the Proposed Action. The description of the relocation presented in 2.4.3.9 characterizes how the relocation would be completed under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative.

2.5 Preferred Alternative

~~The DOI has not identified a Preferred~~Both Alternative~~. After receiving public comment on this Draft EIS/EIR~~ 2 and ~~further consultation with cooperating agencies and other stakeholders, the DOI will either adopt one of the existing alternatives (potentially modified) or a new alternative as its Preferred~~ Alternative~~. The Preferred Alternative or new alternative may be a combination of existing alternatives or an alternative within the spectrum of alternatives already analyzed.~~ 3 include removal of the Four Facilities and implementation of KBRA and both alternatives more fully meet the Purpose and Need (Sections ES.3 and 1.5.2.1). Some key benefits provided by implementation of Alternative 2 and Alternative 3 include (for a full discussion of the Alternatives, see Chapter 3):

- Largely eliminates in 2020 elevated late summer/fall water temperatures in and below the Hydroelectric Reach by removing the largest reservoirs
- Largely eliminates 2020 dissolved oxygen and pH problems produced in reservoirs in the Hydroelectric Reach and transported downstream
- Largely eliminates in 2020 algal toxins produced in the Hydroelectric Reach and transported downstream3
- Anadromous fish would access low gradient historical habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate Reservoirs
- Provides for natural recruitment of spawning gravel and river processes within and below the Hydroelectric Reach through dam removal
- Provides optimal efficiency beginning in 2020 of upstream and downstream salmonid migration through the Hydroelectric Reach by creating a free-flowing river
- Reduces concentration of myxospores associated with carcasses accumulating below hatchery facilities, thus reducing disease

Removal of the Four Facilities and implementation of KBRA are important components of a durable, long-term solution for local communities and tribes regarding the development, administration, allocation, and advancement of water and native fishery

resources of the Klamath Basins. Alternative 2 and Alternative 3 provide a greater opportunity for expanding restoration of salmonids, which, over time would improve harvest opportunities of salmonids, and when compared to the other alternatives, resolve more societal hardships and conflicts that result from over-allocation of scarce natural resources.

Although Alternative 2 and Alternative 3 are similar, Alternative 2 would remove nearly all structures associated with the Four Facilities, while Alternative 3 would allow some structures to remain. By leaving no structures along the shore of the Klamath River, Alterative 2 leads to positive permanent changes in the human environment such as improvements to scenic quality, less long-term maintenance by land-management agencies, and is more protective of public safety. For these reasons Alternative 2 is the preferred alternative.

2.6 References

Bureau of Land Management (BLM). 2011. Klamath River Gravel Placement and Bypass Barrier Removal Environmental Assessment. Available from: http://www.blm.gov/or/districts/lakeview/plans/index.php?display=Lakeview. Accessed on September 13, 2011.

Bureau of Reclamation (Reclamation). 2011. Reservoir Area Management Plan for the Secretary‘s Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-19. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO. Report dated June 2011. Available at: http://klamathrestoration.gov/keep-me-informed/secretarial-determination/role-of-science/secretarial-determination-studies.

_____. 2012a. Detailed Plan for Dam Removal – Klamath River Dams, Klamath Hydroelectric Project, FERC License No. 2082, Oregon – California. July 2012. Available from: http://klamathrestoration.gov/keep-me-informed/secretarial-determination/role-of-science/secretarial-determination-studies.

_____. 2012b. “Hydrology, Hydraulics and Sediment Transport Studies for the Secretary’s Determination on Klamath River Dam Removal and Basin Restoration,” Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO. Available from: http://klamathrestoration.gov/keep-me-informed/secretarial-determination/role-of-science/secretarial-determination-studies.

CH2M Hill. 2003. Fish Passage Facilities Technical Memorandum 6-9. Prepared for Fish Engineering Subgroup by Bob Gatton. February 26.

Department of the Interior (DOI~~) and National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries Service~~). 2007. ~~United States~~ The Department of the

~~Interior and National Marine Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis Pursuant to Section 18 and Section 33 of the Federal Power Act for the~~ Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project ~~(FERC Project~~, No.~~-~~ 2082). January 26, 2007. Sacramento, CA. 650 p.

~~DOI. 2011. Technical Report No. SRH-2011-02 Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration Klamath River, Oregon and California.~~

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.

Klamath Riverkeeper~~:~~. Photo of Copco 1 Powerhouse, taken October 22, 2009. Accessed ~~2/~~February 28~~/~~, 2011. Available at: ~~http://lh5.ggpht.com/_Vmqtjopo_5s/SvEJz1sgbyI/AAAAAAAABtM/LCNFl1bbY8g/s720/SHP_8722.JPG~~http://picasaweb.google.com/klamathriverkeeper/PacifiCorpKlamathHydroProject#.

~~NOAA Fisheries Service. 2008. Southwest Regional Office – Protected Resource Division.~~Klamath Settlement Parties. 2010. Summary of the Klamath Basin Settlement Agreements. May 2010. Accessed ~~web page~~ December 22, 2011. Available at: ~~http://swr.nmfs.noaa.gov/deter/index.htm~~http://www.edsheets.com/Klamath/Summary%20of%20Klamath%20Settlement%20Agreements%201-7-10.pdf ~~(10/18/10).~~ .

Lane and Lane. 1981. The Copco Dams and the Fisheries of the Klamath Tribe. Prepared for the Bureau of Indian Affairs.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service. 2007. National Marine Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis for the Klamath Hydroelectric Project (FERC Project No. 2082). January 26, 2007. Sacramento, CA. 151 p.

_____. 2008. Anadromous Salmonid Passage Facility Design. NOAA Fisheries Service, Northwest Region, Portland, Oregon.

_____. 2010. Biological Opinion, ~~U.S.~~ Bureau of Reclamation, Operation of the Klamath Project between 2010 and 2018. National Marine Fisheries Service, Southwest Region. March 15, 2010.

~~NOAA Fisheries Service. 2011. Federal Register Notice of Availability regarding~~ _____. 2012a. Final Environmental Assessment: Authorization for Incidental Take ~~Permit and Habitat Conservation Plan for~~ and Implementation of the PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho

Salmon. February 2012. Available at: ~~http://www.federalregister.gov/articles/2011/05/04/2011-10902/incidental-take-permit-and-habitat-conservation-plan-for-pacificorp-klamath-hydroelectric-project. Accessed on July 13~~http://swr.nmfs.noaa.gov/nepa/FINAL_EA_for_PacifiCorp_ITP_HCP_Feb_2012_v2.pdf~~, 2011~~. Accessed on July 5, 2012.

_____. 2012b. Finding of No Significant Impact for Authorization for Incidental Take and Implementation of the PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho Salmon. February 2012. Available at: http://swr.nmfs.noaa.gov/nepa/Signed_FONSI.pdf. Accessed on July 5, 2012.

North Coast Regional Water Quality Control Board (NCRWCB). 2010a. Final Staff Report for the Klamath River Total Maximum Daily Loads (TMDLs) Addressing Temperature, Dissolved Oxygen, Nutrient and Microcystin Impairments in California, the Proposed Site Specific Dissolved Oxygen Objectives for the Klamath River in California, and the Klamath River and Lost River Implementation Plans.

~~NCRWCB.~~_____. 2010b. Action plan for the Klamath River total maximum daily loads addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in the Klamath River in California and Lost River implementation plan. Santa Rosa, California. http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/.

~~O'Meara, S. B. Greimann, and J. Godaire. 2010. Reservoir Area Management Plan for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. 31 December.~~

Oregon Department of Environmental Quality (ODEQ). 2010. Upper Klamath and Lost Rivers TMDL and WQMP. Available at: http://www.deq.state.or.us/wq/tmdls/klamath.htm#upks. Accessed on March 24, 2011.

PacifiCorp. 2012. PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho Salmon. Prepared by PacifiCorp Energy, Inc, Portland, OR. Submitted to the National Marine Fisheries Service, Arcata Area Office, Arcata, CA. February 16, 2012. Available at: http://swr.nmfs.noaa.gov/nepa/PacifiCorp_Klamath_Coho_HCP_021612_Final.pdf. Accessed on July 5, 2012.

Philip Williams & Associates. 2009. A River Once More: The Klamath River Following Removal of the Iron Gate, Copco and J.C. Boyle Dams. Prepared for the California State Coastal Conservancy.

Ratliff, D~~. et al.~~., Fagan, C., Riehle, M., Powell, M., Carlon, S., Lickwar, P., Stuart, A., DeVito, P., Gauvin, M., Eisner, J.. 1999. Alternatives for Renewing Fish Passage at the

Pelton Round Butte Hydroelectric Project. Prepared for Portland General Electric by the Interagency Fisheries Technical Subcommittee. 133 p.

Taylor, Rob. 2010. Personal communication between R. Taylor, Water Manager for the City of Yreka, and Tom Hepler, Lead Engineer, Bureau of Reclamation. August 24.

United States Fish and Wildlife Service (USFWS). 2008. Formal Consultation on the Bureau of Reclamation's Proposed Klamath Project Operations from 2008 to 2018. ~~April~~ April 2, 2008.

United States Geological Survey (USGS). 2011. USGS Real Time Water Data for USGS 11510700 Klamath River Below John C. Boyle Powerplant, Near Keno, OR. Available ~~from:~~ at: http://waterdata.usgs.gov/or/nwis/rt. Accessed on July 18, 2011.

Chapter 3
Affected Environment/Environmental Consequences

3.1 Introduction

This chapter describes, for each resource area, the affected environment or environmental setting for the region of the Klamath Basin potentially affected by the dam removal and connected actions, should they be implemented. This chapter presents the analyses of the impacts that would result from the No Action/No Project Alternative or implementation of the Proposed Action and alternatives described in Chapter 2. This chapter also presents mitigation measures to reduce or eliminate the impacts. The sections of this chapter, by resource area, are as follows:

- 3.2 Water Quality
- 3.3 Aquatic Resources
- 3.4 Algae
- 3.5 Terrestrial Resources
- 3.6 Flood Hydrology
- 3.7 Groundwater
- 3.8 Water Supply/Water Rights
- 3.9 Air Quality
- 3.10 Greenhouse Gases/Global Climate Change
- 3.11 Geology, Soils, and Geologic Hazards
- 3.12 Tribal Trust
- 3.13 Cultural and Historical Resources
- 3.14 Land Use, Agricultural and Forest Resources
- 3.15 Socioeconomics
- 3.16 Environmental Justice
- 3.17 Population and Housing
- 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power
- 3.19 Scenic Quality
- 3.20 Recreation
- 3.21 Toxic/Hazardous Materials
- 3.22 Traffic and Transportation
- 3.23 Noise and Vibration

Paleontological resources, which may appear in an Environmental Impact Statement (EIS) or an Environmental Impact Report (EIR) for other projects, were not considered in detail in this Klamath Facilities Removal EIS/EIR, with the exception of their potential presence in a diatomite bed near Copco Reservoir, because the Lead Agencies determined that the volcanic nature of the local geology at the dam sites precluded the presence of these resources in the project area. The potential for project related effects on paleontological resources at this diatomite deposit are described in Section 3.11, Geology, Soils, and Geologic Hazards.

3.1.1 Format of the Environmental Analysis

3.1.1.1 Area of Analysis

This document defines and describes an area of analysis for each resource area. In some cases, the area of analysis consists only of facility deconstruction/construction areas, or nearby areas that would be affected directly by the effects of deconstruction/construction, such as for the analysis of noise impacts. More often, the area of analysis includes the entire Klamath Basin. The area of analyses for water supply/water rights and for land use, agricultural and forest resources, for example, includes the entire Klamath Basin because implementation of the Klamath Hydroelectric Settlement Agreement (KHSA) and Klamath Basin Restoration Agreement (KBRA) could affect these resources not only at the project sites, but also in areas upstream of and downstream ~~of~~ from them. In a few cases, the area of analysis is even more geographically broad, such as for socioeconomics.

3.1.1.2 Regulatory Framework

Each resource area is evaluated within the existing framework of ~~federal, state~~Federal, State, and local laws, regulations, policies, and plans. For each resource area, the sub-sections of this chapter briefly list the laws and regulations that are relevant and applicable to the affected environment, area of analysis, and analysis of impacts. Chapter 6 of this EIS/EIR provides further discussion on how laws, regulations, policies, and plans would be addressed through implementation of the Proposed Action or alternatives.

3.1.1.3 Wild and Scenic River Act Component Analysis

The analysis of potential effects on Wild and Scenic River (WSR) components is presented in Section 3.20, Recreation. ~~The specific subsection and page numbers of this analysis are:~~

- ~~Scenic Quality - Section 3.20.4.3, pages 3.20-47 and 59~~
- ~~Recreation - Section 3.20.4.3, pages 3.20-50 and 59~~
- ~~Fisheries - Section 3.20.4.3, pages 3.20-52 and 59~~
- ~~Wildlife - Section 3.20.4.3, pages 3.20-55 and 59~~

3.1.1.4 Coastal Zone Management Act Consistency Determination

The Coastal Zone Management Act ~~(CZMA)~~ requires any applicant seeking a Federal License or permit that could affect land or water uses or resources of the California coastal zone ~~to~~ to perform a Federal Consistency Determination for the proposed project. The determination provides a certification that the ~~proposed action~~ Proposed Action will be conducted in a manner that to the maximum extent possible is consistent with the policies of the California Coastal Management Program as outlined in the California Coastal Act (CCA) of 1976. The analysis of the consistency between the policies of the California Coastal Act and the Proposed Action is discussed in the following section:

- Discussion of CCA Section 30231 - Section 3.3.4.3 page ~~134~~
- 3.3-180
- Discussion of CCA Section 30236 - Section 3.3.4.3 page ~~135~~3.3-181

The focused analysis in Section 3.3.4.3 considers at specific CCA policies; however, this information supplements the more comprehensive analysis of the near-shore impacts in Section 3.2, Water Quality and Section 3.3, Aquatic Resources.

3.1.1.5 Basis of Comparison for the Affected Environment/Environmental Setting

The analysis of impacts requires a basis for comparison of conditions during project construction and post-project. The National Environmental Policy Act (NEPA) basis of comparison is the No Action Alternative. Under the California Environmental Quality Act (CEQA), the basis of comparison is conditions at the time of the Notice of Preparation. As discussed in Chapter 2, the No Action Alternative is similar to conditions at the time of the Notice of Preparation; therefore, the basis of comparison for for NEPA and CEQA are generally the same for this document. The impact analysis for each resource considered both the NEPA and CEQA basis of comparison together and, in cases where these baselines differ, further discussion is provided.

3.1.1.6 Environmental Consequences/Environmental Impacts

The methods used to evaluate impacts are described for each resource area. In general, the Lead Agencies identified the impacts that would result from implementation of each of the alternatives within the context of the environmental baseline and regulatory framework. The Lead Agencies used a variety of data sources, models, design documents, interviews, and various other types of research and analysis to predict the impacts. The Lead Agencies then determined the magnitude or significance of the impacts based on significance criteria, where required.

3.1.1.6.1 Significance Criteria

For each resource area, this chapter presents specific significance criteria that the Lead Agencies used to assess the significance level of the impacts under CEQA. Pursuant to to NEPA, significance is used to determine whether an EIS or some other level of documentation is required, and once the decision to prepare an EIS is made, the magnitude of the impact is evaluated and no further judgment of significance is required. Therefore, any determinations of significance are for CEQA purposes only.

3.1.1.6.2 Impact Discussion

The impacts of each alternative are discussed in Chapter 3 by resource area and alternative. Each resource area section is structured so that an *italicized* impact statement introduces potential changes that could occur from implementation of each alternative. A discussion of how the resource area would be affected by the impact then follows this initial statement. The impact discussion is concluded with a **bold** significance determination that indicates if there is no impact to a resource area or if the impact to a resource area is beneficial, less than significant, or significant.

3.1.1.6.3 Mitigation Measures

For those impacts that would be significant, the Lead Agencies identified feasible mitigation measures, if they exist, to reduce the level of the impact. The discussion of mitigation measures presented in this chapter includes an assessment of which, if any, significant impacts would remain after mitigation. Chapter 5, Other Required

Disclosures, describes any irreversible and irretrievable commitments of resources that the Lead Agencies identified as part of this analysis.

Although existing adverse conditions associated with the No Action/No Project Alternative identified in this chapter would continue, it is not necessary or appropriate to formulate a mitigation measure and ascribe mitigation responsibility for these impacts. In accordance with the intent and requirements of CEQA (Guidelines Section 15126.6), delineating the nature and significance of impacts associated with the No Action/No Project Alternative serves to provide a basis for comparing the impacts of approving the proposed project with the impacts of not approving the proposed project. In particular, the evaluation of alternatives, including the "no project" alternative, serves to determine whether the significant impacts of the alternatives can be avoided or substantially lessened. The analysis presented for the No Action/No Project Alternative in this chapter has determined that the existing adverse conditions would continue for reasons not attributable to the Proposed Action or alternatives; this provides information to be considered by decision-makers in evaluating the impacts that are attributable to the Proposed Action.

3.1.1.6.4 Scope of the KBRA Evaluation

This EIS/EIR provides a project-level analysis of the KHSA and alternatives[1], but it evaluates the KBRA on a programmatic level. While the general goals of the KBRA actions and programs are known, the specific actions that would occur are not yet defined, and additional environmental analyses according to NEPA, CEQA, and other permits and authorizations would be required as necessary once the KBRA activities are defined at a project-level. The Lead Agencies considered the goals, programs, and plans as described in KBRA Appendix C-3 (summarized in this EIS/EIR in Chapter 2) in the impact analyses to determine their anticipated direct, indirect, and cumulative effects on each resource. Additionally, each section contains an analysis of the potential combined effects of KBRA actions and facility removal actions in the KHSA. These combined effects are described as a part of the programmatic significance determination on the specific KBRA actions. The KBRA programs described at a sufficient level of detail to support the programmatic analysis completed in this EIS/EIR are outlined in Table 3.1-1:

[1] With the exceptions of the East and ~~West Side~~Westside Facility Decommissioning, ~~a component of~~ an action connected to the Proposed Action and Alternative 3, and the trap and haul program included in Alternatives 4 and 5, both of which are ~~both~~ analyzed at the programmatic level.

Table 3.1-1 KBRA Plans and Programs Analyzed

KBRA Program	Sections Analyzed
Phase 1 Fisheries Restoration Plan	3.2 Water Quality, 3.3 Aquatic Resources, 3.4 Algae, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.11 Geology and Soils, 3.13 Cultural and Historic Resources, 3.15 Socioeconomics, 3.16 Environmental Justice, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.20 Recreation, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration

Table 3.1-1 KBRA Plans and Programs Analyzed

KBRA Program	Sections Analyzed
Phase 2 Fisheries Restoration Plan	3.2 Water Quality, 3.3 Aquatic Resources, 3.4 Algae, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.11 Geology and Soils, 3.13 Cultural and Historic Resources, 3.15 Socioeconomics, 3.16 Environmental Justice, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.20 Recreation, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration
Fisheries Monitoring Plan	3.3 Aquatic Resources, 3.15 Socioeconomics; 3.16 Environmental Justice
Fisheries Reintroduction and Management Plan	3.2 Water Quality, 3.3 Aquatic Resources, 3.8 Water Rights/Water Supply, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.13 Cultural and Historic Resources, 3.14 Land Use, Agricultural and Forest Resources, 3.15 Socioeconomics, 3.16 Environmental Justice, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.20 Recreation, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration
Wood River Wetland Restoration	3.2 Water Quality, 3.4 Algae, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.8 Water Rights/Water Supply, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.13 Cultural and Historic Resources, 3.15 Socioeconomics, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.20 Recreation, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration
Water Diversion Limitations	3.2 Water Quality, 3.3 Aquatic Resources, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.7 Groundwater, 3.8 Water Rights/Water Supply, 3.14 Land Use, Agricultural and Forest Resources, 3.15 Socioeconomics, 3.19 Scenic Quality, 3.20 Recreation
On-Project Plan	3.3 Aquatic Resources, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.7 Groundwater, 3.8 Water Rights/Water Supply, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.13 Cultural and Historic Resources, 3.15 Socioeconomics, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.20 Recreation, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration
Future Storage Opportunities	3.6 Flood Hydrology, 3.8 Water Rights/Water Supply, 3.15 Socioeconomics
Water Use Retirement Program	3.2 Water Quality, 3.3 Aquatic Resources, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.7 Groundwater, 3.8 Water Rights/Water Supply, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.13 Cultural and Historic Resources, 3.14 Land Use, Agricultural and Forest Resources, 3.15 Socioeconomics. 3.16 Environmental Justice, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.20 Recreation, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration
Power for Water Management	3.10 Global Climate Change/Greenhouse Gases, 3.14 Land Use, Agricultural and Forest Resources, 3.15 Socioeconomics, 3.18 Utilities and Public Services, Solid Waste, Power
Off-Project Water Settlement	3.8 Water Rights/Water Supply, 3.15 Socioeconomics
Off-Project Water Reliance Program	3.8 Water Rights/Water Supply, 3.15 Socioeconomics, 3.16 Environmental Justice

Table 3.1-1 KBRA Plans and Programs Analyzed

KBRA Program	Sections Analyzed
Emergency Response Plan	3.6 Flood Hydrology, 3.7 Groundwater, 3.8 Water Rights/Water Supply, 3.15 Socioeconomics, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power
Climate Change Assessment and Adaptive Management	3.6 Flood Hydrology, 3.8 Water Rights/Water Supply, 3.10 Global Climate Change/Greenhouse Gases, 3.20 Recreation, 3.15 Socioeconomics
Interim Flow and Lake Level Program	3.2 Water Quality, 3.4 Algae, 3.5 Terrestrial Resources, 3.6 Flood Hydrology, 3.7 Groundwater, 3.8 Water Rights/Water Supply, 3.15 Socioeconomics, 3.16 Environmental Justice, 3.19 Scenic Quality, 3.20 Recreation
Fish Entrainment Reduction	3.3 Aquatic Resources, 3.5 Terrestrial Resources, 3.9 Air Quality, 3.10 Global Climate Change/Greenhouse Gases, 3.13 Cultural and Historic Resources, 3.15 Socioeconomics, 3.17 Population and Housing, 3.18 Public Health and Safety, Utilities and Public Services, Solid Waste, Power, 3.19 Scenic Quality, 3.21 Toxic and Hazardous Materials, 3.22 Traffic and Transportation, 3.23 Noise and Vibration
Upper Klamath Lake and Keno Nutrient Reduction	3.2 Water Quality, 3.3 Aquatic Resources, 3.4 Algae, 3.15 Socioeconomics
Tribal Fisheries and Conservation Management Program	3.12 Tribal Trust, 3.15 Socioeconomics, 3.16 Environmental Justice
Tribal Programs Economic Revitalization	3.15 Socioeconomics, 3.16 Environmental Justice
Klamath River Tribes Interim Fishing Site	3.3 Aquatic Resources, 3.12 Tribal Trust, 3.13 Cultural and Historic Resources, 3.15 Socioeconomics, 3.16 Environmental Justice, 3.17 Population and Housing, 3.19 Scenic Quality, 3.22 Traffic and Transportation
Mazama Forest Project	3.5 Terrestrial Resources, 3.12 Tribal Trust, 3.13 Cultural and Historic Resources, 3.14 Land Use, Agricultural and Forest Resources, 3.15 Socioeconomics, 3.16 Environmental Justice
Klamath County Economic Development Plan	3.15 Socioeconomics, 3.16 Environmental Justice
California Water Bond Legislation	3.15 Socioeconomics, 3.16 Environmental Justice
Drought Plan	3.8 Water Rights/Water Supply, 3.10 Global Climate Change/Greenhouse Gases, 3.15 Socioeconomics

3.1.1.6.5 Best Available Information

The Lead Agencies have used their best efforts to identify and disclose as much relevant information as possible in the EIS/EIR based on the review of the best available information at the time of the issuance of the Notice of Intent, as well as, new information developed to support the Secretarial Determination process. Under CEQA, the Lead Agency is not required to conduct every test or perform all research, studies, or experimentation at the commenter's request (Pub. Resources Code, Section 21091(d)(2)(B), CEQA Guidelines sec. 15151 and 15204). The Lead Agencies

implemented various processes to ensure that only high quality and objective science will contribute to the Secretarial Determination, including, but not limited to:

- All new Federal scientific studies used followed Federal guidance requirements on peer review and scientific integrity, including the procedures adopted by the Departments of the Interior and Commerce (DOI and DOC) in response to the 2004 Office of Management and Budget Bulletin on Peer Review, the Presidential Memorandum on Scientific Integrity dated March 9, 2009 (which was incorporated into Appendix J of the KHSA), the Office of Science and Technology Policy 2010 guidance memorandum on scientific integrity, the 2011 DOI Memorandum on Science Integrity (for DOI agencies), and as well as internal procedures used by the Bureau of Land Management (BLM), United States Geological Survey (USGS), Bureau of Reclamation (Reclamation), U.S Fish and Wildlife Service (USFWS), and the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service.
- Any new Federal scientific studies or reports were developed by a Program Manager, who was supported by a Technical Management Team, which included nine sub-teams covering various disciplines (Engineering, Geomorphology, and Constructability; Environmental Compliance; Biological; Water Quality; Tribal/Cultural; Real Estate; Recreation; and Communications). The quality and objectivity of these products and reports all benefited from the expertise of sub-team members representing multiple Federal agencies.
- During the period of project design and execution of new Federal studies, the public and stakeholders were briefed at frequent intervals via public meetings. Public input from these meetings closed data gaps, refined study approaches, and provided additional studies or data to incorporate into the analyses. This involvement of the public improved the quality and the breadth of the science, and ensured that the final reports addressed questions and concerns raised by the public, Indian tribes, and local agencies (e.g., counties).
- When warranted, new studies were undertaken to fill data gaps and to better inform the Secretarial Determination. Some example new studies included,: (1) reservoir sediment drilling and diver inspections of the dam foundations prior to preparing a feasibility engineering plan for dam removal; (2) hydrologic modeling to predict drawdown and transport of reservoir bottom sediments downstream; (3) chemical analysis of sediments and fish tissues to assess the effects of these suspended sediments on humans and biota if they were transported downstream or exposed as new land surfaces; (4) a model of the expected response of Chinook salmon to the Proposed Action; (5) economic analysis of the effects to various sectors on implementing the agreements, locally, regionally and nationally and on Indian Tribes, among many other studies.
- All scientific reports produced by the Technical Management Team (TMT) were reviewed by independent subject matter experts (outside of the Klamath Secretarial Determination process) in accordance with the policies of the agency producing the report. Peer reviews were undertaken to ensure that the reported results were reliable, objective, accurate and scientifically sound.

- In some cases, an existing report important for the Secretarial Determination process had not previously been peer reviewed. Prior to use in contributing to the Secretarial Determination, these previously unreviewed reports were assigned to an independent contractor to obtain one or more critique(s) by subject matter experts to verify their reliability, objectivity, accuracy and to verify their scientific veracity.
- An independent contractor convened four expert panels to evaluate and make findings regarding the likely trajectory of fish populations under both the Proposed Action and the No Action alternatives. The majority of panel members were not from Federal agencies, but were from universities or consulting firms. The four panels evaluated: resident native fish (trout and suckers), lamprey, coho salmon and steelhead, and Chinook salmon. These panels provided an independent evaluation of the information that was available at the time of their deliberations in preparation of their reports. These independent analyses were largely consistent with the findings in the Technical Management Team reports, which provided increased confidence in the science process and the findings relative to fish and fisheries.

One of the goals of scientific analysis is to develop new information and to increase the certainty of conclusions (i.e., reduce scientific uncertainty). Using best available information, however, cannot remove all scientific uncertainty from a decision. No amount of investigating, hypothesis testing, modeling, or peer reviewing will ensure perfect knowledge about how the Klamath River ecosystem would respond to future large changes/actions (e.g., alternatives 2 through 5) or even 50 years of "no action" (e.g., alternative 1). Scientific uncertainty is inherent in any analysis of present and future conditions, particularly in a system as complex as the Klamath Basin.

It is important to understand what is meant by the term scientific "uncertainty" because it has a very different meaning than the meaning more commonly used by the public outside the realm of science; this difference in word usage often leads to serious misunderstandings when science results are communicated. Science and engineering use the word "uncertainty" to define how well something is known, not whether it is known. Because nothing measured, estimated, modeled, or predicted can be known with perfect accuracy and certainty, scientists seek to describe the statistical variability of a number, a range of possibilities, and/or the relative level of confidence in a conclusion. By defining uncertainty, scientists seek to clarify the strength and accuracy of a conclusion. This definition of scientific uncertainty should not be confused with the more common definition of uncertainty (outside the realm of science and engineering), which typically conveys that something is completely unknown, that a result is unreliable, or that the state of knowledge is confused.

In some cases, scientific uncertainty is quantifiable and is often described as the estimated amount an observed, calculated, or modeled value may differ from the true value. For example, a study may show that we have 98 percent confidence that the true value will fall within a defined range of values. This defined range of values is referred

to as the 98 percent confidence interval. For estimating the potential cost of removal of the Four Facilities, engineers were able to determine a most probable cost, as well as the 98 percent confidence interval around the most probable cost, in order to define the range of possible removal costs.

In other cases how well something is known cannot be quantified and uncertainty is often described in relative terms, such as predicting how an ecosystem (e.g., Klamath River) may respond to a potential action (e.g., dam removal). Based on the best available information and analyses, scientists convey the likelihood of these predictions with descriptions such as "highly likely," "probable," or other caveats intended to disclose the level of certainty in a conclusion. For example, predicting the potential benefits of dam removal on juvenile salmon disease in the Klamath Basin cannot be known with perfect accuracy, but most fishery biologists believe removal of the Four Facilities would decrease the infection rates. A lack of certainty of the exact response of the ecosystem does not preclude a conclusion that juvenile salmon disease would likely decrease. This conclusion is based on studies of other river systems, investigations of salmon disease in the Klamath River, and knowledge of the specific factors contributing to salmon disease and how these factors would change if dams were removed.

In order to provide a sound foundation for a Secretarial Determination on removal of the Four Facilities, multiple strategies were used to weigh the validity of hypotheses, reach scientific conclusions, and decrease scientific uncertainty around those conclusions. These strategies included: (1) developing new studies, that test multiple hypotheses, in order to fill critical information gaps; (2) developing numerical models (when gathering empirical data is not possible) to predict the probable ecosystem response; (3) repeating investigations on critical topics to ensure past results are reproducible; (4) obtaining independent expert opinions on important topics; and (5) drawing conclusions based on the weight of evidence and multiple lines of evidence.

Using multiple lines of evidence refers to a process when conclusions are not drawn from a single study but from two or more studies that have different approaches. For example, the conclusion that dam removal and KBRA implementation could increase Chinook production in the Klamath Basin was based on a recent synthesis of previous study findings (Hamilton et al. 2011), two new independent modeling studies (Hendrix 2011; Lindley and Davis 2011), a Chinook expert panel report (Goodman et al. 2011), among others. Although the authors of each of these four peer-reviewed reports used different approaches and assumptions, as well as presented different levels of confidence in quantifying their conclusions and scientific uncertainty, they all concluded that Chinook salmon would increase in number relative to the "no action alternative" of leaving dams in place and not implementing KBRA. Considering several diverse lines of evidence decreased scientific uncertainty and strengthened this overarching conclusion.

In some situations, where studies present conflicting results, the "weight of evidence" for a conclusion considers the quantity of evidence supporting that conclusion as well as when and how studies were done; generally weight is given to more recent studies and

studies done with more scientific rigor (e.g., peer review). When there is a significant amount of conflicting information, a conclusion is often expressed with a higher degree of uncertainty.

During the period of time when the EIS/EIR was being developed, new scientific information has become available that has improved our understanding of the complicated interactions between river ecosystems, aquatic resources, and the people that rely on those resources in the Klamath Basin. That new information has been incorporated into the EIS/EIR as it has become available. Through the diligent efforts of the scientific community, the state of scientific knowledge in the Klamath Basin continues to improve and will result in valuable reports and information in the future. Therefore we fully anticipate that new scientific information will become available in the interim period between issuance of the Final EIS/EIR and the Secretarial Determination, particularly in the areas of active research on juvenile salmon disease, life cycle models of Klamath Basin salmon, causes of water quality problems in the Klamath River and Upper Klamath Lake, and the poor survival of juvenile endangered suckers in Upper Klamath Lake. An example of a draft report that will likely become finalized (and citable) in late 2012 is a Klamath coho life cycle model that analyzes the potential effects of dam removal on threatened coho salmon; a draft of this report (Cramer 2011) can be found at http://www.fishsciences.net/projects/klamathcoho/model.php. As with all EIS/EIR, however, only current best available information can form the basis of a NEPA/CEQA analysis; as new scientific information becomes available the Lead Agencies shall evaluate whether subsequent NEPA/CEQA analysis is needed before any decision is made regarding dam removal.

3.1.2 References

Cramer Fish Science. 2011. Simulated Effects of Dam Removal on Coho Salmon in the Klamath Basin, Klamath Coho Integrated Modeling Framework Version 1.4. April 2011. Available at: http://www.fishsciences.net/projects/klamathcoho/model.php .

Goodman, D., Harvey, M., Hughes, R., Kimmerer, W., Rose, K., Ruggerone, G. 2011. Klamath River Expert Panel, Addendum to Final Report, Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon. Addendum to Final Report. Prepared with the assistance of Atkins, Portland, Oregon.

Hamilton, J.B., Rondorf, D., Hampton, M., Quinones, R., Simondet, J., Smith, T. 2011. Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath. Prepared by the Biological Subgroup for the Secretarial Determination Regarding Potential Removal of the Lower Four Dams on the Klamath River. Available at: http://klamathrestoration.gov/keep-me-informed/secretarial-determination/role-of-science/secretarial-determination-studies . Accessed on: December 21, 2011.

Hendrix, N. 2011. Forecasting the response of Klamath Basin Chinook populations to dam removal and restoration of anadromy versus no action. Review Draft Report. R2 Resource Consultants, Redmond, Washington.

Lindley, S.T., Davis H. 2011. Using model selection and model averaging to predict the response of Chinook salmon to dam removal. Review Draft Report. National Marine Fisheries Service, Fisheries Ecology Division, NMFS Southwest Fisheries Science Center, Santa Cruz, California.

3.2 Water Quality

This section describes the effects of the Proposed Action and alternatives on water temperature, suspended sediments, nutrients (total phosphorus [TP], total nitrogen [TN], ortho-phosphorus, nitrate, and ammonium), dissolved oxygen, pH, algal toxins and chlorophyll-*a*, and inorganic and organic contaminants within the area of analysis. Effects of the Proposed Action and alternatives on the algal community (phytoplankton, aquatic macrophytes, riverine phytoplankton and periphyton) in the area of analysis are discussed in Section 3.4, Algae. Algal toxins are a water quality concern that ~~affect~~affects designated beneficial uses of water, so this section also includes a brief analysis of project effects on algal toxins as related to beneficial uses. Similarly, water quality parameters relevant to the analysis of fish disease and parasitism (e.g., water temperature, nutrient availability) are included here as part of the Proposed Action effects analysis; the full analysis of fish disease and parasitism is in Section 3.3, Aquatic Resources.

3.2.1 Area of Analysis

The area of analysis for water quality includes the three main tributaries to Upper Klamath Lake (Wood, Williamson, and Sprague Rivers), Upper Klamath Lake, Link River, and the mainstem Klamath River in the Upper Klamath Basin and the mainstem Klamath River, the Klamath Estuary, and the marine nearshore environment in the Lower Klamath Basin~~s~~ (see Figure 3.2-1~~), which for~~). For the purposes of the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) ~~are~~the area of analysis is organized into the following analysis segments:

Upper Klamath Basin

- Wood, Williamson, and Sprague Rivers
- Upper Klamath Lake
- Link River Dam to Klamath River upstream of J.C. Boyle Reservoir
- Hydroelectric Reach (J.C. Boyle Reservoir to Iron Gate Reservoir)

Lower Klamath Basin

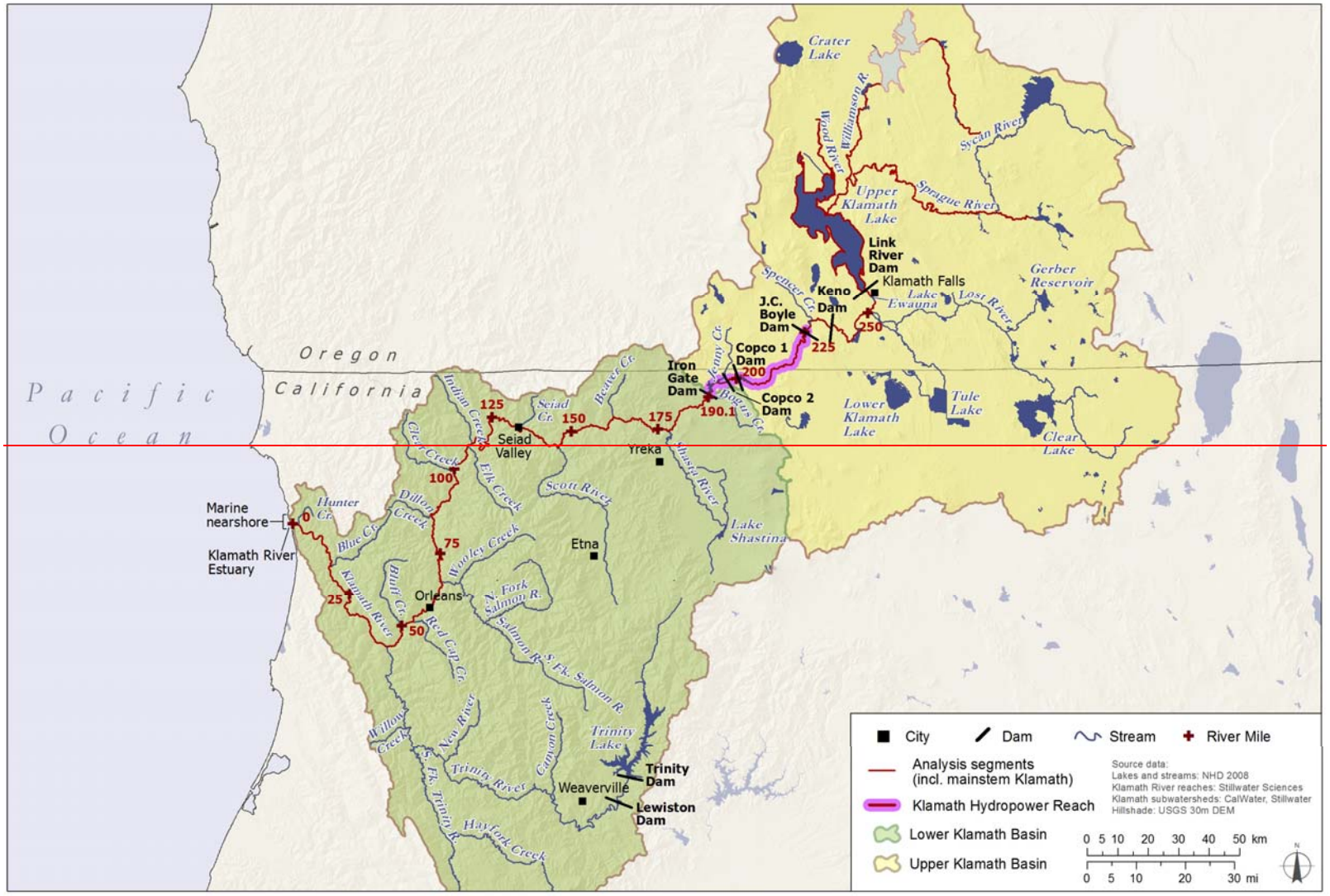
- Iron Gate Dam to Salmon River
- Salmon River to Klamath Estuary
- Klamath Estuary
- Marine nearshore

Table 3.2-1 lists the river mile (RM) locations of the above reaches and of features relevant to the water quality area of analysis.

Table 3.2-1. Location of Klamath Basin Features Relevant to the Water Quality Area of Analysis

Feature	River Mile[1]
Upper Klamath Basin	
Wood River	282.3+
Williamson, and Sprague rivers	272.3+
Upper Klamath Lake/Agency Lake	254.3 to 282.3
Link River Dam	253.7
Keno Impoundment ~~(including~~ /Lake Ewauna~~)~~	233.0 to 253 (Lake Ewauna ≈247 to 253)
Keno Impoundment at Miller Island	246
Klamath Straits Drain (at Pumping Plant F)	240.5
J.C. Boyle Reservoir	224.7 to 228.3
Oregon-California ~~state~~State line	208.5
Copco 1 Reservoir	198.6 to 203.1
Copco 2 Reservoir	198.3 to 198.6
Iron Gate Reservoir	190.1 to 196.9
Lower Klamath Basin	
Klamath River confluence with Shasta River	176.7
Klamath River confluence with Scott River	143.0
Seiad Valley	129.4
Klamath River confluence with Salmon River	66.0
Hoopa Valley Tribe	≈45 to 46
Weitchpec	43.5
Klamath River confluence with Trinity River	42.5
Klamath River at Turwar	5.8
Klamath Estuary	0 to ≈2

Notes:
[1] ~~–~~River Mile (RM) refers to distance upstream ~~from~~of the mouth of the Klamath River.


Crater Lake
Williamson R.
Wood River
Sycan River
Upper Klamath Lake
Sprague River
Link River Dam
Klamath Falls
Keno Dam
Lake Ewauna
Lost River
Gerber Reservoir
Spencer Cr.
J.C. Boyle Dam
250
225
Copco 1 Dam
200
Iron Gate Dam
Copco 2 Dam
190.1
Bogus Cr.
Jenny Cr.
Beaver Cr.
Seiad Cr.
150
175
125
Seiad Valley
Indian Creek
Clear Creek
100
Elk Creek
Yreka
Shasta River
Scott River
Lower Klamath Lake
Tule Lake
Clear Lake
Lake Shastina
Oregon
California
Pacific Ocean
Marine nearshore
Klamath River Estuary
Hunter Cr.
Blue Cr.
Dillon Creek
0
75
Wooley Creek
Etna
Bluff Cr.
Klamath River
25
Orleans
50
Red Cap Cr.
N. Fork Salmon R.
Salmon R.
S. Fk. Salmon R.
Willow Creek
New River
Canyon Creek
Trinity Lake
Trinity River
S. Fk. Trinity R.
Trinity Dam
Weaverville
Lewiston Dam
Hay Fork Creek
City
Dam
Stream
River Mile
Analysis segments (incl. mainstem Klamath)
Klamath Hydropower Reach
Lower Klamath Basin
Upper Klamath Basin
Source data:
Lakes and streams: NHD 2008
Klamath River reaches: Stillwater Sciences
Klamath subwatersheds: CalWater, Stillwater
Hillshade: USGS 30m DEM
0 5 10 20 30 40 50 km
0 5 10 20 30 mi
N

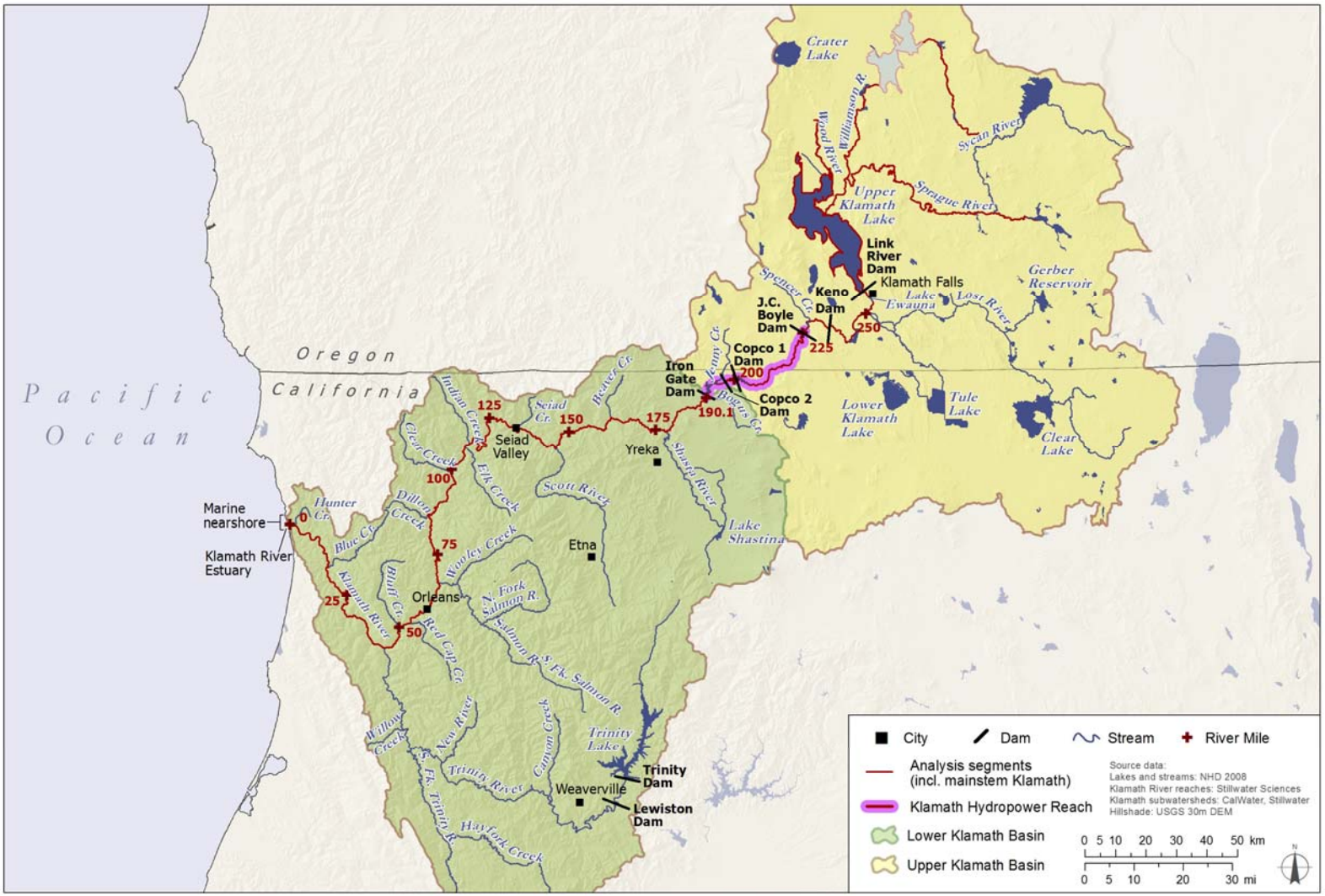


Figure 3.2-1. Water Quality Area of Analysis

3.2.2 Regulatory Framework

Multiple ~~federal, state~~Federal, State, and tribal programs and planning documents are applicable to the regulation and protection of water quality in the area of analysis, including but not limited to the following:

- Clean Water Act (Title 33 U.S.C. §1313 [1972])
- Safe Drinking Water Act (Title 42 U.S.C. Chapter 6A §300f-j [1973 as amended])
- Oregon Administrative Rules for Water Pollution Control (OAR 340-041)
- North Coast Region Basin Plan (as required by Sections 13240–13247 of Porter-Cologne Water Quality Act)
- Hoopa Valley Tribe Water Quality Control Plan
- Coastal Zone Management Act
- California Ocean Plan (C.W.C. §13170.2)

3.2.2.1 Designated Beneficial Uses of Water

Beneficial uses of water are designated by the Oregon Department of Environmental Quality (ODEQ), the State and Regional Water Quality Control Boards, and the Hoopa Valley Tribe. Other tribal water quality programs, including the development and adoption of beneficial uses, are underway by the Karuk Tribe, the Resighini Rancheria, and the Yurok Tribe. These tribes have not yet completed processes for United States Environmental Protection Agency (USEPA) approved delegation under the Clean Water Act (CWA) (North Coast Regional Water Quality Control Board [NCRWQCB] 2010a). Approved beneficial uses within the area of analysis are presented below (Table 3.2-2).

Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board ~~2006a)~~2011)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)[1]
Aesthetics and Cultural			
Aesthetic Quality	N/A	Wild and Scenic (W&S)	N/~~A[1]~~A[2]
N/A	Native American Culture (CUL)	Ceremonial and Cultural Water Use (CUL)**	N/A
Agricultural Water Supply			
Irrigation	Agricultural Supply (AGR)	Agricultural Supply (AGR)*	N/A
Livestock Watering			

Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board ~~2006a)~~2011)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)[1]
Commercial			
Fishing	Commercial and Sport Fishing (COMM)	N/A	Commercial and Sport Fishing (COMM)
N/A	Shellfish Harvesting (SHELL)	N/A	Shellfish Harvesting (SHELL)
N/A	Aquaculture (AQUA)	N/A	~~N/A~~Mariculture (AQUA)
Fish & Wildlife			
Fish & Aquatic ~~Life~~[2]Life[3]	Warm Freshwater Habitat (WARM)	N/A	N/A
	Cold Freshwater Habitat (COLD)	Cold Freshwater Habitat (COLD)	N/A
	Migration of Aquatic Organisms (MIGR)	Migration of Aquatic Organisms (MIGR)	Fish Migration ~~of Aquatic Organisms~~ (MIGR)
	Spawning, Reproduction, and/or Early Development (SPWN)	Spawning, Reproduction, and/or Early Development (SPWN)	Fish Spawning (SPAWN)
N/A	Estuarine Habitat (EST)	N/A	N/A
N/A	Marine Habitat (MAR)	N/A	Marine Habitat (MAR)
Wildlife & Hunting	Wildlife Habitat (WILD)	Wildlife Habitat and Endangered Species (WILD)	N/A
N/A	N/A	N/A	Preservation and Enhancement of Designated Areas of Special Biological Significance (BIOL)
N/A	Rare, Threatened, or Endangered Species (RARE)	Preservation of Threatened and Endangered Species (T&E)	Rare and Endangered Species (RARE)
Potable Water Supply			
Public Domestic Water Supply	Municipal and Domestic Supply (MUN)	Municipal and Domestic Supply (MUN)*	N/A
Private Domestic Water Supply			
Industrial Water Supply			
Industrial Water Supply	Industrial Service Supply (IND)	Industrial Service Supply (IND)	Industrial Water Supply (IND)

Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board ~~2006a)~~2011)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)[1]
	Industrial Process Supply (PROC)	Industrial Process Supply (PROC)	
Hydro ~~Power[3]~~Power[4]	Hydropower Generation (POW)	N/A	N/A
Navigation			
Commercial Navigation & ~~Transportation[3]~~Transportation[4]	Navigation (NAV)	N/A	Navigation (NAV)
Replacement/Recharge			
N/A	Groundwater Recharge (GWR)	Groundwater Recharge (GWR)	N/A
N/A	Freshwater Replenishment (FRSH)	N/A	N/A
Recreation			
Water Contact Recreation	Water Contact Recreation (REC-1)	Water Contact Recreation (REC-1)	Water Contact Recreation (REC-1), including Aesthetic Enjoyment
Boating	Non-contact Water Recreation (REC-2)	Non-contact Water Recreation (REC-2)	Non-contact Water Recreation (REC-2), including Aesthetic Enjoyment

Notes:

[1] The Ocean Plan is currently before the SWRCB for amendment, including the proposed amendment of beneficial uses.

[2] See also Recreation REC-2 designation including "aesthetic enjoyment."

[3] The "Fish & Aquatic Life" use designated for the Klamath River from Upper Klamath Lake to Keno Dam is: "Cool Water Species (no salmonid use)." The "Fish & Aquatic Life" use designated for the Klamath River from Keno Dam to the Oregon-California State line is "Redband or Lahontan Cutthroat Trout." OAR 340-041-0180, Figure 180A.

[4] Applicable for mainstem Klamath River from Upper Klamath Lake to Keno Dam (RM 255 to 232.5) (ODEQ 340-041-0180)

Key:
OAR: Oregon Administrative Rules
N/A: Not applicable
* = Proposed Beneficial Use
** = Historical Beneficial Use

~~[2] Designated basin specific beneficial uses for the Klamath Basin (OAR 340-041-0180) include specific fish uses to be protected (i.e., bull trout spawning and juvenile rearing, core cold water habitat, redband trout, and cool water species [no salmonid use]) and are depicted in Oregon DEQ 2004.~~

~~[3] Applicable for mainstem Klamath River from Upper Klamath Lake to Keno Dam (RM 255 to 232.5) (Oregon DEQ 340-041-0180)~~

~~Key:~~
~~OAR: Oregon Administrative Rules~~
~~N/A: Not applicable~~

Table 3.2-2. Designated Beneficial Uses of Water in the Area of Analysis

Upper Klamath Lake and Tributaries and Klamath River in Oregon (Oregon Department of Environmental Quality [ODEQ] OAR 340-41-0180)	Klamath River in California (North Coast Regional Water Quality Control Board ~~2006a)~~2011)	Hoopa Valley Tribe Beneficial Uses (Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008)	Ocean Plan Beneficial Uses (State Water Resources Control Board [SWRCB] 2001)[1]

~~* = Proposed Beneficial Use~~
~~** = Historical Beneficial Use~~

~~3~~3.2.2.2.~~2~~ Water Quality Standards

3.2.2.2.1 Freshwater

Water quality standards for fresh surface waters have been established by ODEQ, NCRWQCB, and the Hoopa Valley Tribe to protect the designated beneficial uses listed in Table 3.2-2.

~~Oregon administrative ruling~~Oregon Revised Statutes ORS 468B.025(1) states "...no person shall: (a) Cause pollution of any waters of the ~~state~~State or place or cause to be placed any wastes in a location where such wastes are likely to escape or be carried into the waters of the state by any means; and~~,~~ (b) Discharge any wastes into the waters of the ~~state~~State if the discharge reduces the quality of such waters below the water quality standards established by rule for such waters by the Environmental Quality Commission." ORS 468B.050 and 468B.053 provide for ODEQ to issue permitted exemptions from ORS 468B.025(1).

The California Porter-Cologne Act defines water quality using chemical, physical, biological, bacteriological, radiological, and other properties and characteristics of water that affect its use. It further defines water quality objectives as the limits or levels of water quality constituents or characteristics that are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.

Water quality objectives adopted by the Hoopa Valley Tribe establish water quality objectives for those portions of the Trinity and Klamath rivers under the jurisdiction of the tribe. The Yurok and Karuk Tribes have also adopted water quality objectives, as has the Resighini Rancheria; however, the associated water quality plans have not yet been approved by USEPA (NCRWQCB 2010a, see also discussion regarding tribal beneficial uses in Section 3.2.2.1). Surface-water quality objectives relevant to the Proposed Action and alternatives are listed in Table 3.2-3 through 3.2-7.

Table 3.2-3. Oregon Surface-Water Quality Objectives Relevant to the Proposed Action and Alternatives.

Parameter	Criteria/Description[1]
Biocriteria OAR 340-041-0011	Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
Dissolved Oxygen OAR 340-041-0016	Sufficient concentrations of dissolved oxygen are necessary to support aquatic life.
	Coldwater aquatic life 8.0 mg/L minimum
	Cool water aquatic life 6.5 mg/L minimum
	Warm water aquatic life 5.5 mg/L minimum
	Spawning 11.0 mg/L minimum
	Spawning 8.0 mg/L minimum intergravel
Nuisance Algae Growth OAR 340-041-0019	Algal growth which impairs the recognized beneficial uses of the water body is not allowed. For natural lakes that do not thermally stratify, reservoirs, rivers and estuaries, average chlorophyll-*a* concentrations at or above 0.015 mg/l identify water bodies where phytoplankton may impair the recognized beneficial uses.
pH OAR 340-041-0021 & OAR 340-041-0185	pH values may not fall outside the range of 6.5–9.0. When greater than ~~25~~ 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department will determine whether the values higher than 8.7 are anthropogenic or natural in origin. Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria are not in violation of the standard, if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria.
~~Temperature~~ ~~OAR 340-041-0028 &~~ ~~OAR 340-041-0185~~	~~Water temperature must support all life stages of temperature sensitive aquatic communities.~~ ~~Natural Conditions Criteria. Where the department determines that the natural thermal potential of all or a portion of a water body exceeds the biologically-based criteria, the natural thermal potential temperatures supersede the biologically based criteria, and are deemed to be the applicable temperature criteria for that water body.~~ ~~From June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C (0.5°F) above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream. This criterion supersedes OAR 340-041-0028(9)(a) during the specified time period for NPDES permitted point sources.~~
	~~**Salmon/steelhead spawning**~~ ~~13°C (55.4 F)~~
	~~**Core coldwater habitat**~~ ~~16°C (60.8 F)~~

Table 3.2-3. Oregon Surface-Water Quality Objectives Relevant to the Proposed Action and Alternatives~~.~~

Parameter	Criteria/Description[1]
	~~**Salmon/trout rearing**~~ ~~18°C (64.4 F)~~
	~~**Redband trout habitat**~~ ~~20°C (68 F)~~
	~~**Bull trout spawning and juvenile rearing**~~ ~~12°C (53.6 F)~~
~~Turbidity~~ ~~OAR 340-041-0036~~	~~Numeric criterion generally prohibits turbidity increases which exceed 10-percent above background.~~ ~~Dredging, Construction or other Legitimate Activities: Permit or certification authorized under terms of CWA Section 401 or 404 (Permits and Licenses, Federal Water Pollution Control Act) or OAR 141-085-0100 et seq. (Removal and Fill Permits, Division of State Lands), with limitations and conditions governing the activity set forth in the permit or certificate.~~
~~Toxic material~~ ~~OAR 340-041-0033~~	~~Toxic substances may not be introduced above natural background levels in waters of the state in amounts, concentrations, or combinations that may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare or aquatic life, wildlife, or other designated beneficial uses) Levels of toxic substances may not exceed the criteria listed in Table 20 [from the OAR] and the new Table 40.~~[2]

~~*Source: Oregon DEQ (OAR 340-041).*~~

~~[1] Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.~~

~~[2] On June 16, 2011, Oregon DEQ revised human health criteria for toxic pollutants using a fish consumption rate of 175 grams per day, which is based on tribal consumption rates for tribes that live in Oregon. The new criteria will be applicable for purposes of the Clean Water Act following approval by USEPA. This section also applies to the revised iron, manganese, and arsenic criteria the commission adopted in December 2010 and April 2011, respectively.~~

~~Table 3.2-4. California Surface-Water Quality Objectives~~

Temperature OAR 340-041-0028 & OAR 340-041-0185	Water temperature must protect designated temperature-sensitive, beneficial uses, including specific salmonid life cycle stages in waters of the State. **Redband or Lahonton cutthroat trout habitat** 20°C (68°F) **Coolwater species (no salmonids) – Basin-specific Criterion** From June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C (0.5°F) above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream. This criterion supersedes OAR 340-041-0028(9)(a) during the specified time period for NPDES permitted point sources. Natural Conditions Criteria. Where the department determines that the natural thermal potential of all or a portion of a water body exceeds the biologically-based criteria, the natural thermal potential temperatures supersede the biologically-based criteria, and are deemed to be the applicable temperature criteria for that water body.
Turbidity OAR 340-041-0036	Numeric criterion generally prohibits turbidity increases which exceed 10-percent above background. Dredging, Construction or other Legitimate Activities: Permit or certification authorized under terms of CWA Section 401 or 404 (Permits and Licenses, Federal Water Pollution Control Act) or OAR 14l-085-0100 et seq. (Removal and Fill Permits, Division of State Lands), with limitations and conditions governing the activity set forth in the permit or certificate.
Toxic material OAR 340-041-0033	Toxic substances may not be introduced above natural background levels in waters of the State in amounts, concentrations, or combinations that may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare or aquatic life, wildlife, or other designated beneficial uses) Levels of toxic substances may not exceed the criteria listed in Table 20 [from the OAR] and the new Table 40 [2]

Source: ODEQ (OAR 340-041).

[1] Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.

[2] On June 16, 2011, ODEQ revised human health criteria for toxic pollutants using a fish consumption rate of 175 grams per day, which is based on tribal consumption rates for tribes that live in Oregon. The new criteria were approved by USEPA on October 17, 2011. This section also applies to the revised iron, manganese, and arsenic criteria the commission adopted in December 2010 and April 2011, respectively.

Table 3.2-4. California Surface-Water Quality Objectives

Parameter	Description[1]
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Turbidity	Turbidity shall not be increased more than 20% above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.
Temperature	**COLD, WARM** (for nontidal waters) The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the NCRWQCB that such alteration in temperature does not adversely affect beneficial uses. The temperature of any ~~cold~~COLD or ~~warm~~WARM freshwater habitat shall not be increased by more than 2.8ºC (5ºF) above natural receiving water temperature.
Dissolved Oxygen	**WARM, MAR, Inland Saline Water Habitat (SAL), COLD, SPWN** Klamath River Mainstem Specific Water Quality Objectives based on natural receiving water temperatures (see Table 3.2-5 for minimum DO concentrations in mg/L) • From Oregon-California ~~state~~State line (RM 208.5) to the Scott River (RM 143), 90% saturation October 1-March 31 and 85% saturation April 1-September 30. • From Scott River (RM 143) to Hoopa Valley Tribe boundary (≈RM 45), 90% saturation year round. • From Hoopa Valley Tribe boundary to Turwar (RM 5.8), 85% saturation June 1-August 31 and 90% saturation September 1-May 31. • For upper and middle Klamath River Estuary (RM 0-2), 80% saturation August 1-August 31, 85% saturation September 1-October 31 and June 1-July 31, and 90% saturation November 1-May 31. • **EST** For ~~lower~~Lower Klamath River Estuary (RM 0), DO content shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.
Biostimulatory Substances	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.
Nitrate – N	**MUN** 45 mg/L as NO_3 [2]
Nitrate + Nitrite	**MUN** 10 mg/L as N [3]

Table 3.2-4. California Surface-Water Quality Objectives

Parameter	Description[1]
pH	The pH shall not be depressed below 6.5 units nor raised above 8.5 units
	COLD, WARM Changes in normal ambient pH levels shall not exceed 0.2 units within the range specified above.
	For the Klamath River upstream of Iron Gate Dam, including Iron Gate & Copco reservoirs, and the Klamath River downstream ~~of~~from Iron Gate Dam pH shall not be depressed below 7 units nor raised above 8.5 units.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Pesticides	No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life. Waters designated for use as domestic or municipal supply shall not contain concentrations of pesticides in excess of the limiting concentrations set forth in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 4, Section 64444.5 (Table 5), and listed in Table 3-2 of the Basin Plan.
Chemical Constituents	Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 (Tables 2 and 3), and Section 64444.5 (Table 5), and listed in Table 3-2 of the Basin Plan. Waters designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts which adversely affect such beneficial use.

Source: NCRWQCB ~~2010a~~2011 unless otherwise noted.

[1] Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.

[2] Maximum contaminant level for domestic or municipal supply.

[3] Maximum contaminant level (shall not be exceeded in water supplied to the public) as specified in Table 64431-A (Inorganic Chemicals) of Section 64431, Title 22 of the California Code of Regulations (CCR), as of April 23, 2007.

~~[2] Maximum contaminant level for domestic or municipal supply.~~

~~[3] Maximum contaminant level (shall not be exceeded in water supplied to the public) as specified in Table 64431-A (Inorganic Chemicals) of Section 64431, Title 22 of the California Code of Regulations (CCR), as of April 23, 2007.~~

Table 3.2-5. Minimum DO Concentrations Based on Percent Saturation Criteria[1] (NCRWQCB 2010a)~~.~~

DO Concentrations (mg/L)	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Stateline to Scott River – 90% October 1 through March 31 and 85% April 1 through September 30												
Stateline	10.4	9.6	8.5	7.6	7.0	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Copco Dam	10.4	9.6	8.5	7.6	6.9	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Iron Gate Dam	10.8	9.9	8.8	7.8	7.1	6.5	6.5	6.5	7.1	8.1	9.7	10.9
Upstream Shasta River	10.8	10.0	8.9	7.9	7.1	6.6	6.4	6.4	7.1	7.9	9.6	10.8
Downstream Shasta River	10.8	10.1	9.0	7.9	7.2	6.7	6.5	6.5	7.2	8.0	9.7	10.9
Upstream Scott River	10.9	10.2	9.1	8.1	7.2	6.7	6.4	6.5	7.1	7.9	9.8	10.9
Scott River to Hoopa – 90% all year												
Downstream Scott River	10.8	10.2	9.3	8.7	7.9	7.3	6.9	6.9	7.6	8.0	9.8	10.9
Seiad Valley	10.9	10.2	9.3	8.8	7.8	7.2	6.9	6.9	7.5	7.9	9.9	10.9
Upstream Indian Creek	11.0	10.3	9.4	8.9	8.0	7.3	7.0	7.0	7.5	7.9	9.9	10.8
Downstream Indian Creek	11.0	10.3	9.5	9.0	8.1	7.4	7.0	7.0	7.6	8.0	9.9	10.8
Upstream Salmon River	11.2	10.6	9.8	9.3	8.4	7.5	7.2	7.2	7.7	8.2	10.0	11.0
Downstream Salmon River	11.1	10.6	9.9	9.4	8.5	7.6	7.2	7.2	7.7	8.2	10.0	10.9
Hoopa to Turwar – 90% September 1 through May 31 and 85% June 1 through August 31												
Hoopa	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.1	11.0
Upstream Trinity River	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.0	11.0
Downstream Trinity River	10.9	10.6	9.9	9.5	8.6	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Youngsbar	10.9	10.6	9.9	9.5	8.7	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Turwar	10.9	10.5	9.9	9.5	8.6	7.2	6.9	6.8	7.6	8.1	9.8	10.8
Upper and Middle Estuary – 90% November 1 through May 31, 85% September 1 through October 31 and June 1 through July 31, 80% August 1 through August 31												
Upper Estuary	10.9	10.6	10.1	9.5	8.6	7.3	7.1	6.7	7.6	8.0	10.0	10.7
Middle Estuary	10.9	10.6	10.1	9.6	8.6	7.3	7.2	6.8	7.8	8.2	10.1	10.8
Lower Estuary – Narrative Objective												

[1] ~~-~~The "Alternative 3" analysis conducted by the NCRWQCB (2010a) to arrive at the DO concentrations listed in this table is not the same as the Alternative 3 referred to in the Klamath Facilities Removal EIS/EIR. Estimates of site-specific natural temperatures inherent to the DO percent saturation estimates are derived from the T1BSR run of the Klamath TMDL model (NCRWQB 2010a).

Table 3.2-6. Hoopa Valley Tribe Surface-Water Quality Objectives

Parameter	Criteria/Description[1]
Ammonia (NH3, as mg/L N)	**COLD** Because ammonia toxicity to fish is influenced by pH, waters designated for the purpose of protection of threatened and endangered fish species in cold freshwater habitat shall meet conditions for ammonia based on maximum one-hour (acute) and 30-day average (chronic) concentrations linked to pH by a formula (HVTEPA 2008).
Periphyton	150 mg chlorophyll-*a* /m^2
Dissolved oxygen[2]	**COLD** 8.0 mg/L minimum
	SPWN 11.0 mg/L minimum
	SPWN 8.0 mg/L minimum in inter-gravel water
Total Nitrogen (TN)[3,4]	0.2 mg/L
Total Phosphorous (TP)	0.035 mg/L
pH	The pH in the Klamath River shall be between 7.0 and 8.5 at all times
Microcystis aeruginosa cell density	**MUN, REC-1** <5,000 cells/mL for drinking water <40,000 cells/mL for recreational water
Microcystin toxin Concentration	**MUN, REC-1** <1µg/L total microcystins for drinking water <8 µg/L total microcystins for recreational water
Total potentially toxigenic cyanobacteria species[5]	**MUN, REC-1** <100,000 cells/mL for recreational water
Cyanobacterial scums	**MUN, REC-1** There shall be no presence of cyanobacterial scums
Nitrate	**MUN** 10 mg/L

Source: HVTEPA (2008)

[1] Relevant beneficial uses are shown in bold and all caps. If no beneficial use is specified, the objective or criteria applies to all beneficial uses.

[2] HVTEPA (2008) includes a natural conditions clause stating "If dissolved oxygen standards are not achievable due to natural conditions, then the COLD and SPAWN standard shall instead be dissolved oxygen concentrations equivalent to 90% saturation under natural receiving water temperatures." USEPA has approved the Hoopa Valley Tribe definition of natural conditions; the provision that site-specific criteria can be set equal to natural background and the procedure for defining natural background have not been finalized as of June 2011.

[3] HVTEPA (2008) includes a natural conditions clause stating "If total nitrogen and total phosphorus standards are not achievable due to natural conditions, then the standards shall instead be the natural conditions for total nitrogen and total phosphorus." USEPA has approved the Hoopa definition of natural conditions; the provision that site-specific criteria can be set equal to natural background and the procedure for defining natural background have not been finalized as of June 2011.

[4] 30-day mean of at least two sample per 30-day period.

[5] Includes: *Anabaena, Microcystis, Planktothrix, Nostoc, Coelosphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia*, and *Oscillatoria.*

3.2.2.2.2 Marine

Narrative and numeric water quality objectives to support designated beneficial uses under the Ocean Plan are listed below in Table 3.2-7.

Table 3.2-7. California Marine Water Quality Objectives Relevant to the Proposed Action and Alternatives.

Water Quality Objective[1]	Description
Physical Characteristics	• Floating particulates and grease and oil shall not be visible. • The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface. • Natural light shall not be significantly reduced at any point outside the initial dilution zone as the result of the discharge of waste. • The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded.
Chemical Characteristics	• The dissolved oxygen concentration shall not at any time be depressed more than 10% from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials. • The pH shall not be changed at any time more than 0.2 units from that which occurs naturally. • The dissolved sulfide concentration of waters in and near sediments shall not be significantly increased above that present under natural conditions. • The concentration of substances set forth in Chapter II, Table B (SWRCB 2001), in marine sediments shall not be increased to levels which would degrade indigenous biota. The concentration of organic materials in marine sediments shall not be increased to levels that would degrade marine life. • Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota. • Numerical Water Quality Objectives for discharges are listed in California State Water Resources Control Board (SWRCB) (2001), including objectives for the protection of marine aquatic life (i.e., metals, inorganics, organics, chronic and acute toxicity, pesticides and PCBs, radioactivity) and objectives for the protection of human health (noncarcinogenic and carcinogenic compounds).

Source: SWRCB (2001) unless otherwise noted.

[1] WQOs for bacterial characteristics and elevated temperature (thermal) wastes are not included, as these water quality parameters are not anticipated to be affected by the Project.

3.2.2.3 Water Quality Impairments

Section 303(d) of the CWA requires states States to identify water bodies that do not meet (as of February 2012) water quality objectives and are not supporting their designated beneficial uses. These water bodies are considered to be impaired with respect to water quality. ODEQ and NCRWQCB have both included the Klamath Basin and specifically, the Klamath and Lost Rivers on their CWA Section 303(d) lists of water bodies with water quality impairments (see Table 3.2-8).

Table 3.2-8. Water Quality Impaired Water Bodies within the Area of Analysis[1]

Water Body Name	Water Temperature	Sedimentation	pH	Organic Enrichment/ Low Dissolved Oxygen	Nutrients	Ammonia	Chlorophyll-a	Microcystin
~~Oregon~~[4]Oregon[2]								
Sprague River and tributaries	X[s]		X[s]	X[s]				
Williamson River and tributaries	X							
Upper Klamath Lake and Agency Lake			X	X			X	
Upper Klamath River (Keno Dam to Link River Dam, including Keno Impoundment~~ and~~ /Lake Ewauna)			X[s]	X[sp,s,f,w] (~~2~~)3)		X[sp,s,f,w]	X[s]	
Upper Klamath River Oregon-California ~~state~~State line to Keno Dam (including J.C. Boyle Reservoir)(~~3~~)4)	X[sp,s,f,w] (~~4~~)5)			X[sp,s,f,w] (~~2~~)3)				
California								
~~Middle Klamath River Oregon-California state line to Iron Gate Dam (including Copco Lake Reservoir [1 and 2] and Iron Gate Reservoir)~~Lower Lost River (Tule Lake, Lower Klamath Lake National Wildlife Refuge, and Mt Dome)	~~X~~		X	~~X~~	X			~~X~~
Middle Klamath River Oregon-California State line to Iron Gate Dam ~~to Scott River Reach~~[5](including Copco Lake Reservoir [1 and 2] and Iron Gate Reservoir)	X			X	X			X
Middle Klamath River Iron Gate Dam to Scott River Reach[6]	X			X	X			X
Shasta River	X			X				
Scott River	X	X						
Salmon River	X							
Middle and Lower Klamath River Scott River to Trinity River ~~Reach~~[6]Reach[7]	X			X	X			X
Lower Klamath River-Trinity River to Mouth	X	X		X	X			

Notes:

[1] ~~Oregon lists specific reaches of the Klamath River by river mile and includes specific seasons, in some cases (Kirk et al. 2010).~~[1] While there are additional water quality impaired waterbodies in the area of analysis, the waterbodies listed in this table are the ones that are directly relevant to the water quality analysis for this Klamath Facilities Removal EIS/EIR.

[2] ~~Listed for dissolved oxygen only (non-spawning) (Kirk et al.~~[2] Oregon lists specific reaches of the Klamath River by river mile and includes specific seasons, in some cases (Kirk et al. 2010).

[3] ~~Oregon defines particular river miles for their listings.~~ [3] Listed for dissolved oxygen only (non-spawning) (Kirk et al. 2010).

[4] ~~Non-spawning (Kirk et al. 2010).~~[4] Oregon defines particular river miles for their listings.

[5] ~~Selected minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include Beaver Creek, Cow Creek, Deer Creek, Hungry Creek, and West Fork Beaver Creek (USEPA 2010a~~[5] Non-spawning (Kirk et al. 2010).

[6] ~~Minor~~Selected minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include ~~China~~Beaver Creek, ~~Fort Goff~~Cow Creek, ~~Grider~~Deer Creek, ~~Portuguese Creek, Thompson~~Hungry Creek, and ~~Walker~~West Fork Beaver Creek (USEPA 2010a).

[7] Minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include China Creek, Fort Goff Creek, Grider Creek, Portuguese Creek, Thompson Creek, and Walker Creek (USEPA

2010a).

Key:

Sp =	Listed for spring season
S =	Listed for summer season
F =	Listed for fall season
W =	Listed for winter season

3.2.2.4 Total Maximum Daily Loads

For water quality impaired water bodies (i.e., 303[d]-listed water bodies), Total Maximum Daily Loads (TMDLs) must be developed by the ~~state~~State with jurisdiction over the water body to protect and restore beneficial uses of water. TMDLs (1) estimate the water body's capacity to assimilate pollutants without exceeding water quality standards; and, (2) set limits on the amount of pollutants that can be added to a water body while still protecting identified beneficial uses. ODEQ and the NCRWQCB cooperated on the development of TMDLs for the impaired water bodies of the Klamath Basin (see ~~Table~~ Table 3.2-8). Table 3.2-9 lists the status of TMDLs in the Klamath Basin. Table 3.2-9 is followed by a brief narrative summary of TMDLs for each water body to provide relevant context for TMDL-related discussions in Section 3.2.4.3, Effects Determinations. Additional information regarding the Oregon TMDLs can be found on ODEQ's ~~website (http://www.deq.state.or.us/WQ/TMDLs/klamath.htm)~~ Web site http://www.deq.state.or.us/WQ/TMDLs/klamath.htm and for the California TMDLs ~~on~~ on the North Coast Regional Water Quality Control Board ~~website (http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/index.shtml).~~ Web site: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/

Table 3.2-9. Status of TMDLs in the Klamath Basin as of February 2012

Water Body	Pollutant/Stressor	Agency	Original Listing Date	TMDL Completion Date[1]
Oregon				
Upper Klamath Lake Drainage	Temperature, dissolved oxygen, and pH	ODEQ	1998	2002
Upper Klamath and Lost Rivers (in Oregon)	Temperature, dissolved oxygen, pH, ammonia toxicity, and chlorophyll-*a*	ODEQ	1998	~~2011~~2012
California				
Lower Lost ~~River~~[2] River (Tule Lake, Lower Klamath Lake National Wildlife Refuge, and Mt Dome)[2]	pH and nutrients	USEPA	1992 (Nutrients), 2002 (pH)	2008
Klamath River	Temperature, organic enrichment/low dissolved oxygen[3], nutrient, and ~~microcystin~~ microcystin[4]	NCRWQCB	~~1996, 1998, 2006, and 2008~~1992 (Temperature and nutrients), 1998 (Dissolved oxygen), 2006 and 2010 (Microcystin)	2010

Table 3.2-9. Status of TMDLs in the Klamath Basin as of February 2012

Water Body	Pollutant/Stressor	Agency	Original Listing Date	TMDL Completion Date[1]
Shasta River	Temperature and dissolved oxygen	NCRWQCB	~~1998 and 2008~~1992 (Dissolved oxygen), 1994 (Temperature)	2007

Table 3.2-9. Status of TMDLs in the Klamath Basin as of February 2012

Water Body	Pollutant/Stressor	Agency	Original Listing Date	TMDL Completion Date[1]
Scott River	Temperature and sediment	NCRWQCB	~~1992, 1996, and 1998~~1992 (Sediment), 1996 (Temperature)	2006
Salmon River	Temperature	NCRWQCB	~~1996~~1992	2005
Trinity	Sediment	USEPA	~~1994 and 2006~~1992	2001
South Fork Trinity	Sediment	USEPA	~~1994 and 2002~~1992	1998

Notes:

[1] The TMDL completion date is the year the USEPA approved or is expected to approve the TMDL.

[2] The Upper Lost River upstream of the Oregon border (i.e., in California), Clear Lake Reservoir, and tributaries were previously listed for water temperature and nutrients. In 2004, North Coast Regional Board staff completed an analysis of beneficial uses and water quality conditions in the Upper Lost River watershed (in California) and concluded that the water temperature and nutrient listings were not warranted.

[3] Listing applies only to the mainstem Klamath River.

[4] Listings occurred in 2006 for the mainstem Klamath River from the Oregon-California State line to Iron Gate Dam (including Copco and Iron Gate Reservoirs), and in 2010 for the mainstem Klamath River from Iron Gate Dam to the Trinity River.

~~[2] The Upper Lost River upstream of the Oregon border, Clear Lake Reservoir, and tributaries are listed for water temperature and nutrients. In 2004, North Coast Regional Board staff completed an analysis of beneficial uses and water quality conditions in the Upper Lost River watershed and concluded that the listing is not warranted.~~

Key:

TMDL~~:~~ =
Total Maximum Daily Load
ODEQ~~:~~ =
Oregon Department of Environmental Quality
USEPA~~:~~ =
U.S. Environmental Protection Agency
NCRWQCB~~:~~ =
North Coast Regional Water Quality Control Board

3.2.2.4.1~~–~~ Upper Klamath Lake Drainage TMDLs

The Upper Klamath Lake TMDLs cover temperature, dissolved oxygen, and pH. The geographic extent of the Upper Klamath Lake TMDLs includes the northern portion of the Upper Klamath Basin, which comprises three sub-basins (i.e., Upper Klamath Lake, Williamson River, and Sprague River). TMDL targets were developed for (1) TP loading as the primary method of improving pH and dissolved oxygen conditions in Upper Klamath and Agency Lakes; (2) heat loads for anthropogenic and background nonpoint sources throughout the basin; (3) dissolved oxygen in the Sprague River (USEPA 1987); and, (4) pH in the Sprague River. Specific implementation actions, including designated Best Management Practices (BMPs), are under development by the designated management agencies (DMAs) (ODEQ 2002).

3.2.2.4.2 Upper Klamath River and Lost River (in Oregon) TMDLs

The Upper Klamath River and Lost River TMDLs cover temperature, dissolved oxygen, pH, ammonia toxicity, and ~~cholorophyll-*a*~~chlorophyll-*a*. ODEQ approved the Upper Klamath and Lost River subbasins TMDLs in December 2010 and USEPA is expected to approve these TMDLs in 2011 (S. Kirk, pers. comm., 9 March 2011). The TMDLs cover the southern portion of the Upper Klamath Basin including (1) the Klamath River from Upper Klamath Lake to the Oregon-California ~~state~~State line and (2) impounded and riverine sections of the Lost River from the ~~state~~State line downstream ~~of~~from the Malone Dam to the ~~state~~State line upstream of Tule Lake, and the Klamath Straits Drain from the ~~state~~State line to the confluence with the Klamath River. The TMDLs require reductions in phosphorus, nitrogen, and biochemical oxygen demand (BOD) loading from both point sources and nonpoint sources in the Upper Klamath River, as well as augmentation of dissolved oxygen in the impoundments. There are no permitted point sources of elevated water temperatures for these TMDLs. The heat load allocation for nonpoint sources is equivalent to 0.2°C (0.4 F) above applicable criteria. ~~Once the TMDLs are final, specific~~The Upper Klamath River and Lost River TMDLs were designed to ensure that Oregon's water quality criteria for the Klamath River would be attained at the point where the Lost River discharges into the Klamath River. Specific implementation actions, including designated BMPs, will be developed by the DMAs (Kirk et al. 2010).

3.2.2.4.3 Lower Lost River (in California) TMDLs

The Lower Lost River TMDLs cover pH and nutrients. The geographic extent of the Lower Lost River TMDLs in California includes the Lost River from the Oregon-California ~~state~~State line near Anderson-Rose Dam to the Klamath Straits Drain at the Oregon-California ~~state~~State line, including the Tule Lake and Lower Klamath National Wildlife Refuge areas. Water from the Lower Lost River can be diverted into the Klamath River via the Lost River Diversion Dam and the Klamath Straits Drain (after passing through Tule Lake, the P Canal system, and, in some cases, the Lower Klamath National Wildlife Refuge). The Lower Lost River TMDLs were designed to ensure that California's numeric dissolved oxygen water quality standard would be attained in the Lower Lost River. Implementation measures focus on water quality effects from Reclamation's Klamath Project, the U.S. Fish and Wildlife Service (USFWS) Klamath Refuges, and the Tulelake Wastewater Treatment Plant (USEPA 2008). Note that these TMDLs do not apply to the Upper Lost River; the Upper Lost River upstream of the Oregon border (i.e., in California), Clear Lake Reservoir, and tributaries were previously listed for water temperature and nutrients. In 2004, North Coast Regional Board staff completed an analysis of beneficial uses and water quality conditions in the Upper Lost River watershed and concluded that the water temperature and nutrient listings were not warranted.

3.2.2.4.4 Klamath River TMDLs

The Klamath River TMDLs cover temperature, organic enrichment/low dissolved oxygen, nutrient, and microcystin. The geographic extent of the California Klamath River TMDL analyses includes the river from ~~state~~State line to the Pacific Ocean. The

TMDLs do not specifically address existing sedimentation/siltation impairments in the Klamath River from the Trinity River to the Pacific Ocean; currently, sediment TMDLs for the Trinity and South Fork Trinity Rivers address these impairments. Additionally, the Action Plans do not cover tribal lands. The TMDLs assign three load allocations to the Klamath Hydroelectric Project (KHP) in California (NCRWQCB 2010a):

- Create a compliance lens in Copco and Iron Gate Reservoirs, such that water temperature and dissolved oxygen conditions are suitable for cold water fish during the critical summer period.
- Annual TP and TN loading reduction (TP=22,367 lbs and TN=120,577 lbs) to offset the reduced nutrient assimilative capacity[1] in the reservoirs (as compared to a free-flowing river condition) that is associated with nuisance blooms of green algae and cyanobacteria in the reservoirs. TMDL targets are established for chlorophyll-*a*, *Microcystis aeruginosa* cell density, and microcystin.
- Daily average (and daily maximum) increase in water temperatures relative to inflow temperatures for reservoir tailrace waters (0.1°C [0.18°F] for Iron Gate and 0.5°C [0.9°F] for Copco 1 and 2).

The first two load allocations include a provision for the use of reservoir management measures to achieve the TMDL targets. Numerous implementation actions are described in NCRWQCB (2010b).

Even though pH infrequently meets California North Coast Basin Plan Water Quality Objectives for the Klamath River, it was not listed under the 303(d) list for the River in 2006 (Table 3.2-8), prior to the development of the 2010 TMDLs; instead it was explicitly incorporated into the TMDLs as a nutrient-related water quality impairment including the KHP. The linkage between these impairments is discussed in the TMDL Staff Report (NCRWQCB 2010a). As such, meeting the nutrient objectives will mitigate pH impairments.

3.2.2.4.5 Shasta River TMDLs

The Shasta River TMDLs for temperature and dissolved oxygen cover the Shasta River, a tributary to the mainstem Klamath River, located in the central portion of the Lower Klamath Basin. The TMDL extends from the headwaters to the confluence with the Klamath River, and includes tributaries to the Shasta River and Lake Shastina. Implementation actions build upon ongoing watershed restoration and enhancement work (e.g., increasing riparian vegetation to decrease water temperature and improve bank stability; controlling tailwater discharges to prevent the release of elevated temperature and nutrient enriched waters; promoting efficient water use to increase dedicated cold water flow; addressing proximal land use activities that contribute to low dissolved oxygen and high water temperatures in the watershed, such as timber harvest and road building) (NCRWQCB 2006~~b~~, 2007).

[1] The phrase "assimilative capacity" here refers to the maximum amount of nutrients that can enter the reservoirs and still allow for water quality conditions in the reservoirs to meet water quality objectives (e.g., dissolved oxygen and microcystin).

3.2.2.4.6 Scott River TMDLs

The Scott River TMDL for temperature and sediment covers the Scott River, a tributary to the mainstem Klamath River, located in the central portion of the Lower Klamath Basin. The TMDL extends from the headwaters of the Scott River to its confluence with

the mainstem Klamath River. Implementation of the Scott River TMDL is expected to achieve water quality standards for water temperature and sediment within 40 years of plan approval. Implementation actions include the following (NCRWQCB ~~2007~~2011):

- Controlling road-caused sediment;
- Reviewing dredge mining effects;
- Promoting the preservation of riparian vegetation and regulating its suppression and/or removal;
- Implementing water conservation practices;
- Studying groundwater uses and effects;
- Ensuring flood control and bank stabilization activities
- Minimizing vegetation removal/suppression and sediment delivery;
- Regulating discharges related to timber harvest; and,
- Minimizing the effect of grazing.

3.2.2.4.7~~–~~ __Salmon River TMDL

The Salmon River TMDL for temperature covers the Salmon River, a tributary to the mainstem Klamath River located in the southern portion of the Lower Klamath Basin. The Salmon River TMDL target for water temperature applies throughout the Salmon River watershed and is necessary to achieve the Basin Plan water quality objective for temperature. The Basin Plan criterion requires no alteration of temperature without demonstrations that an increase will not adversely affect beneficial uses nor may the temperature of any cold water be increased by more than 5°F above natural receiving temperature (NCRWQCB 2005). The North Coast Regional Board signed a Memorandum of Understanding with the United States Forest Service (USFS), which manages 98 percent of the lands within the Salmon River watershed, regarding USFS activities within the basin and implementation of the Salmon River TMDL.

3.2.2.4.8~~–~~ __Trinity River TMDL

The Trinity River TMDL for sediment covers the portions of the mainstem Trinity River watershed governed by California water quality standards (i.e., not lands under tribal jurisdiction) in the southern portion of the Lower Klamath Basin, to the confluence of the Trinity and Klamath rivers; the TMDL does not apply to the South Fork Trinity River. The Trinity River TMDL target for sediment is a set loading capacity of 125 percent ~~of~~ of the background sediment delivery rate (USEPA 2001). Examples of ongoing implementation actions include, but are not limited to, completing watershed and road analyses in ~~United States Forest Service (~~USFS~~)~~ and Bureau of Land Management (BLM) lands, watershed restoration, limiting suction dredge operations, comprehensive aquatic monitoring, improving Timber Harvest Plan (THP)s, and continued road/erosion control and fuels management.

3.2.2.4.9~~–~~ __South Fork Trinity River TMDL

The South Fork Trinity River TMDL for sediment covers the South Fork Trinity River from its headwaters in the North Yolla Bolly Mountains in the southern portion of the Lower Klamath Basin, to the confluence with the Trinity River, and includes Hayfork

Creek and other smaller tributaries. The TMDL for sediment is approximately 737 tons per square mile per year. Ongoing implementation actions include encouraging landowner-based sediment reduction plans, specifying requirements for sediment reduction plans, and providing alternative land management guidelines (USEPA 1998). Additional actions include developing a monitoring process for the basin.

3.2.3 Existing Conditions/Affected Environment

3.2.3.1 Overview of Water Quality Processes in the Klamath Basin

Water quality in the Klamath River is affected by the geology and meteorology of the Klamath Basin, as well as current and historical land- and water-use practices. Cold air temperatures and precipitation generally occur from November to March (see Section 3.6, Flood Hydrology), corresponding to periods of higher flows and colder water temperatures. Warmer air temperatures and drier conditions occur from April to October (see Section 3.6, Flood Hydrology), corresponding to periods of lower flows and warmer water temperatures. The relatively low relief, volcanic terrain of the ~~upper~~Upper Klamath Basin (see Section 3.11, Geology, Soils, and Geologic Hazards) supports large, shallow natural lakes (Upper Klamath Lake, Agency Lake, Tule Lake, Lower Klamath Lake) and wetlands, with soils that are naturally high in phosphorus. Human activities in the upper basin, including wetland draining, agriculture, ranching, logging, and water diversions have altered seasonal stream flows and water temperatures, increased concentrations of nutrients (nitrogen and phosphorus) and suspended sediment in watercourses, and degraded other water quality parameters such as pH and dissolved oxygen concentrations. The ~~lower~~Lower Klamath Basin is composed of generally steeper, mountainous terrain (see Section 3.11, Geology, Soils, and Geologic Hazards), where historical hillslope and in-channel gold mining and extensive logging have occurred, along with agricultural ~~and~~ and ranching activities that divert water in many of the lower tributary basins. These activities have altered streamflows, increased concentrations of suspended sediment and nutrients in watercourses, and increased summer water temperatures.

The presence and operation of the Four Facilities in the Klamath Hydroelectric Reach of the ~~upper~~Upper Klamath Basin affect many aspects of water quality in the Klamath River. The most common effects of hydroelectric projects on water quality result from changes in the physical structure of the aquatic ecosystem. Dams slow the transport of water downstream, intercept and retain sediment, organic matter, nutrients, and other constituents that would otherwise be transported downstream, as well as alter seasonal water temperatures when compared to free-flowing stream reaches.

- **River and reservoir water temperatures**. The primary effects of hydroelectric project operations on the natural temperature regime of streams and rivers are related to alterations in water surface area, depth, and velocity due to water diversions into or out of the stream corridor, including reservoir impoundments and conveyance through pipelines or penstocks. These changes influence the amount of heat entering and leaving water bodies (such as from solar radiation

and nighttime re-radiation), which determines the water temperature. Because reservoirs are often deep, they can retain their water temperature for weeks or months, thereby shifting the natural water temperature patterns below reservoirs. For example, water released from reservoirs in the springtime is typically cooler than would naturally occur because the reservoir retains some of the cold water it received in the winter. Similarly, water released from reservoirs in the fall is typically warmer than would naturally occur because the reservoir still contains water that was heated during the summer months. Additionally, due to surface heating of the reservoir in the late spring and summer, a warmer, less dense water layer forms on the reservoir surface (the epilimnion), which overlies colder, denser water (the hypolimnion). This process is called thermal stratification and often persists for months.

- **Reservoir mixing and dissolved oxygen.** The water column in most deep reservoirs has a characteristic thermal and chemical structure that is independent of the size of the reservoir. With thermal stratification (in summer and fall), the isolated deeper water is not exposed to the atmosphere and often completely loses its supply of dissolved oxygen over a period of weeks or months as organic matter in bottom sediments decays. Releases of this deeper, oxygen-depleted water from the bottom of the reservoir can cause serious problems for downstream fish and other aquatic biota. In the fall, thermal stratification typically breaks down as the surface layer cools and wind mixing of the water column occurs. This process is called reservoir turnover.
- **Algae in reservoirs.** Because large reservoirs have long retention times for water and thermally stratify in the summer months, they often provide ideal conditions for the growth of suspended algae (phytoplankton) in the epilimnion. Depending upon available nutrients, extensive phytoplankton blooms can develop in these reservoirs. Algal photosynthesis during the day releases dissolved oxygen and consumes carbon dioxide. At night, algal respiration consumes dissolved oxygen and releases carbon dioxide. This can result in wide swings in dissolved oxygen and pH, which is stressful to aquatic biota. Under nutrient-rich conditions, harmful blooms of blue-green algae can occur, producing cyanotoxins (e.g., cyclic peptide toxins that act on the liver such as microcystin, alkaloid toxins such as anatoxin-a and saxitoxin that act on the nervous system). Cyanotoxins have been found to be harmful to a wide range of biota including exposed fish, shellfish, livestock, and humans. Releases of impounded waters can transport algae and/or toxins to downstream waters and algal blooms can die abruptly ("crash"), releasing cyanotoxins into the water column. The subsequent decomposition of organic matter associated with algal remains can create periods of low dissolved oxygen in reservoir bottom waters.
- **Nutrient cycling in reservoirs and internal loading.** Nutrients entering reservoirs can undergo many changes and be involved in many biochemical processes. On an annual basis, the majority of nutrients entering a reservoir from a watershed are eventually discharged downstream, with only a small fraction being retained in the reservoir bottom sediments. Dissolved nutrients (e.g., ortho-phosphorus, nitrate, and ammonium) entering a reservoir can be used

directly by algae when growing conditions are good. Some of these algae eventually die and settle to the bottom of reservoirs, also contributing nutrients (and organic matter) to the bottom sediments. Under low oxygen conditions, nutrients contained within bottom sediments can be re-released to the water column, creating a source of internal nutrient loading to the reservoir. This is particularly important for phosphorus and results in highly enriched bottom waters during periods of reservoir stratification. At turnover, these nutrient rich waters are mixed throughout the reservoir, can be released downstream, and can result in a secondary (fall) algae bloom.

- **Sediment deposition in reservoirs**. The characteristically slow-moving waters in reservoirs result in trapping of deposition of fine sediments and organic particulate matter. Contaminants found in the bottom sediments of reservoirs are typically transported from the watershed in association with particulate matter. Trace metals are mostly attached to (inorganic) clays and silts. Organic contaminants, such as pesticides and dioxin, are attached (adsorbed) to organic matter.

The following sections summarize general water quality trends by parameter in the Klamath River, from the upper basin to the lower basin. Additional detail, including data from multiple agency and tribal monitoring programs throughout the Klamath Basin, is presented in Appendix C.

3.2.3.2 Water Temperature

Water temperatures in the Klamath Basin vary seasonally and by location. In the Upper Klamath Basin, water temperatures are typically very warm in summer months as ambient air temperatures heat surface waters. Water temperatures (measured as 7-day-average maximum values) in Upper Klamath Lake and much of the reach from Link River Dam to the Oregon-California ~~state~~State line exceed 20°C (68°F) in June through August. Both Upper Klamath Lake and the Keno Impoundment/Lake Ewauna undergo periods of intermittent, weak summertime stratification, but water temperatures in these water bodies are generally similar throughout the water column and among the warmest in the Klamath Basin (peak values >25°C [>77°F]). Upper basin locations influenced ~~by~~ by groundwater springs, such as the Wood River and the mainstem Klamath River downstream ~~of~~ from J.C. Boyle Dam, have relatively constant water temperatures year-round and can be 5–15ºC (9–27ºF) cooler than other local water bodies during summer months, depending on the location.

Water temperatures in the Klamath Hydroelectric Reach are influenced by the presence of the Four Facilities. The relatively shallow depth and short hydraulic residence times in J.C. Boyle Reservoir do not support thermal stratification (Federal Energy Regulatory Commission [FERC] 2007; Raymond 2008, 2009, 2010) and this reservoir does not directly provide a source of cold water to downstream reaches during summer (National Research Council [NRC] ~~2003~~2004). However, current power-peaking operations at the J.C~~.~~. Boyle Powerhouse contribute to the availability of cold water in the river just

downstream ~~of~~from the dam (≈RM 221), where cold groundwater springs enter the river. During daily peaking operations at J.C. Boyle Powerhouse, warm reservoir discharges are

diverted from the ~~bypass reach~~Bypass Reach allowing cold groundwater to dominate flows in the river (PacifiCorp 2006a). Water temperatures in the ~~bypass reach~~ Bypass Reach can decrease by 5–15°C (9~~-~~–27°F) when ~~peaking~~ bypass operations are underway (Kirk et al. 2010).

Iron Gate and Copco 1 Reservoirs are the two deepest reservoirs in the Klamath Hydroelectric Reach. These reservoirs thermally stratify beginning in April/May and the surface and bottom waters do not mix again until October/November (Raymond 2008, 2009, 2010). The large thermal mass of the stored water in the reservoirs delays the natural warming and cooling of riverine water temperatures on a seasonal basis such that spring water temperatures in the Klamath Hydroelectric Reach are generally cooler than would be expected under natural conditions, and summer and fall water temperatures are generally warmer (NCRWQCB 2010a). In the Hydroelectric Reach, maximum weekly maximum temperatures (MWMTs), which generally occur in late July, regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a).

The temporal water temperature pattern of the Hydroelectric Reach is repeated in the Klamath River immediately downstream ~~of~~from Iron Gate Dam, where water released from the reservoirs is 1–2.5°C (1.8–4.5°F) cooler in the spring and 2–10°C (3.6–18°F) warmer in the summer and fall as compared to modeled conditions without the dams (PacifiCorp 2004a, Dunsmoor and Huntington 2006, NCRWQCB 2010a). This trend is discussed in more detail in Section 3.2.4.3.2.1, Lower Klamath Basin. Immediately downstream ~~of~~from Iron Gate Dam (RM 190.1), water temperatures are also less variable than those documented farther downstream in the Klamath River (Karuk Tribe of California 2009, 2010).

Farther downstream, the presence of the Four Facilities exerts less influence and water temperatures are more influenced by solar energy, the natural heating and cooling regime of ambient air temperatures, and tributary inputs of surface water. Meteorological control of water temperatures result in increasing temperature with distance downstream ~~of~~from Iron Gate Dam. For example, daily average temperatures between June and September are approximately 1–4°C (1.8–7.2°F) higher near Seiad Valley (RM 129.4) than those just downstream ~~of~~from the dam (Karuk Tribe of California 2009, 2010; see Appendix C for more detail). By the Salmon River (RM 66), the ~~affects~~effects of the Four Facilities on water temperature are significantly diminished. Downstream from the Salmon River, the influence of the dams on water temperature ~~are~~in the Klamath River is not discernable~~.~~

from the modeled data (PacifiCorp 2005, NCRWQCB 2010a, Dunsmoor and Huntington 2006).

Downstream ~~of~~from the Salmon River (RM 66), summer water temperatures begin to decrease slightly with distance as coastal meteorology (i.e., fog and lower air temperatures) decrease longitudinal warming (Scheiff and Zedonis 2011) and cool water

tributary inputs increase the overall flow volume in the river. In general, however, the slight decrease in water temperatures in this reach is not sufficient to support cold water fish habitat during summer months. Daily maximum summer water temperatures have been measured at values greater than 26°C (78.8°F) just upstream of the confluence with the Trinity River (Weitchpec [RM 43.5]), decreasing to 24.5°C (76.1°F) near Turwar Creek (RM 5.8) (Yurok Tribe Environmental Program [YTEP] 2005, Sinnott 2010). As is the case further upstream, MWMTs in the Klamath River downstream ~~of~~from Iron Gate Dam to the Klamath River estuary regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a).

Water temperatures in the Klamath River estuary are linked to temperatures and flows entering the estuary, salinity of the estuary and resulting density stratification, as well as the timing and duration of the formation of a sand berm across the estuary mouth. When the estuary mouth is open, denser salt water from the ocean sinks below the lighter fresh river water, resulting in a salt wedge that moves up and down the estuary with the daily tides (Horne and Goldman 1994, Wallace 1998, Hiner 2006). The salt water wedge results in thermal stratification of the estuary with cooler, high salinity ocean waters remaining near the estuary bottom, and warmer, low salinity river water near the surface. Under low-flow summertime conditions, when the mouth can close~~d~~, surface water temperatures in the estuary have been observed at 18–24°C (64.4–75.2°F) and greater (Wallace 1998, Hiner 2006, Watercourse Engineering, Inc. 2011). Input of cool ocean water and fog along the coast minimizes extreme water temperatures much of the time (Scheiff and Zedonis 2011).

3.2.3.3 Suspended Sediments

For the purposes of the Klamath Facilities Removal EIS/EIR, suspended sediment refers to ~~settleable~~ suspended material in the water column. Bed materials, such as gravels and ~~larger~~ larger substrates, are discussed in Section 3.3.3.2, Aquatic Resources – Existing Conditions/Affected Environment – Physical Habitat Descriptions. Two types of suspended material are important to water quality in the Klamath Basin and are discussed below: algal-derived (organic) suspended material and mineral (inorganic) suspended material. Sources of each type of suspended material differ, as do spatial and temporal trends for each, within the Upper and Lower Klamath Basins.

Suspended sediments in the tributaries to the Upper Klamath Lake are generally derived from mineral (inorganic) materials, with peak values associated with winter and spring high flows. Of the three main tributaries to the Upper Klamath Lake, the Sprague River has been identified as a primary source of sediment to Upper Klamath Lake. Because phosphorus is naturally high in Klamath Basin sediments, the Sprague River is also an important source of this nutrient to the lake (Gearheart et al. 1995, ODEQ 2002, Connelly and Lyons 2007). Sources of the sediment inputs within the Sprague River drainage include agriculture, livestock grazing and forestry activities, and road-related erosion (ODEQ 2002, Connelly and Lyons 2007, Rabe and Calonje 2009).

Between Link River at Klamath Falls (RM 253.1) and the upstream end of J.C. Boyle Reservoir (RM 224.7), algal-derived (organic) suspended material is the predominant form of suspended material affecting water quality. Summer and fall algal-derived (organic) suspended materials decrease with distance downstream, as algae are exported from Upper Klamath Lake and into ~~Lake Ewauna and~~ the Keno Impoundment/Lake Ewauna, where they largely settle out of the water column (Sullivan et al. 2009). Data from June through November during 2000~~-~~–2005 indicate that the largest relative decrease in mean total suspended solids (TSS) in the upper Klamath River occurs between Link River Dam and Keno Dam (see Appendix C for more detail). Suspended materials generally continue to decrease through the Hydroelectric Reach (PacifiCorp 2004b), where further interception, decomposition, and retention of algal-derived (organic) suspended materials originating from Upper Klamath Lake occurs, as well as dilution from the springs downstream ~~of~~ from J.C. Boyle Dam. However, increases in suspended material can occur in Copco 1 and Iron Gate reservoirs due to *in situ* summertime algal blooms, which can adversely affect beneficial uses.

In the winter months, suspended material in the Hydroelectric Reach is dominated by mineral sediment loads from several tributaries that join the river in this reach (primarily Shovel Creek, Spencer Creek, Jenny Creek, Fall Creek). The suspended materials (silts, clays with diameters < 0.063 mm), which are primarily transported during high flow events, ~~which can also~~ generally settle out in the KHP reservoirs such that water column concentrations generally decrease with distance downstream in the Hydroelectric Reach (see also Appendix C, Section C.2.1). Likewise, the reservoirs trap bedload or fluvial sediment (coarse sand, gravels, and larger materials with diameters > 0.063 mm) from the tributaries. On the scale of the entire Klamath Basin, the trapping of fine sediments and suspended materials does not appear to be a critical function with respect to the overall cumulative sediment delivery including downstream tributaries (see also Section 3.11.3.3 for ~~more detail~~a discussion of basin sediment supply and transport), since a relatively small (3.4 percent) fraction of total sediment supplied to the Klamath River on an annual basis originates from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River). Beneficial uses in the upper Klamath River are currently not impaired due to mineral (inorganic) suspended material (see Table 3.2-8).

Just downstream ~~of~~ from Iron Gate Dam (RM 190.1), summer and fall suspended sediment concentrations become relatively low. Between Iron Gate Dam and Seiad Valley (~~RM~~ RM 129.4), suspended materials can increase due to the transport of in-reservoir algal blooms to downstream reaches of Klamath River, as well as river bed scour and resuspension of previously settled materials (YTEP 2005, Sinnott 2007, Armstrong ~~and~~ and Ward 2008, Watercourse Engineering, Inc. 2011). Further downstream, near the confluence with the Scott River (RM 143.0) concentrations of suspended materials tend to decrease with distance as suspended materials gradually settle out of the water column farther downstream or are diluted by tributary inputs (see Appendix C for more detail).

Mineral (inorganic) suspended sediments begin to have prominence again in the Klamath River downstream ~~of~~ from Iron Gate Dam, as major tributaries to the mainstem contribute large amounts of mineral (inorganic) suspended sediments to the river during winter and spring (Armstrong and Ward 2008). Steeper terrain and land use activities such as timber harvest and road construction result in high sediment loads during high-flow periods. Two of the three tributaries that contribute the largest amount of sediment to the Klamath River are in this reach; the Scott River (RM 143) (607,300 tons per year or 10 percent of the cumulative average annual delivery from the basin), and the Salmon River (RM 66.0) (320,600 tons per year or 5.5 percent of the cumulative average annual delivery from the basin) (Stillwater Sciences 2010). The Trinity River contributes 3,317,300 tons per year of sediment to the Klamath River or 57 percent of the cumulative average annual delivery from the basin (Stillwater Sciences 2010) (see Appendix C for more detail).

3.2.3.4~~.~~ Nutrients

Primary nutrients including nitrogen and phosphorus are affected by the geology of the surrounding watershed of the Klamath River, upland productivity and land uses, as well as a number of physical processes affecting aquatic productivity within reservoir and riverine reaches. Nitrogen arriving in Upper Klamath Lake has been attributed to upland soil erosion, runoff and irrigation return flows from agriculture, as well as *in situ* nitrogen fixation by cyanobacteria (ODEQ 2002). Although the relatively high levels of phosphorus present in the Upper Klamath Basin's volcanic rocks and soils have been identified as a major contributing factor to phosphorus loading to the lake (ODEQ 2002), land use activities in the Upper Klamath Basin have also been linked to increased nutrient loading (Kann and Walker 1999, Snyder and Morace 1997, Bradbury et al. 2004, Colman et al. 2004, Eilers et al. 2004; see Appendix C, Section C.3.1.2 for more detail), subsequent changes in its trophic status, and associated degradation of water quality. Extensive monitoring and research has been conducted for development of the Upper Klamath Lake TMDLs (ODEQ 2002) that shows the lake is a major source of nitrogen and phosphorus loading to the Klamath River (see Appendix C for additional details).

Nutrient and organic matter inputs from the Lost River Basin via Klamath Straits Drain and the Lost River Diversion Channel are also an important source of nutrients to the Upper Klamath River (Sullivan et al. 2009, et al. 2011; Kirk et al. 2010) (see Appendix C, Section C.3.1.3 for additional detail).Allowing for seasonal reservoir dynamics in the Hydroelectric Reach, nutrient levels in the Klamath River generally decrease with distance downstream ~~of~~ from Upper Klamath Lake due to particulate trapping in reservoirs, dilution, and uptake along the river channel. In a recent study of nutrient dynamics in the Klamath River, May through December nutrients for 2005–2008 followed a decreasing longitudinal pattern, with the highest concentrations (approximately 0.1–0.5 mg/L TP and 1–4 mg/L TN) measured in the Klamath River downstream ~~of~~ from Keno Dam (RM 228–233) (Asarian et al. 2010). On an annual basis, nutrients typically decrease through the Hydroelectric Reach due to the dilution by the springs downstream ~~of~~ from J.C. Boyle Reservoir. Nutrient concentrations in the

springs, which represent natural sources, are approximately 0.22 mg/L TN (almost exclusively dissolved) and ~~settling~~approximately 0.06 – 0.08 mg/L TP, which is also mostly dissolved (Asarian et al. 2010). Settling of particulate matter and associated nutrients in Copco 1 and Iron Gate ~~reservoirs~~Reservoirs also contributes to the overall decreasing trend for nutrients in the Hydroelectric Reach on an annual basis. On a seasonal basis, TP, and to a lesser degree, TN can increase in this reach due to the release (export) of dissolved forms of phosphorus (ortho-phosphorus) and nitrogen (ammonium) from reservoir sediments during periods of summer and fall hypolimnetic anoxia (see Appendix C for additional

details). The seasonal nutrient releases can occur during periods of in-reservoir algal growth, ~~or~~and in the case of TP can be transported downstream to the ~~lower~~Lower Klamath River where they may stimulate periphyton growth.

Downstream ~~of~~ from the Four Facilities, TP values typically range 0.1–0.25 mg/L in the Klamath River between Iron Gate Dam and Seiad Valley, with the highest values occurring just downstream ~~of~~ from the dam. TN concentrations in the river downstream ~~of~~ from Iron Gate Dam generally range from <0.1 to over 2.0 mg/L and are generally lower than those in upstream reaches due to reservoir retention and dilution by springs in the Hydroelectric Reach (Asarian et al. 2009) (see Appendix C for additional details). Further decreases in TN occur in the mainstem river due to a combination of tributary dilution and in-river nutrient spiraling processes by periphyton (Mulholland 1996). These processes strongly affect nitrogen concentrations in flowing rivers through removal processes such as denitrification and/or assimilation and storage related to biomass uptake (Asarian et al. 2010~~)~~), or by late-seasonal recycling of nutrients downstream as active periphyton growth wanes. Ratios of nitrogen to phosphorus (TN:TP) measured in the Klamath River downstream ~~of~~ from Iron Gate Dam suggest the potential for nitrogen-limitation of primary productivity with some periods of co~~-~~-limitation by both nitrogen and phosphorus. ~~-~~However, concentrations of both nutrients are high enough that other factors (i.e., light, water velocity, or available substrate) may be more limiting to primary productivity than nutrients are, particularly in the vicinity of Iron Gate Dam (FERC 2007, Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008, Asarian et al. 2010) (see Appendix C for additional details). This is particularly important with regard to factors controlling periphyton growth in this portion of the Klamath River (see ~~Section 3.~~Section 3.4, Algae).

Downstream ~~of~~ from the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River as compared with those measured farther upstream due to tributary dilution and nutrient retention. Contemporary data (2005–2008) indicate that TP concentrations in this reach are generally 0.05–0.1 mg/L with peak values occurring in September and October. For TN, contemporary data indicate that on a seasonal basis~~,~~, this nutrient increases from May through November, with peak concentrations (<0.5 mg/L) typically observed during September and October. ~~Relative to the higher concentrations measured near Iron Gate Dam, these lower nutrient concentrations may be limiting periphyton growth in this portion of the river.~~ Both TP and TN are at or above the Hoopa Valley Tribe numeric criterion of 0.2 mg/L TN and 0.035 mg/L TP (see Table 3.2-6).

Nutrient levels in the Klamath Estuary experience inter-annual and seasonal variability. Measured levels of TP in the estuary are typically below 0.1 mg/L during summer and fall (June–September) and TN levels are consistently below 0.6 mg/L (June–September) (Sinnott 2011~~); however, as with upstream reaches, these levels do not meet~~). While the ~~narrative~~ California Basin Plan water quality objective for biostimulatory substances ~~due to the promotion of~~is narrative rather than numeric, as with upstream reaches,

the measured levels in the Klamath Estuary may promote algal growth at levels that cause nuisance effects or adversely affect beneficial uses (see Table 3.2-4).

3.2.3.5 Dissolved Oxygen

Dissolved oxygen concentrations in the Klamath Basin depend on several factors, including water temperature (colder water absorbs more oxygen), water depth and volume, stream velocity (as related to mixing and re-aeration), atmospheric pressure, salinity, and the activity of organisms that depend upon dissolved oxygen for respiration. This last factor (respiratory consumption) is strongly influenced by the availability of nitrogen and phosphorus for supporting algal and aquatic plant growth.

In tributaries to Upper Klamath Lake, limited data indicate that dissolved oxygen varies from <7−13 mg/L (Kann 1993, ODEQ 2002). Concentrations in the lake itself exhibit high seasonal and spatial variability, ranging from less than 4 mg/L to greater than 10 mg/L. High nutrient loading is the primary cause of eutrophication and subsequent low dissolved oxygen levels in Upper Klamath Lake. Water quality data collected by the Klamath Tribes contains periods of weeks during the summer months when dissolved oxygen levels in the lake are continuously below the ODEQ criterion of 5.5 mg/L for support of warm water aquatic life (Kann et al. 2010). Low (0–4 mg/L) dissolved oxygen concentrations occur most frequently in August, the period of declining algal blooms in the lake and warm water temperatures (ODEQ 2002, Walker 2001) (see Appendix C for additional details).

In the downstream Keno Impoundment (including /Lake Ewauna), dissolved oxygen reaches very low levels (< 1−2 mg/L) during July−October as algae transported from Upper Klamath Lake settle out of the water and decay. Four facilities discharge treated wastewater to the Keno Impoundment/Lake Ewauna; however, these facilities contribute a very small amount (<1.5% of the organic material loading) to the overall oxygen demand in the Keno Reach. Decomposition of algae transported from Upper Klamath Lake appears to be the primary driver of low oxygen in the Keno Impoundment (including /Lake Ewauna) Organic matter and nutrient inputs from the Lost River Basin via Klamath Straits Drain and the Lost River Diversion Channel also contribute to low dissolved oxygen levels in this reach (Sullivan et al. 2009, et al. 2011; Kirk et al. 2010) (see Appendix C, Section C.4.1.3 for additional detail).

During summer, the reservoirs of the Four Facilities exhibit varying degrees of dissolved oxygen super-saturation (i.e., >100% saturation) in surface waters (due to high rates of internal photosynthesis by algae) and hypolimnetic oxygen depletion in bottom waters (due to microbial decomposition of dead algae). Although J.C. Boyle Reservoir, a relatively long, shallow reservoir, does not stratify, large variations in dissolved oxygen are observed at its discharge due to conditions high oxygen demand from water in the upstream reach from Link River Dam through the Keno Impoundment (including /Lake Ewauna), and in Upper Klamath Lake (see Appendix C for more detail). Copco 1 and Iron Gate Reservoirs thermally stratify beginning in April/May and do not mix again

until October/November (FERC 2007). ~~-~~Dissolved oxygen in Iron Gate and Copco 1 surface waters during summer months is generally at or, in some cases above, saturation while levels in hypolimnetic waters reach minimum values near 0 mg/L by July (see Appendix C for more detail).

Based upon measurements collected immediately downstream ~~of~~from Iron Gate Dam, dissolved oxygen concentrations regularly fall below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion is now based on percent saturation, see Table 3.2-5) (Karuk Tribe of California 2001, 2002, 2007, 2009). Continuous Sonde data collected at other Klamath River locations downstream ~~of~~from Iron Gate Dam during summer 2004–2006, show that roughly 45 to 65 percent of measurements immediately downstream ~~of~~from the dam did not achieve 8 mg/L. Daily fluctuations of up to 1–2mg/L measured in the Klamath River downstream ~~of~~from Iron Gate Dam (RM 190.1) have been attributed to daytime algal photosynthesis and nighttime bacterial respiration (Karuk Tribe of California 2002, 2003; YTEP 2005; NCRWQCB 2010a). Farther downstream in the mainstem Klamath River, near Seiad Valley (RM 129.4), dissolved oxygen concentrations increase relative to the reach immediately downstream ~~of~~from Iron Gate Dam, but continue to exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to (supersaturated concentrations of) approximately 10.5 mg/L, from June through November, 2001–2002 and 2006–2009 (Karuk Tribe of California ~~[~~2001, 2002, 2007, 2009~~]~~).

Measured concentrations of dissolved oxygen in the mainstem Klamath River downstream ~~of~~from Seiad Valley (RM 129.4) continue to increase with increasing distance from Iron Gate Dam. Dissolved oxygen concentrations near Orleans (RM 59) continue ~~to~~ to be variable, with typical daily values ranging from approximately 6.5 mg/L to (supersaturated concentrations of) 11.5 mg/L from June through November, 2001–2002 and 2006–2009 (Karuk Tribe of California ~~[~~2001, 2002, 2007, 2009~~]~~~~,~~; Ward and Armstrong 2010~~,~~; NCRWQCB 2010a). Further downstream, near the confluence with the Trinity River (RM 42.5) and at the Turwar gage (RM 5.8), minimum dissolved oxygen concentrations below 8 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) have been observed for extended periods of time during late summer/early fall (YTEP 2005, Sinnott 2010). In 2010, minimum dissolved oxygen concentrations remained above 2010 amended Basin Plan minimum dissolved oxygen concentration criteria based on percent saturation (see Appendix C for additional details).

Dissolved oxygen concentrations in the Klamath Estuary vary both temporally and spatially; concentrations in the deeper, main channel of the estuary are generally greater than 6 to 7 mg/L throughout the year (Hiner 2006, YTEP 2005). Low dissolved oxygen concentrations (<1 to 5 mg/L) have been observed during summer months in the relatively shallow, heavily vegetated south slough (Hiner 2006, Wallace 1998). The low levels of dissolved oxygen observed in the slough are likely due to high rates of growth and subsequent decomposition of algae and macrophytes, which are not abundant elsewhere in the estuary.

3.2.3.6 pH

Levels of pH in the Klamath Basin varyBecause the Klamath River is a weakly buffered system (i.e., has typically low alkalinity <100 mg/L; PacifiCorp [2004a], Karuk Tribe of California [2010]) it is susceptible to photosynthesis-driven daily, seasonally, and by location and seasonal swings in pH. In the Upper Klamath Basin, summertime pH levels are elevated above neutral (i.e., up to 8.2 in the Wood River subbasin and 8.5–9.5 in the Sprague River). These elevated pH levels have been linked primarily to high rates of photosynthesis by periphyton (i.e., benthic or attached algae) (ODEQ 2002). During November–April, pH levels in Upper Klamath Lake are near neutral (Aquatic Scientific Resources [ASR] 2005) but increase to very high levels (>10) in summer (ODEQ maximum pH is 9.0, see Table 3.2-3). Extended periods of pH greater than 9 have been associated with large summer algal blooms in Upper Klamath Lake (Kann 2010). On a daily basis, algal photosynthesis can elevate pH levels by up to 2 pH units over a 24-hour period. Generally, pH in the reach from Link River Dam through the Keno Impoundment/Lake Ewauna increases from spring to early summer and decreases in the fall; however, there are site-dependent variations in the observed trend. Peak values can exceed the ODEQ maximum of 9.0 (see Appendix C for additional details).

In the Hydroelectric Reach, pH is seasonally variable, with levels near neutral during the winter, increasing in the spring and summer. Peak values (8–9.2) have been recorded during the months of May and September with lower values documented June through August (7.5–8) (Raymond 2010), where the ODEQ pH maximum is 9 units (for the Klamath River upstream of the Oregon-California state State line; Table 3.2-3) and the California pH maximum is 8.5 units (for the river downstream of statefrom State line; Table 3.2-4). Longitudinally, the lowest pH values were recorded downstream ofrom J.C. Boyle Reservoir and the highest values in Copco and Iron Gate Reservoirs (Raymond 2008, 2009, 2010). High pH levels typically coincide with high algal photosynthesis rates at or near the water surface during periods of thermal stratification and high nutrient concentrations in the KHP reservoirs (Raymond 2008).

In the Lower Klamath Basin, seasonally high pH values continue to occur, with the highest pH values generally occur during late-summer and early-fall months (August–September). Daily cycles in pH also occur in this reach, with pH usually peaking during later afternoon or early evening, following the period of maximum photosynthesis (NCRWQCB 2010a). The California North Coast Basin Plan pH maximum of 8.5 units (Table 3.2-4) is regularly exceeded in the Klamath River downstream ofrom Iron Gate Dam for the May–October 2005 dataset (see Appendix C for more detail). The most extreme pH exceedances typically occur just upstream of Shasta River; values generally decrease with distance downstream (FERC 2007; Karuk Tribe of California 2007, 2009, 2010). During the summer months, pH values also are elevated in the lowerLower Klamath River from Weitchpec downstream to approximately Turwar Creek (see Appendix C for more detail).

pH was incorporated into the Klamath River TMDLs as a nutrient-related water quality impairment including in the Project reservoirs (see Section 3.2.2.4.4) and as such,

meeting the nutrient objectives of the TMDLs will mitigate pH impairments. In the Klamath Estuary, pH ranges between approximately 7.5 and 9, with peak values also occurring during the summer months (YTEP 2005). Daily variations in pH are typically on the order of 0.5 pH units, and fluctuations tend to be somewhat larger in the late summer and early fall. When large daily fluctuations are observed, they are likely caused by algal blooms that are transported into the estuary.

3.2.3.7~~–~~ Chlorophyll-a and Algal Toxins

As primary producers, algae are critical components of riverine and lacustrine ecosystems. Their presence and abundance affect food web dynamics as well as physical water quality parameters (e.g., dissolved oxygen, pH, turbidity, and nutrients), the latter through rates of photosynthesis, respiration, and decay of dead algal cells (Horne and Goldman 1994). Cyanobacteria are also photosynthetic and can often be a nuisance aquatic species, occurring as large seasonal blooms that alter surrounding water quality. Some cyanobacteria species~~, such as *M. aeruginosa*,~~ produce cyanotoxins (e.g., cyclic peptide toxins such as microcystin that act on the liver~~ such as microcystin~~, alkaloid toxins such as anatoxin-a and saxitoxin that act on the nervous system~~) that~~). Cyanotoxins can cause irritation, sickness, or in extreme cases, death to exposed organisms, including humans (World Health Organization [WHO] 1999). Species capable of producing microcystin include *M. aeruginosa*, while species in the genus *Anabaena* can produce anatoxin-a and saxitoxin. More complete listings of specific toxins produced by genera of cyanobacteria worldwide are provided in Lopez et al. (2008) and ODEQ (2011).

Chlorophyll-*a*, a pigment produced by photosynthetic organisms including algae and cyanobacteria, is often used as a surrogate measure of algal biomass. Algae suspended in the water column (phytoplankton) can be represented as a concentration of chlorophyll-*a* (mg/L), while algae attached to bottom sediments or channel substrate (periphyton) can be represented as an areal biomass (mg chl-a/m^2). Periphyton data are discussed in Section 3.4, Algae.

In the tributaries to Upper Klamath Lake, algae are generally present as periphyton (i.e., benthic or attached algae) species. Periphyton in these streams can cause water quality impairments for dissolved oxygen and pH (see Appendix C for more detail). In Upper Klamath Lake, algae are dominated by phytoplankton or suspended algae. Large summertime blooms of cyanobacteria are typically dominated by *Aphanizomenon flos-aquae*, with relatively smaller amounts of *M. aeruginosa* present. Despite this, *M. aeruginosa* is believed to be responsible for the production of microcystin in the lake, with concentrations in 2007–2008 equal to or greater than the World Heath Organization (WHO) limit for drinking water (1 µg/L) and peaked at 17 µg/L, which is above the Oregon Department of Public Health guidelines for issuing public health advisories. Additional microcystin data collection in Upper Klamath Lake is ongoing, including measurement of toxin levels in studies of possible effects of algal toxins on native suckers (Vanderkooi et al. 2010, see Section 3.3, Aquatic Resources for more detail).

High (i.e., near 300 ug/L) summer chlorophyll-*a* concentrations in the Keno Impoundment (including /Lake Ewauna) are due to large populations of algae, predominantly
A. flos-aquae, entering the Klamath River from Upper Klamath Lake in summer (Kann Kann 2006,; Sullivan et al. 2008, et al. 2009, et al. 2010,; FERC 2007). Such high concentrations do not persist farther downstream in J.C. Boyle Reservoir; however, in the the two largest reservoirs (i.e., Copco 1 and Iron Gate) in the Hydroelectric Reach, chlorophyll-*a* concentrations increase again. Levels Seasonal algal blooms and elevated chlorophyll-*a* concentrations have been observed in the Hydroelectric Reach historically, including a USEPA survey in Iron Gate Reservoir in 1975 documenting algal blooms in March, July, and October, and including diatoms and blue green algae (USEPA 1978). More contemporary data indicates that chlorophyll-*a* levels in Copco 1 and Iron Gate Reservoirs can be 2 to 10 times greater than those documented in the mainstem river, although they are not as high as those found in the Keno Impoundment/Lake Ewauna (NCRWQCB 2010a) (see Appendix C for more detail). High levels of microcystin also occur during summer months in Copco 1 and Iron Gate Reservoirs; peak measured concentrations exceeded the California State Water Resources Control Board (SWRCB)/ Office of Environmental Health and Hazard Assessment (OEHHA) public health threshold of 8 µg/L (SWRCB et al. 2010) by over 1000 times in Copco 1 Reservoir during 2006–2009 and extremely high concentrations (1,000–73,000 µg/L) were measured during summer algal blooms in both Copco 1 and Iron Gate Reservoirs during 2009 (Watercourse Engineering 2011, see Appendix C for more detail).

Throughout the Klamath River, high chlorophyll-*a* concentrations have been shown to correlate with the toxigenic cyanobacteria blooms where *M. aeruginosa* was present in high concentrations and sharp increases in microcystin levels above WHO numeric targets (Kann and Corum 2009) and SWRCB, California Department of Public Health, and OEHHA guidelines (Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms [SWRCB et al. 2010]). Since 2007, high levels of microcystin have prompted the posting of public health advisories around the reservoirs and, during certain years, along the length of the Klamath River during summer months. In 2010, the KHP

reservoirs and the entire river downstream ~~of~~from Iron Gate Dam (including the estuary) were posted to protect public health due to elevated cyanobacteria cell counts and cyanotoxin (i.e., microcystin) concentrations.

Microcystin can also bioaccumulate in aquatic biota (Kann 2008, Kann et al. 2011); 85 percent of fish and mussel tissue samples collected during July through ~~September~~ September 2007 in the Klamath River, including Iron Gate and Copco 1 Reservoirs, exhibited microcystin bioaccumulation (Kann 2008) (see Appendix C for more detail). Estuarine and marine nearshore effects (e.g., sea otter deaths) from cyanobacteria exposure have been reported in other California waters; however, none have been documented to date for the Klamath Estuary or marine nearshore (Miller et al. 2010). Section 3.3.3.2, Physical Habitat Descriptions - Water Quality - Algal Toxins presents a discussion of algal toxins as related to fish health.

3.2.3.8~~–~~ Inorganic and Organic Contaminants

In general, information regarding contaminants in the Upper Klamath Basin upstream of the Hydroelectric Reach is unavailable. Human activities such as illegal dumping may ~~be~~ be a source of inorganic and organic contaminants to the lower Sprague and Williamson river sub-basins (Rabe and Calonje 2009). ~~The~~Arsenic is an exception to this ~~is arsenic~~; natural geologic sources of arsenic may be causing relatively high levels of this chemical element in the Upper Klamath Basin (Smith et al. 2009; GeoEngineers 2011; D. Smith, USGS, Denver, CO, written communication, June 25, 2012), as is the case in other south central and southeastern Oregon basins (Sturdevant 2010). Generally elevated background nickel concentrations have also been found in soils in the Klamath Basin (Smith et al. 2009; GeoEngineers 2011; D. Smith, USGS, Denver, CO, written communication, June 25, 2012; see Appendix C for more detail).

3.2.3.8.1~~–~~ Water Column Contaminants

Existing water quality data are available from the California Surface Water Ambient Monitoring Program (SWAMP). SWAMP data from 2001 through 2005 indicate that at eight monitoring sites from the California-Oregon ~~state~~State line (RM 208.5) to Klamath River at Klamath Glen (RM 5.8) the majority of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), were in compliance with water quality objectives. Aluminum concentrations in some samples may have been slightly elevated above USEPA freshwater aquatic life and secondary standards for drinking water, where a greater sampling frequency would be required to determine actual exceedances. Grab samples were analyzed for 100 pesticides, pesticide constituents, isomers, or metabolites; 50 polychlorinated biphenyls (PCBs) congeners; and 6 phenolic compounds. Results indicated no PCBs and only occasional detections of pesticides (NCRWQCB 2008) (see Appendix C for more detail).

3.2.3.8.2~~–~~ Sediment Contaminants

To investigate the potential for toxicity of the sediments trapped in the reservoirs of the Four Facilities, Shannon & Wilson, Inc. (2006) collected sediment samples from J.C~~.~~ Boyle, Copco 1, and Iron Gate Reservoirs during 2004–2005 and analyzed them ~~for~~

for contaminants including acid volatile sulfides, metals, pesticides, chlorinated acid herbicides, PCBs, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), cyanide, and dioxins. No herbicides or PCBs were found above screening levels and only one sample exceeded applicable screening levels for VOCs ethyl benzenes and total xylenes (Shannon & Wilson, Inc. 2006). While cyanide was detected in multiple sediment cores, it was not found in the bioavailable toxic free cyanide form (HCN or CN^-).

Dioxin, a known carcinogen, was also measured in the Shannon & Wilson, Inc. (2006) study. Long-term exposure to dioxin in humans is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions. In the 2004–2005 reservoir samples, measured levels were 2.48–4.83 pg/g (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations) and did not exceed applicable screening levels for human health and ecological receptors (Shannon & Wilson, Inc. 2006, Dillon 2008, USEPA 2010b) or estimated background dioxin concentrations (2–5 ppt) for non-source-impacted sediments throughout the U.S. and specifically in the western U.S. (USEPA 2010b) (see Appendix C for more detail). The measured levels did exceed Oregon human health and bioaccumulation thresholds; however, Oregon's human health thresholds include risk-based values for subsistence fishers as well as the general consuming public and are quite a bit lower (0.0011–1.1 pg/g dry weight (DW) Toxicity equivalency quotient [TEQ]) than many other screening levels (ODEQ 2007) (see Appendix C for more detail).

As part of the Klamath Dam Removal Secretarial Determination studies, a sediment evaluation was undertaken during 2009–2011 to evaluate potential environmental and human health impacts of the downstream release of sediment deposits currently stored behind the dams under the Proposed Action[2]. Sediment cores were collected during 2009–2010 at multiple sites and at various sediment depths per site in J.C. Boyle Reservoir, Copco 1 Reservoir, Iron Gate Reservoir, and the Klamath Estuary (~~Department of the Interior [DOI]~~Bureau of Reclamation 2010). A total of 501 analytes were quantified in the sediment samples, including metals, poly-cyclic aromatic hydrocarbons (PAHs), PCBs, pesticides/ herbicides, phthalates, VOCs, SVOCs, dioxins, furans, and polybrominated diphenyl ethers (PBDEs) (i.e., flame retardants). Samples were analyzed for sediment chemistry and elutriate (pore water) chemistry, and bioassays were conducted on the sediment and elutriate using fish and invertebrate national benchmark toxicity species (see below for discussion of the bioaccumulation component of this study). Five exposure ~~scenarios~~pathways were evaluated, which generally correspond to potential effects evaluated in this Klamath Facilities Removal EIS/EIR.

[2] ~~Estimates of the volume~~There are currently 13.1 million yd^3 of sediment deposits stored within J.C. Boyle, Copco 1 and 2, and Iron Gate Reservoirs ~~include 10.0 million m^3 (13.1 million yd^3) (Greimann et al. 2010), 11.1 million m^3 (Eilers and Gubala 2003), and 15.6 million m^3 (GEC 2006) (14.5 to 20.4 million yd^3). See~~(Reclamation 2012) (see also Section ~~3.11~~2.2, text box on sediment weight and volume, of this Klamath Facilities Removal EIS/EIR~~.~~). Prior estimates of the sediment deposits were 14.5 million yd^3 (Eilers and Gubala 2003) and 20.4 million yd^3 (GEC 2006).

Based on comparisons of sediment chemistry to (1) screening levels (SLs) ~~and the results of bioassays (see Section C.7.1.1. for more detail), the~~ within the sediment evaluation framework (SEF) and human health criteria and (2) the relatively small number of chemicals of potential concern (COPCs) identified in sediment, reservoir sediments do not appear to be ~~highly~~notably contaminated~~.~~ (for an explanation of the SEF see Section 3.2.4.1). No consistent pattern of elevated chemical composition was observed across discrete sampling locations within a reservoir~~ and no single reservoir was observed to be consistently more or less contaminated. Where~~ ; however, sediment in J.C. Boyle Reservoir does have marginally higher chemical concentrations and more detected COPCs in sediment when compared to the other reservoirs and the estuary. Also, J.C. Boyle Reservoir had more COPCs based on comparison to both freshwater ecological and human health SLs. However, in the case of J.C. Boyle Reservoir and in other instances where elevated concentrations of chemicals in sediment were found, ~~the~~ the degree of exceedance based on comparisons of measured detected chemical concentrations to SLs was small and in several cases (i.e., arsenic, mercury, 2,3,7, 8-TCDD, total PCBs) may reflect regional background conditions (~~CDM 2011;~~ see Section C.7.1.1 for more detail).

Toxicity tests generally indicated low potential for sediment toxicity to benchmark benthic indicator species; the exception to this occurred in a single sample from J.C. Boyle Reservoir, where survival of the benthic amphipod *Hyalella azteca* indicated a moderate potential for sediment toxicity~~ (CDM 2011). TEQs for dioxin, furan, and dioxin-like PCBs in reservoir and estuary sediment samples were within the range of local background values and suggest a limited potential for adverse effects for fish exposed to reservoir sediments (CDM 2011). Lastly, sediment samples were also evaluated for levels of known bioaccumulative compounds; ODEQ~~. Results of the laboratory bioaccumulation ~~sediment screening level values (SLVs) were not exceeded in J.C. Boyle Reservoir sediments, with the exception of a small number of samples for dichlorodiphenyltrichloroethane (DDT)s (see~~tests indicated no consistent pattern of contaminant distribution among chemicals, media type, or location, although some chemicals accumulated in invertebrate tissues (i.e., acenaphthene, arsenic, benzo(a)pyrene, DDD/DDE, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, hexachlorobenzene, lead, mercury, phenanthrene, pyrene, total PBDEs, total PCBs) (CDM 2011). In all cases the differences from one reservoir to another and between reservoirs and laboratory controls were small and not likely to be ecologically significant (see Appendix C, Section C.7.1.1 for more detail).

3.2.3.8.3 Contaminants in Aquatic Biota

A discussion of algal toxins (i.e., microcystin) in fish tissue is presented in Section 3.2.3.7. Assessments of other contaminants in fish tissue for the Hydroelectric Reach have been undertaken by SWAMP and PacifiCorp. SWAMP data include sport fish tissue samples collected during 2007 and 2008 to evaluate accumulated contaminants in nearly 300 lakes statewideStatewide. Sport fish were sampled to provide information on potential human exposure to selected contaminants and to represent the higher aquatic trophic levels (i.e., the top of the aquatic food web).

In the Hydroelectric Reach, fish tissue samples were collected in Copco 1 and Iron Gate Reservoirs and analyzed for total mercury, selenium, and PCBs (Iron Gate Reservoir only) (Davis et al. 2010). SWAMP data for Iron Gate and Copco reservoirs indicate mercury tissue concentrations above the USEPA criterion of 300 ng/g methylmercury (for consumers of noncommercial freshwater fish); and greater than OEHHA public health guideline levels advisory tissue levels (Klasing and Brodberg 2008) for consumption for 3 and 2 servings per week (70 and 150 ng/g wet weight, respectively) and the fish contaminant goal (220 ng/g wet weight). Measured selenium concentrations concentrations were 3–4 orders of magnitude lower than OEHHA thresholds of concern (concern (2,500–15,000 ng/g wet weight) and PCB concentrations were below the lowest OEHHA threshold (i.e., ., fish contaminant goal of 3.6 ng/g wet weight) (Davis et al. 2010).

In a screening-level study of potential chemical contaminants in fish tissue in Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, and in Upper Klamath Lake, PacifiCorp analyzed metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine (pesticide) compounds, and PCBs in largemouth bass (*Micropterus salmoides*) and black bullhead catfish (*Ameiurus melas*) (PacifiCorp 2004c). PacifiCorp reported that, in general, contaminant levels in fish tissue were below screening level values for protection of human health (USEPA 2000) and recommended guidance values for the protection of wildlife (MacDonald 1994). Exceptions to this include some tissue samples for total mercury, arsenic, total DDTs and total PCBs, when compared to screening levels for wildlife and subsistence fishers (individual comparisons are shown in Appendix C for more detail). Dioxins were not tested.

To supplement existing fish tissue data and provide additional lines of evidence in the Secretarial Determination sediment evaluation (see above and Section C.7.1.1), the potential for chemicals in sediment and elutriate samples to bioaccumulate in aquatic species at concentrations above screening levels for ecological receptors (i.e., fish, birds, humans/mammals) was investigated. Bioaccumulation studies were conducted using laboratory invertebrates exposed to reservoir-derived sediments and two species of field-caught fish were collected during late September 2010 from J.C. Boyle, Copco 1, and Iron Gate reservoirs and analyzed for contaminant levels in fish tissue (CDM 2011, see Section C.7.1.1 for more detail). Results indicate that multiple chemicals were found in invertebrate (acenaphthene, arsenic, benzo(a)pyrene, DDD/DDE, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, hexachlorobenzene, lead, mercury,

~~phenanthrene, pyrene, total PBDEs, total PCBs) and~~ fish tissue (i.e., ~~2,3,7,8-TCDD,~~ arsenic, DDE/DDT, dieldrin, endrin, mercury, mirex, selenium, and total PCBs) ~~tissue~~ under current conditions (CDM 2011). Mercury exceeded tissue-based toxicity reference values (TRVs) for perch in Iron Gate Reservoir and bullhead samples in all three reservoirs (CDM 2011). TRVs are not available for several chemicals detected in invertebrate and fish tissue (CDM 2011, see Section C.7.1.1 for more detail). TEQs for dioxin, furan, and dioxin-like PCBs in reservoir and estuary

sediment samples were within the range of local background values and suggest a potential to cause minor or limited adverse effects for fish exposed to reservoir sediments (CDM 2011).

3.2.4 Environmental Consequences

3.2.4.1 Environmental Effects Determination Methods

The Klamath Facilities Removal EIS/EIR water quality analysis includes consideration of the effects of the Proposed Action and alternatives on water temperature, suspended sediments, nutrients (TN, TP, nitrate, ammonium, ortho-phosphorus), dissolved oxygen, pH and alkalinity, chlorophyll-*a* and algal toxins, and inorganic and organic contaminants in water and reservoir sediments. For all water quality parameters, the analysis approach for water quality effects associated with facilities removal under Klamath Hydroelectric Settlement Agreement (KHSA) is conducted at the project-level and is presented by water quality parameter. Elements of Klamath Basin Restoration Agreement (KBRA) restoration projects that would affect water quality are identified and analyzed at a program-level.

For water quality, existing conditions is generally defined as physical, chemical, and biological characteristics of water in the area of analysis at the time of the Notice of Preparation (Water Year [WY] 2010). However, while some water quality parameters to be analyzed here are well-represented by data collected during WY2010, most are represented by data collected within the past 5 to10 years (WY2000–WY2010). Further, the start of the period of analysis period for the hydrology, water temperature, and suspended sediment modeling conducted as part of Secretarial Determination studies corresponds to was WY2012, or just following the expected date for the Secretarial Determination regarding dam removal (Section 1.4.1). Despite several existing regulations or agreements that may be partially implemented between WY2010 and WY2012 and that would affect water quality, in general, conditions in the Klamath River are not expected to be substantially different in WY2012 than conditions during WY2000–WY2010. Therefore, for the water quality analysis, existing conditions generally encompass the 10 to12-year period prior to WY2012 (summarized in Section 3.2.3; additional detail provided in Appendix C).

The KHSA presents nine water-quality-related Interim Measures (IMs) (KHSA Section 1.Section 1.2.4):

- IM 3, Iron Gate Turbine Venting
- IM 5, Iron Gate Flow Variability
- IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement
- IM 8, J.C. Boyle Bypass Barrier Removal
- IM 10, Water Quality Conference
- IM 11, Interim Water Quality Improvements
- IM 13, Flow Releases and Ramp Rates

- IM 15, Water Quality Monitoring
- IM 16, Water Diversions

As discussed in Chapter 2, IM 3 is ~~already complete~~ongoing with pilot study data available from 2008 and 2010 and thus this interim measure is included ~~in~~ as part of existing conditions~~. IMs 5, 7, 8, and 13 are part of the No Action/No Project Alternative because they would be implemented as part of PacifiCorp's Habitat Conservation Plan[3]~~. IM 5, Iron Gate Flow Variability, would alter flow variability, but the flows would stay within the ~~historic~~ range of ~~operations~~historical flows. One year of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement is included in the No Action/No Project Alternative ~~because work is scheduled to begin in Fall~~and was completed during November 2011~~ before the Secretary makes a determination~~. IM 8, J.C. Boyle Bypass Barrier Removal, could have construction-related water quality effects. IM 13, Flow Releases and Ramp Rates stipulates no change in the current flows from J.C~~.~~. Boyle, so no water quality effects are anticipated as part of existing conditions.

~~[3] DOI has incorporated by reference pertinent information in this chapter from: NOAA Fisheries 2011. Draft Environmental Assessment for Authorization for Incidental Take and Implementation of the PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan for Coho Salmon Available at: http://klamathrestoration.gov/. DOI encourages readers to review this source document for more detailed information than is summarized in this EIS/R. Though not final this environmental analysis in NOAA Fisheries 2011 found no significant impact from IM implementation on Water Resources (Climate and Water Flow and Water Quality) or Biological Resources.~~

Remaining IMs are included in Alternatives 2 and 3. Seven years of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could affect water quality. Planning efforts under IM 10, Water Quality Conference, and IM11, Interim Water Quality Improvements, are ongoing; however, pilot scale projects are still in the data collection or planning stage, so an assessment of water quality impacts is not yet practical. IM 16, the elimination of three screened diversions on Shovel and Negro Creeks and relocation of the points of diversion from the creeks to the Klamath River, could have construction-related water quality effects. IM 15 has been used to augment existing water quality monitoring programs in the basin by PacifiCorp, Karuk, Yurok and Reclamation. Additionally, IM 15, Water Quality Monitoring, has produced ~~some~~ monitoring results which, as available, were incorporated into the existing conditions summary (Watercourse Engineering, Inc. 2011) that are incorporated into the existing conditions summary. Cyanobacteria monitoring reports for public health, reported by individual monitoring entities, are produced separately; these and many planning documents and reports of results from this process are posted online at: http://www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring/

Within the period of analysis (i.e., 50 years) reasonably foreseeable actions associated with water quality are anticipated to be the following:

- Ongoing restoration activities in the Klamath Basin (see Section 2.4.2).
- Implementation of TMDLs for Oregon and California (see Section 3.2.2.4)
- National Oceanic and Atmospheric Administration (NOAA) Fisheries Service 2010 Biological Opinion mandatory flows (see Section 2.3.1).
- California Department of Fish and Game (CDFG) Code Section 5937 instream flow mandate for tributaries to the mainstem Klamath River[4]
- Climate change (see Section 3.10.3.1).

Therefore, under the No Action/No Project Alternative, elements of ongoing restoration projects, TMDLs, and programs mandating stream flows that would affect future water quality are identified for a specific reach and/or water quality parameter and included as part of the analysis narrative in a qualitative or, if possible, a quantitative manner. Long-term quantitative analyses for the No Action/No Project Alternative rely on existing models developed by PacifiCorp for the FERC relicensing process, the NCRWQCB for development of the Klamath River TMDLs, and the Secretarial Determination studies (see Appendix D for details). Multiple numeric models are used for the water quality analyses conducted in the Klamath Facilities Removal EIS/EIR because no individual existing numeric model captures all of the long-term water quality conditions anticipated for and encompassed by the No Action/No Project Alternative.

Water quality models are inherently complex, especially ones depicting a large and variable system such as the Klamath River. In the case of the California Klamath River

[4] This action is not included in the project description (Section 2) since it will occur only in tributaries to the middle and ~~lower~~Lower Klamath River. It may increase flows to the mainstem Klamath River, thus it is briefly discussed as part of the No Action/No Project Alternative analysis for water quality.

TMDLs, a significant five-year effort was employed by the NCRWQCB in collaboration with PacifiCorp and working jointly with USEPA Region's 9 and 10, ODEQ, and USEPA's contractor Tetra Tech on the modeling work for the TMDL. That work was subject to extensive peer review and public comment before the NCRWQCB adoption. It was further reviewed and subject to additional public comment before approved unanimously by the SWRCB. It was then subsequently reviewed and approved by the USEPA. The California Klamath River TMDL models are sufficiently reliable for the purpose in which they are used in the Klamath Facilities Removal EIS/EIR.

Under the Proposed Action and remaining alternatives, the analysis of water quality effects considers both the short~~-~~ term (<2 years following dam removal/construction of fish passage facilities~~)~~)[5] and long~~-~~ term (2–50 years following dam removal/construction of fish passage facilities~~)~~[6]~~.~~). While the timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects, some short-term effects are anticipated and, for water quality, would be heavily influenced by the release of fine sediment deposits currently stored behind the dams to the downstream river reaches, the estuary, and the marine nearshore environment. This is because mobilization of reservoir sediment deposits would be most intense during the first year or two following dam removal, when the majority of sediments would be eroded by river flows (~~Greimann et al. 2011~~Reclamation 2012, Stillwater Sciences 2008). Short-term effects would also occur as a result of construction activities related to fish passage structures and restoration activities associated with dam removal and KBRA implementation. Under the Proposed Action and other dam removal alternatives, long-term effects on water quality would be primarily characterized by the shift from lacustrine to riverine environments in the Hydroelectric Reach and the concomitant changes in physical and chemical processes on water quality in this reach and downstream river reaches. Parameter-specific analysis methods are discussed below. As described for the No Action/No Project Alternative, long-term quantitative analyses for the Proposed Action rely on existing models developed by PacifiCorp for the FERC relicensing process, the NCRWQCB for development of the Klamath River TMDLs, and the Secretarial Determination studies (see Appendix D for details). Multiple numeric models are used for the water quality

[5] Note that for the purposes of this analysis the use of "short term" as <2 years is not the same as the use of "short term (acute)" when applied to numeric water quality criteria for determining thresholds of aquatic life toxicity (i.e., 24-hr or 96-hr exposure periods).

~~[6] Note that for the purposes of this analysis the use of "short-term" as <2 years is not the same as the use of "short-term (acute)" when applied to numeric water quality criteria for determining thresholds of aquatic life toxicity (i.e., 24-hr or 96-hr exposure periods).~~

analyses conducted in the Klamath Facilities Removal EIS/EIR because individual existing numeric model captures all of the long-term water quality conditions anticipated for and encompassed by the Proposed Action and the remaining alternatives.

3.2.4.1.1 Water Temperature

Short-term (<2 years following dam removal/construction of fish passage facilities) effects of the alternatives on water temperature are assessed based on the existing conditions understanding of the seasonal effects of the KHP reservoirs on water temperature within the Hydroelectric Reach and downstream of from the dam.

For long-term (2–50 years following dam removal/construction of fish passage facilities) effects of the alternatives, quantitative Klamath River water quality model (KRWQM) results for "current conditions" and dams-out conditions are available (PacifiCorp 2004a, Dunsmoor and Huntington 2006, FERC 2007; see Appendix D for more detail), but they do not include implementation of the Oregon and California TMDLs, which are considered as reasonably foreseeable actions under the No Action/No Project Alternative (see above list). The Klamath TMDL model includes a dams-in scenario (T4BSRN) assuming full attainment of the Oregon and California TMDLs with all Four Facilities in place (Tetra Tech 2009), similar to the conditions for the No Action/No Project Alternative. The Klamath TMDL model T1BSR natural conditions scenario is also useful for analyzing water temperature, since this parameter relies upon a comparison to background or natural levels for regulatory water quality compliance. The Klamath TMDL TOD2RN and TCD2RN scenarios assume the removal of the Four Facilities and full TMDL implementation (Tetra Tech 2009), which is similar to the Proposed Action; to place the Proposed Action analysis in the proper context, results of these modeling scenarios are generally considered interpreted in this EIS/EIR with respect to starting assumptions (i.e., model boundary conditions) about water temperature. These One boundary condition that differs from the Proposed Action is that, in the T1BSR, TOD2RN, and TCD2RN scenarios also represent(but not T4BSRN), Keno Dam as is replaced by the historical natural Keno Reef, such that the Keno Reach is not a free-flowing reachstill partially impounded even though the reef's elevation is two feet lower than the current full pool elevation of Keno Impoundment/Lake Ewauna (Tetra Tech 2009).

, Kirk et al. 2010).

Since the TMDL model scenarios do not include climate change projections or changes in future hydrology included under KBRA, one additional set of water temperature modeling results is used for the Klamath Facilities Removal EIS/EIR analysis; the RBM10 model was developed as part of the Secretarial Determination studies and includes the effects of climate change and KBRA hydrology on future water temperatures (Perry et al. 2011). RBM10 model results use climate change predictions from five Global Circulation Models (GCMs) (see Appendix D for more detail).

Appendix D, Table D-1 shows the reaches where KRWQM, Klamath TMDL, and RBM10 model results are used for the water quality analysis under each alternative.

Since no one existing model captures all of the elements analyzed for water temperature in this Klamath Facilities Removal EIS/EIR, where possible, model outputs are used in combination to assess similar spatial and temporal trends in predicted water temperature.

3.2.4.1.2 Suspended Sediments

The Proposed Action was optimally developed as an alternative~~, to allow~~ that allows reservoir drawdown to occur during winter months when precipitation, river flows, and turbidity are naturally highest. Results from the sediment mobility analysis conducted by ~~the DOI~~Reclamation are used to provide estimates of short-term (<2 years following dam removal) suspended sediment concentrations (SSCs[7]) downstream ~~of~~ from Iron Gate Dam under the Proposed Action and other dam removal alternatives. The sediment mobility analysis used existing suspended sediment data collected by the U. S. Geological Survey (USGS) at the Shasta River near Yreka (USGS gage no. 11517500), Klamath River near Orleans (USGS gage no.11523000), and Klamath River near Klamath (USGS gage no. 11530500) gages to estimate daily total SSCs (mg/L) as a function of flow (cfs) using the SRH-1D sediment transport model (Sedimentation and River Hydraulics–One Dimension Version 2.4) (Huang and Greimann 2010, ~~Greimann et al. 2011).~~ Reclamation 2012). Daily total SSCs were modeled for existing conditions representing WY 1961–2008 ("background") and for short-term conditions following dam removal (WY 2020–2021). SRH-1D model output representing total sediments, including both inorganic (i.e., mineral) and organic (~~i.~~e.~~,~~ g., algal-derived) sediments, is applied herein to the ~~Klamath Facilities Removal EIS/EIR~~ suspended sediment analysis. The SRH-1D model assumes a three-phase drawdown for Copco 1 Reservoir beginning on November 1, 2019, and a single-phase drawdown for J.C. Boyle and Iron Gate Reservoirs beginning on January 1, 2020 consistent with the Proposed Action. This would allow maximum SSCs to occur during winter months when flows are naturally high in the mainstem river (Stillwater Sciences 2008, ~~Greimann et al. 2011~~Reclamation 2012). The analysis of short-term (<2 years following dam removal) effects also considers results from previous studies (e.g., Stillwater Sciences 2010) regarding anticipated sediment release from Klamath River Dam removal within the context of ~~basin~~ sediment delivery~~.~~

at the basin scale.

To inform long-term (2–50 years following dam removal/construction of fish passage facilities) effects determinations on suspended materials under all of the alternatives, existing data sources for TSS and turbidity sources to the Hydroelectric Reach and the ~~lower~~ Lower Klamath River (e.g., PacifiCorp 2004a, 2004b; YTEP 2005) are used. Existing analyses of the potential effects of dam removal on long-term sediment supply (Stillwater Sciences 2010) are also considered.

3.2.4.1.3 Nutrients

Under the Proposed Action, short-term (<2 years following dam removal) nutrient loads associated with high SSCs are assessed in a qualitative manner, considering the likelihood of sediment deposition in the lower river, seasonal rates of primary

[7] For the purposes of this report, SSC is considered equivalent to TSS. As needed, data from multiple sources reported as either TSS or SSC are used interchangeably, despite potential differences in the numeric values reported by each method (Gray et al. 2000).

productivity and microbially mediated nutrient cycling, and potential light limitation ~~of~~ of primary producers given the high sediment concentrations in the river.

To determine general long-term spatial and temporal trends of nutrients in the Hydroelectric Reach and the ~~lower~~Lower Klamath River under all of the alternatives, results of the T4BSRN, TOD2RN and TCD2RN Klamath TMDL scenarios (Tetra Tech 2009) are presented. To place the Proposed Action analysis in ~~the proper~~ context, results of the TOD2RN and TCD2RN scenarios are generally ~~considered~~interpreted with respect to starting assumptions (i.e., model boundary conditions) about nutrient concentrations. Reaches where T4BSRN, TOD2RN and TCD2RN information is available include all reaches associated with the EIS/EIR nutrient analysis from J.C. Boyle Reservoir to the Klamath Estuary (see Appendix D, Table D-1).

Additionally, an existing analysis regarding potential nutrient dynamics under a "dams-out" scenario (i.e., Asarian et al. 2010) is used to inform the assessment of the long-term effects of the Proposed Action on nutrients. Using nutrient measurements and hydrologic data for the Klamath River, Asarian et al. (2010) constructed mass-balance nutrient budgets to evaluate nutrient dynamics in free-flowing reaches of the Klamath River, including longitudinal trends in absolute and relative retention of phosphorus and nitrogen. The analysis also compared nutrient retention rates between free-flowing river reaches and reservoir reaches and developed a range of estimates for ~~how~~the degree to which seasonal TP and TN concentrations downstream ~~of~~ from Iron Gate Dam might be altered by dam removal. The analysis used hydrologic and nutrient data collected by a variety of tribal, ~~federal, and state~~Federal, and State agencies, and PacifiCorp, during June-October of 2005–2008. The mass balance estimates for 2005–2008 improve upon estimates for the period 1998–2002 (Asarian and Kann ~~2006b~~2006a) by using flow- and season-based multiple regression models for predicting daily nutrient concentrations and loads and quantification of uncertainty, relatively lower laboratory reporting limits, higher sampling frequency, and nutrient speciation (i.e., not just TN and TP). The mass balance also uses improved accounting for peaking flows in the J.C. Boyle Bypass Reach and their effect on retention times and mixing dynamics in Copco 1 Reservoir. The effects of dam removal were quantified using calculated relative retention rates in river reaches and comparing them to results from a retention study of Copco 1 and Iron Gate Reservoirs by Asarian et al. (2009).

3.2.4.1.4~~-~~ __Dissolved Oxygen

Both short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2-50 years following dam removal/construction of fish passage facilities) dissolved oxygen effects due to the alternatives are analyzed. For short-term effects under the Proposed Action and dam removal alternatives, results of numerical modeling conducted by the Lead Agencies as part of the Klamath Dam Removal Secretarial Determination studies are used to describe predicted short-term dissolved oxygen levels in the Hydroelectric Reach and downstream ~~of~~from Iron Gate Dam due to ~~mobilization of fine sediments following~~ oxygen demand from mobilized reservoir sediments during dam removal. In the 1-dimensional, steady-state model, the different short-term oxygen

demand ~~terms~~parameters (i.e., BOD, immediate oxygen demand [IOD], and sediment oxygen demand [SOD]) are off-set by tributary dilution and re-aeration using an approach similar in concept to Streeter and Phelps (1925) dissolved oxygen-sag. This BOD/IOD spreadsheet model also includes chemical oxygen demand generated from the conversion of ammonium and other nitrogenous

compounds in reservoir sediments to nitrate under oxic conditions. This is termed nitrogenous oxygen demand and is inherently included in the oxygen demand rate constants used in the BOD/IOD spreadsheet model (Stillwater Sciences 2011).

IOD and BOD are predicted in the spreadsheet model using empirically derived oxygen depletion rates for a particular SSC based on laboratory incubations conducted under the Secretarial Determination oxygen demand study (Stillwater Sciences 2011). Oxygen depletion rates are scaled to the level of suspended sediments expected under each of the three water year types considered for the ~~DOI~~Reclamation hydrology and sediment transport modeling assessment (i.e., typical dry, median, and typical wet water years) (see ~~Section~~ Section 3.2.4.1).

The BOD/IOD spreadsheet model assumes a three-phase drawdown for Copco 1 Reservoir beginning on November 1, 2019, and a single-phase drawdown for J.C. Boyle and Iron Gate Reservoirs beginning on January 1, 2020 consistent with the Proposed Action (~~Greimann et al. 2011~~Reclamation 2012). This would allow maximum SSCs to occur during winter months when flows are naturally high in the mainstem river (Stillwater Sciences 2008, ~~Greimann et al. 2011~~Reclamation 2012). While the KHP reservoirs exhibit varying degrees of thermal stratification and hypolimnetic anoxia during summer months (see Section 3.2.3.1), all of the reservoirs tend to experience fully-mixed conditions by November/December and remain mixed through April/May. Thus, drawdown beginning in December is expected to involve a well-oxygenated water column and inflowing water and, potentially, an oxic surficial sediment layer. This is important because the spreadsheet model is highly sensitive to background concentrations of dissolved oxygen (Stillwater Sciences 2011), which are generally highest in the KHP reservoirs during winter months (see Section 3.2.3.1). The BOD/IOD spreadsheet model results encompass a 6-month period following drawdown in order to estimate potential dissolved oxygen minimums corresponding to the period of greatest sediment transport in the river under the Proposed Action.

For long-term (2–50 years following dam removal/construction of fish passage facilities) effects, existing information on water quality dynamics and physical, chemical, and biological drivers for dissolved oxygen in the river are used to inform the effects determination for all of the alternatives. Dissolved oxygen model results from PacifiCorp relicensing efforts (FERC 2007) and the California Klamath River TMDL (NCRWQCB 2010a; see Section 3.2.2.7.4) are also used for the long-term effects analysis. Where possible, the Klamath TMDL model output is used in combination with KRWQM output to assess similar spatial and temporal trends in predicted dissolved oxygen. To place the Proposed Action analysis in the ~~proper~~ context, the TOD2RN and TCD2RN model predictions (Tetra Tech 2009) are ~~considered~~interpreted with respect to starting assumptions (i.e., model boundary conditions) about dissolved oxygen (and nutrient) concentrations. Reaches where T4BSRN, TOD2RN and TCD2RN information is available include all reaches associated with the EIS/EIR dissolved oxygen analysis from J.C. Boyle Reservoir to the Klamath Estuary (see Appendix D, Table D-1).

3.2.4.1.5 pH

Short-term (<2 years following dam removal/construction of fish passage facilities) effects of the alternatives on pH are assessed based on the existing conditions understanding of the seasonal effects of the KHP reservoirs on pH within the Hydroelectric Reach and downstream ~~of~~from the dam.

For long-term (2–50 years following dam removal/construction of fish passage facilities) effects, existing data on pH in the Hydroelectric Reach and the Lower Klamath Basin are used to inform the effects determination for the Proposed Action. As for water temperature, nutrients, and dissolved oxygen, T4BSRN, TOD2RN and TCD2RN Klamath TMDL scenarios (Tetra Tech 2009) are available for pH. Reaches where T4BSRN, TOD2RN and TCD2RN information is available include all reaches associated with the EIS/EIR pH analysis from J.C. Boyle Reservoir to the Klamath Estuary (see Appendix D, Table D-1).

3.2.4.1.6 *Chlorophyll-a* and Algal Toxins

Effects of the alternatives on the algal community (phytoplankton, aquatic macrophytes, riverine phytoplankton and periphyton) in the Klamath River are discussed in Section 3.4, Algae. Chlorophyll-*a* is analyzed as a separate water quality parameter in the Klamath Facilities Removal EIS/EIR because it is a surrogate measure of algal biomass and it is included as a numeric criterion associated with the Oregon nuisance algae growth water quality objective (see Table 3.2-3) and a target specific to the KHP reservoirs in the California Klamath River TMDLs (NCRWQCB 2010a). The Hoopa Valley Tribe water quality objective for chlorophyll-*a* is a measure of attached (benthic) algal growth (see Table 3.2-6) and is discussed further in Section 3.4, Algae.

Quantitative predictive tools for chlorophyll-*a* are not available for the alternatives. While the California Klamath TMDLs model includes a chlorophyll-*a* component, covering both periphyton and phytoplankton, the model appears to over predict chlorophyll-*a* under the "dams out" scenario (Tetra Tech 2008) and is therefore not used for the Klamath Facilities Removal EIS/EIR analysis. The chlorophyll-*a* target (10 ug/L) developed for the KHP reservoirs in the California Klamath TMDLs is based on a Nutrient Numeric Endpoints (NNE) analysis, which appears to be a conservative estimate of mean summer chlorophyll-*a* concentrations required to move the system toward support of beneficial uses (Creager et al. 2006, Tetra Tech 2008).

The chlorophyll-*a* effects determinations are based on a qualitative assessment of whether the alternatives would result in exceedances of the Oregon 15 ug/L water quality objective or the California 10 ug/L target for the KHP reservoirs and adversely affect beneficial uses with respect to water column concentrations of chlorophyll-*a*. Growth conditions for suspended algae (i.e., nutrient availability, impounded water) are considered as part of the qualitative analysis, where predicted ~~increases~~changes in nutrient availability, water temperatures, and the availability of lacustrine (lake or reservoir) conditions would correspondingly ~~increase~~ affect chlorophyll-*a* concentrations.

Since algal toxins are a water quality concern and have the potential to affect designated beneficial uses of water, an analysis of project effects on algal toxins as related to ~~water~~ water quality standards and beneficial uses is included in the water quality effects determinations. There are no quantitative models predicting algal toxin trends under ~~a~~ a dam removal scenario, thus the effects determinations are based upon trends in the density of *M. aeruginosa* (or other toxin-producing blue-green algae) to algal toxin concentrations (see Section 3.2.3.7) discerned from data collected in the Hydroelectric Reach and the Lower Klamath Basin. This information is considered along with the potential for changes in habitat availability for *M. aeruginosa* (or other toxin-producing blue-green algae) under the alternatives.

3.2.4.1.7 Inorganic and Organic Contaminants

The determination of potential toxicity and bioaccumulation with respect to aquatic species and humans under the alternatives is based on the evaluation of existing data on inorganic and organic contaminants associated with both reservoir water quality and sediment deposits, as well as new sediment contaminant data collected as part of the ongoing Secretarial Determination studies.

The Secretarial Determination sediment evaluation process has followed screening protocols of the Sediment Evaluation Framework (SEF) for the Pacific Northwest, issued in 2009 by the interagency Regional Sediment Evaluation Team (RSET). The SEF is a regional guidance document that provides a framework for the assessment and characterization of freshwater and marine sediments in Idaho, Oregon, and Washington (RSET 2009). The SEF involves a data screening assessment to compare reservoir sediment data to available and appropriate sediment maximum levels, screening levels, and bioaccumulation triggers. It It also provides guidance for conducting elutriate chemistry, toxicity bioassays, and bioaccumulation tests, and special evaluations such as tissue analysis and risk assessments (the latter not utilized for this evaluation). The results of the SEF--based evaluation for the 2009–2010 Klamath River sediment samples are used primarily to inform the water quality effects determinations related to inorganic and organic contaminants under the Proposed Action.

To systematically consider potential impact pathways for each of the alternatives for the Secretarial Determination process, sediment data were compared to established sediment screening values in a step-wise manner. Elutriate (sediment pore water) data were also evaluated through comparison with a suite of regional, stateState and federalFederal standards for water quality; the comparison is first carried outperformed without consideration of dilution as a conservative approach (CDM 2011).

Biological testing was also conducted, using the SEF approach, and consisted of sediment and elutriate toxicity testing and tissue analyses, or other special evaluations designed to provide more empirical evidence regarding the potential for sediment contaminant loads to have adverse effects on receptors (RSET 2009). While whole sediment toxicity tests identify potential contamination that may affect bottom-dwelling (benthic) organisms, toxicity tests using suspension/elutriates of dredged material assess potential water column toxicity. Bioaccumulation evaluation is undertaken when bioaccumulative chemicals of concern exceed or may exceed sediment screening levels, and thus further evaluation is needed to determine whether they pose a potential risk to human health or ecological health in the aquatic environment (RSET 2009).

Results from elutriate and sediment toxicity bioassays and sediment bioaccumulation tests carried out for the Secretarial Determination studies are used to provide additional information beyond simple comparisons of sediment contaminant levels to individual-contaminant regional or national screening levels. The results of sediment and elutriate toxicity bioassays provide a direct assessment of potential toxicity that takes into account

possible interactive effects of mixtures of multiple contaminants, and of potential contaminants that may be present but were not individually measured.

3.2.4.2~~–~~ _Significance Criteria

Significance criteria to be used for the determination of impacts on beneficial uses of water and water quality are listed below. These criteria are excerpted from the list of ten significance criteria generally applicable to hydrology and water quality environmental factors for proposed projects in California (Appendix E in California Resources Agency [2010]). The criteria also encompass elements of Oregon and California water quality standards.

Effects on beneficial uses of water and water quality will be considered significant if the Proposed Action or alternatives would do any of the following:

- Result in regular exceedances of water quality standards or waste discharge requirements.
- Result in substantial adverse effects on beneficial uses of water.

For the purposes of this EIS/EIR, substantial is defined as "of considerable importance ~~to~~ to water quality and the support of beneficial uses". "Substantial adverse effects" are intended to correspond ~~-~~to water quality parameters that are included on the CWA ~~Section~~ Section 303(d) list (see Table 3.2-8) because if a parameter is listed, it has already been determined that beneficial uses are not supported due to regular exceedances of established numeric standards or water quality objectives. Substantial adverse effects ~~can~~ can also apply to water quality parameters that would experience degradation within the EIS/EIR short-term time from of less than ~~two~~2 years.

Additional criteria related to groundwater and hydrology (i.e., drainage, runoff, stormwater, flooding, and inundation) will be addressed in Section 3.6, Flood Hydrology or Section 3.7, Groundwater.

3.2.4.2.1 Thresholds of Significance for Numeric Standards or Water Quality Objectives

Thresholds of significance for established numeric standards and water quality objectives are the numeric values themselves. The numeric values for Oregon, California, Hoopa Valley Tribe, and the Ocean Plan are presented in Tables 3.2-3 through 3.2-7.

Numeric values presented in Tables 3.2-3 through 3.2-7 are used as thresholds of significance for water temperature, dissolved oxygen, and pH. Other numeric values presented in Tables 3.2-3 through 3.2-7, including Oregon and California turbidity standards, California nitrate and nitrite standards for the support of municipal beneficial uses, the Hoopa Valley Tribe criterion for chlorophyll-*a* as periphyton, and the Hoopa Valley Tribe ammonia and nitrate standards for the support of cold freshwater habitat and municipal beneficial uses, are not used as thresholds of significance. The reasons for not using these numeric standards in the water quality effects determinations are discussed below, by parameter.

3.2.4.2.2 Thresholds of Significance for Narrative Standards or Water Quality Objectives

~~3.2.4.2.2.1~~ Suspended Sediments

Oregon has a numeric turbidity standard based upon increases relative to background levels (see Table 3.2-3), and California's water quality objective for turbidity is based upon increases relative to natural conditions (see Table 3.2-4). Turbidity levels under natural conditions are not readily available in the Klamath River data record. While a relationship between turbidity and suspended sediment can be developed on a watershed-specific basis, seasonal coincident suspended sediment and turbidity data for the Klamath Basin are not currently sufficient, either temporally or spatially, to develop a robust relationship between these two parameters for either background levels or natural conditions levels (Stillwater Sciences 2009). For these reasons, the established numeric water quality objectives for turbidity in Oregon and California are not used for the water quality effects determination; instead, the narrative sediment water quality objectives are applied to the analysis.

California's North Coast Basin Plan water quality objectives for suspended material, settleable material, and sediment are narrative and require that waters do not contain concentrations that cause nuisance or adversely affect beneficial uses (see Table 3.2-4). While the Klamath River has multiple designated beneficial uses (see Table 3.2-2), the use most sensitive to water quality is the cold freshwater habitat (COLD) associated with salmonids (NCRWQCB 2010a). In order to adequately protect this use from *short-term* (<2 years following dam removal) effects of the Proposed Action, the water quality effects determination methods focus on the suspended material water quality objective and rely upon the extensive sediment transport modeling effort undertaken for the Secretarial Determination process to quantify predicted SSCs for 1 to 2 years following dam removal (see Section 3.2.4.1). An alternative "dose-response" approach to developing a numeric suspended sediments threshold of significance for potential short-term effects has been adopted, as detailed in Appendix D, Section D.2. Based on this

approach, the water quality effects determination uses a predicted suspended sediment value of 30 mg/L over a 4-week exposure period as a general threshold of significance for analyzing the *short-term* effects of the alternatives.

A more detailed analysis of suspended sediment effects on key fish species, including consideration of specific life history stages, SSCs, and exposure period, is required for a comprehensive assessment of the impacts of the alternatives on the cold water designated beneficial use. This level of analysis is presented in Section 3.3, Aquatic Resources and appendices to this section. Further discussion of particular effects of suspended sediment on shellfish and estuarine and marine organisms is also presented in Section 3.3.4.3, Aquatic Resources.

~~3.2.4.2.2.2~~ Nutrients

Oregon does not stipulate numeric nutrient water quality standards (see Table 3.2-3). California has a narrative water quality objective for biostimulatory substances and does not stipulate numeric nutrient water quality standards for the cold water habitat beneficial use (see Table 3.2-4). California does have numeric nitrate and nitrite standards for the support of municipal beneficial uses (i.e., drinking water). However, these standards are much higher than concentrations that have been measured in the Klamath Basin, such that there is no indication that the municipal beneficial use is not being met or would not be met in the future. Hoopa Valley Tribe also has a nitrate standard for municipal beneficial uses, which is similarly high.

The California Klamath River TMDLs provide the numeric interpretation of the narrative biostimulatory substances objective for the Klamath River through numeric targets for nutrients, organic matter, chlorophyll-*a*, *M. aeruginosa* and microcystin. The numeric TMDL targets for nutrients (TP and TN) and organic matter (as carbonaceous biochemical oxygen demand [CBOD]) vary by month are established for the tailraces ~~of~~ of Copco 2 and Iron Gate Dams. The numeric TP targets range 0.023–0.029 mg/L for May–October and 0.024–0.030 mg/L for November–April. The numeric TN targets range 0.252–0.372 mg/L for May–October and 0.304–0.395 mg/L for November–April (NCRWQCB 2010a). These targets are based on the T4BSRN scenario (Appendix D, Section D-1) and are established as the monthly mean concentrations that allow achievement of the in-reservoir chlorophyll-*a* summer mean target of 10 µg/L, the *M. aeruginosa* cell density target of 20,000 cells/mL, and the microcystin target of 4 µg/L (NCRWQCB 2010a).

For multiple locations in the Klamath River, the TMDL model results indicate large daily variability in TP and TN that exceeds the small range in the monthly TMDL targets, particularly during summer and early fall (i.e., generally June–October) (Tetra Tech 2009). Therefore, the nutrient effects analysis as part of the TMDL considers whether a general downward (or upward) trend in TP and TN toward (or away from) the numeric targets would occur and, qualitatively, whether such a trend would support or alleviate the growth of nuisance and/or noxious phytoplankton or nuisance periphyton.

Chlorophyll-a and Algal Toxins

Within the area of analysis, Oregon possesses a numeric criterion for chlorophyll-*a* that is associated with the nuisance algae growth water quality objective and applies to natural lakes that do not thermally stratify, reservoirs, rivers, and estuaries (see Table 3.2-3). The Klamath River TMDLs establish a chlorophyll-*a* target specific to the KHP of 10 µg/L during the growth season, based on a ~~Nutrient Numeric Endpoint~~NNE analysis (NCRWQCB 2010a). The Hoopa Valley Tribe has a chlorophyll-*a* criterion (150 mg/m^2; see Table 3.2-6) for their periphyton density water quality objective, which is applicable to a short reach
(≈RM 45–46) of the Klamath River upstream of the Trinity River. However, since effects of the Proposed Action on periphyton growth are addressed in Section 3.4, Algae, chlorophyll-*a* as a measure of periphyton density is not discussed further in the water quality effects analysis.

The Oregon criterion (15 ug/L) and the California TMDL target (10 ug/L) are used as chlorophyll-*a* thresholds of significance for J.C. Boyle Reservoir and Copco 1 and Iron Gate reservoirs, respectively. Anticipated regular exceedances of these thresholds would constitute a significant impact for this analysis.

For algal toxins, both Oregon and California have narrative water quality objectives for general toxicity (see Table 3.2-3 and 3.2-4). The Hoopa Valley Tribe has numeric objectives for algal toxins (see Table 3.2-6). The WHO has set numeric thresholds for recreational exposures of microcystin toxin at 4 µg/L for a low probability of adverse health effects, and 20 µg/L for a moderate probability of adverse health effects (Falconer et al. 1999, Chorus and Cavalieri 2000). The WHO thresholds are general levels representing a variety of toxigenic cyanobacteria. Oregon has adopted public health guidelines for recreational exposures similar to the WHO values, and California uses the *Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms* (SWRCB et al. 2010) developed jointly by the California Department of Public Health, SWRCB and OEHHA. To avoid conditions that lead to water quality impairments, the California Klamath River TMDLs use the WHO low probability of adverse health effects thresholds as targets specific to the California reaches of the KHP for *M. aeruginosa* and microcystin toxin (see Table 3.2-10).

Since it is common to Oregon, California, and the Hoopa Valley Tribe (see Table 3.2-10), the < 8 ug/L criterion for microcystin in recreational water is used as the threshold of significance for this Klamath Facilities Removal EIS/EIR. As is the case with chlorophyll-*a*, quantitative predictive tools for algal toxins are not available for the Proposed Action. Therefore, the algal toxin effects determinations are based on a qualitative assessment of whether the Proposed Action would result in exceedances of the criterion and adversely affect the human health recreational beneficial uses (REC-1, REC-2; Table 3.2-2). Growth conditions for toxigenic suspended algae (i.e., nutrient availability, impounded water) are considered as part of the qualitative analysis, where predicted changes in nutrient availability, water temperatures, and the availability of

lacustrine (lake or reservoir) conditions would correspondingly affect algal toxin concentrations.

Table 3.2-10. Summary of Water Quality Guidance, Criteria, or Targets for Toxigenic Blue-Green Algae and Algal Toxins in the Area of Analysis

Source	Description
Oregon[1]	
Public health guidelines for recreational exposure	40,000 cells/mL *M. aeruginosa*, or 8 µg/L microcystin
California[2]	
Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms	>100,000 cells/mL potentially toxigenic blue-green algae, or 40,000 cells/mL *M. aeruginosa*, or 8 µg/L microcystin
California Klamath River TMDL[3]	
Chl-*a* target for California KHP reservoirs (growth season)	< 20,000 cells/L *M. aeruginosa*, or < 4 ug/L microcystin
Hoopa Valley Tribe[4]	
Microcystis aeruginosa cell density	<5,000 cells/mL for drinking water <40,000 cells/mL for recreational water
Microcystin toxin Concentration	<1µg/L total microcystin for drinking water <8 µg/L total microcystin for recreational water
Total potentially toxigenic cyanobacteria species[5]	<100,000 cells/mL for recreational water

[1] ~~Oregon DEQ (OAR 340-041~~ODEQ (2011): At these levels, water is considered impaired.
[2] SWRCB et al. (2010): At these levels, water is considered impaired.
[3] NCRWQCB (2010a): These targets are set to avoid conditions that could lead to water quality impairments.
[4] HVTEPA (2008): At these levels, water is considered impaired.
[5] Includes: *Anabaena*, *Microcystis*, *Planktothrix*, *Nostoc*, *Coelosphaerium*, *Anabaenopsis*, *Aphanizomenon*, *Gloeotrichia*, and *Oscillatoria*.

~~[2] SWRCB (2010): At these levels, water considered impaired.~~
~~[3] NCRWQCB (2010a): These targets are set to avoid conditions that could lead to water quality impairments.~~
~~[4] HVTEPA (2008): At these levels, water considered impaired.~~
~~[5] *Includes:* Anabaena, Microcystis, Planktothrix, Nostoc, Coelosphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia, *and* Oscillatoria.~~

~~Since it is common to Oregon, California, and the Hoopa Valley Tribe (see Table 3.2-10), the < 8 ug/L criterion for microcystin in recreational water is used as the threshold of significance for this Klamath Facilities Removal EIS/EIR. As is the case with chlorophyll-*a*, quantitative predictive tools for algal toxins are not available for the Proposed Action. Therefore, the algal toxin effects determinations are based on a qualitative assessment of whether the Proposed Action would result in exceedances of the criterion and adversely affect the human health recreational beneficial uses (REC-1,~~

~~REC-2; Table 3.2-2). Growth conditions for toxigenic suspended algae (i.e., nutrient availability, impounded water) are considered as part of the qualitative analysis, where predicted increases in nutrient availability, water temperatures, and the availability of lacustrine (lake or reservoir) conditions would correspondingly increase algal toxin concentrations.~~

~~3.2.4.2.2.4~~

Inorganic and Organic Contaminants

Both Oregon and California have water quality objectives related to inorganic and organic contaminants. Oregon's toxicity objective has both a narrative and a numeric component (see Table 3.2-3); the numeric component has chemical-specific water-column criteria for freshwater and marine aquatic life and human health (CDM 2011). Oregon's numeric marine aquatic life criteria are not considered further because the Proposed Action would not affect the marine environment in Oregon. California's chemical constituents objective is numeric (listed in the Basin Plan [NCRWQCB ~~2006a~~2011], as noted in Table 3.2-4 and has chemical-specific water-column criteria for freshwater and marine aquatic life and human health, including bioaccumulative chemicals such as PCBs, methylmercury, dioxins, and furans (CDM 2011). California's toxicity and pesticides objectives are narrative (see Table 3.2-4). Hoopa Valley also has an ammonia toxicity objective based on pH and temperature (see Table 3.2-6). However, since available data collected to date suggests no actual ammonia toxicity events associated with the operation of the Four Facilities (NCRWQCB 2010a), and because the increased velocity of stream flow in the Hydroelectric Reach under dam removal would increase nitrification (i.e., oxidation of ammonia), thus minimizing the potential for ammonia toxicity, this objective is not considered further.

Thresholds of significance for the Oregon and California narrative water quality objectives focus on designated beneficial uses and are applicable for contaminants in either the water column or the sediments. For this Klamath Facilities Removal EIS/EIR, establishment of toxicity and/or bioaccumulative potential for sediment contaminants relies upon thresholds developed through regional and ~~state~~State efforts such as the SEF for the Pacific Northwest (Appendix D, Section D.3). The SEF includes bulk sediment screening levels for standard chemicals of concern and chemicals of special occurrence ~~in~~ in marine and freshwater sediments for Idaho, Oregon, and Washington (RSET 2009). Additionally, Oregon has developed bioaccumulation screening level values that are used for this Klamath Facilities Removal EIS/EIR analysis. Similar numeric chemical guidelines for the assessment and characterization of freshwater and marine sediments do not exist for California. Additional information regarding applicable sediment screening levels used for the Secretarial Determination sediment evaluation process is presented in CDM (2011).

Impacts on water quality would be considered significant if results of sediment and elutriate chemical analyses and biological testing indicate that at least one chemical is detected at a level with potential for significant adverse effects based on multiple lines ~~of~~

of evidence (CDM 2011). This evaluation is not intended to be equivalent to the SEF process.

3.2.4.3 Effects Determinations

3.2.4.3.1 Alternative 1: No Action/No Project Alternative

Under this Alternative, the Klamath Hydroelectric Project would continue current operations under the terms of an annual license until a long-term license is finalized. Some restoration actions have already been initiated and would continue under the No Action alternative. These include the Williamson River Delta Project, the Agency Lake and Barnes Ranch Project, fish habitat restoration work, and ongoing climate change assessments. The TMDLs would still be implemented under this and all other alternatives as they are an unrelated regulatory action. Hydroelectric operations would continue as they have been, providing peaking power generation during the summer as demand requires and conditions allow. The No Action/No Project Alternative would leave the Four Facilities in place. In the Upper Klamath Basin, ~~this~~ operation of the Four Facilities would only affect water quality in the Hydroelectric Reach; however, resource management actions elsewhere in the Upper Klamath Basin (i.e., Upper Klamath Lake and tributaries) are also analyzed under this alternative because they would potentially affect water quality further downstream.

~~**3.2.4.3.1.1**~~

Water Temperature

Upper Klamath Basin

Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal water temperatures that are shifted from the natural thermal regime of the river and do not meet applicable ODEQ and California Basin Plan water quality objectives and adversely affect beneficial uses in the Hydroelectric Reach. Under existing conditions, water temperatures (measured as 7-day-average maximum values) in much of the reach from ~~Upper Klamath Lake~~Keno Dam to the Oregon-California ~~state~~State line exceed 20°C (68°F) in June through August and result in non-attainment of the ~~fish and aquatic life~~ designated beneficial use ~~for spawning and rearing of salmon, steelhead, and~~(Redband or Lahonton cutthroat trout~~, as well as core coldwater~~ habitat~~(~~, see Table 3.2-3). The exception to this occurs in the approximately 4-mile long J.C. Boyle Bypass Reach where cold groundwater springs enter the river at a relatively constant 11-12°C (Kirk et al. 2010) and combine with flow releases from J.C. Boyle Dam (i.e., 100 cubic feet per second minimum flow release; FERC [2007]). Due to the constant groundwater input and temperature moderation due to the upstream thermal mass of J.C. Boyle Reservoir, there is also ~~little daily fluctuation~~reduced diel variation in water temperatures in ~~this reach~~the Bypass Reach. Just downstream, in the J.C. Boyle Peaking Reach, water temperatures ~~fluctuate~~vary on a ~~daily~~diel basis due to powerhouse peaking flows. When peaking flows are not occurring, water in the Peaking Reach is dominated by cooler water from the upstream groundwater springs. When peaking flows from J.C~~.~~. Boyle Reservoir enter the reach, water temperatures can increase by several degrees (PacifiCorp 2006b). Further downstream in the California portions of the Klamath River, summer MWMTs ~~throughout the Hydroelectric Reach~~ regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a) and result in non-attainment of designated COLD and WARM beneficial uses (see Table 3.2-4)

Under the No Action/No Project Alternative, several ongoing resource management actions in the Upper Klamath Basin represent reasonably foreseeable actions related to water temperature within the period of analysis (50 years). Underway since 2007, the Williamson River Delta Project is intended to restore wetlands for endangered fish species and improve water quality in Upper Klamath Lake (see Section 2.3.1). Thus far, the project has involved breaching over two miles of agricultural levees along the Williamson River where it flows into Upper Klamath Lake, restoring approximately 3,500 acres of wetlands in 2007 and an additional 1,400 acres in 2008. One of the project goals is to create wetlands with warmer spring water temperatures for rearing fish in the wetlands (as compared to cooler temperatures in the Williamson River or Upper Klamath Lake). The Agency Lake and Barnes Ranches Project would use historically diked and drained portions of the Barnes Ranches as interim pumped water storage areas, ultimately reconnecting them to Agency Lake (see Section 2.3.1). Breaching the dikes would convert the current 63,770 acre feet pumped storage to passive storage in Upper Klamath Lake. Specific options still need to be developed and studied as part of a separate project-level National Environmental Policy Act (NEPA) evaluation and Endangered

Species Act (ESA) consultation. At a programmatic level, these activities may improve springtime water temperatures for spawning and rearing of fish in Upper Klamath Lake

and tributaries to the lake. Additional resource management actions related to spring, summer, and fall water temperatures that are ongoing in tributaries to Upper Klamath Lake (see Section 2.3.1) include the following:

- Floodplain rehabilitation
- Large woody debris replacement
- Riparian vegetation planting
- Purchase of conservation easements and/or land

Although these resource management actions ~~would~~may improve water temperatures in the Upper Klamath Basin under the No Action/No Project Alternative, the effects would only be local and would not measurably improve water temperatures in the Hydroelectric Reach. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation measures focused on water temperature in the Upper Klamath Lake Drainage TMDL and those in the Upper Klamath River and Lost River Sub-basins TMDLs would improve water temperatures in the Hydroelectric Reach. The Oregon TMDLs include heat load allocations for anthropogenic and background nonpoint sources, where effective shade and channel morphology targets are used as surrogate measures for controlling nonpoint source temperature loading (see Section 3.2.2.4).

To support beneficial uses in California, the North Coast Basin Plan stipulates that water temperature can-not be increased by more than 2.8°C (5°F) above natural receiving temperatures (see Table 3.2-4). The NCRWQCB has determined that natural receiving water temperatures in the Klamath River are already too warm to support designated beneficial uses. Therefore, the Klamath TMDL allocates a daily average (and daily maximum) increase in water temperatures of 0.5°C [0.9°F] for Copco 1 and 2 reservoir tailraces and 0.1°C [0.18°F] for the Iron Gate Reservoir tailrace. This allocation is designed to alleviate the late summer/fall 2–10°C (3.6–18°F) warming caused by the reservoirs immediately downstream ~~of~~ from Iron Gate Dam under existing conditions (see Section 3.2.3.2). Additionally, a compliance lens in Copco 1 and Iron Gate Reservoirs must be maintained, such that water temperature and dissolved oxygen conditions would be suitable for cold water fish in the reservoirs during the critical summer period (see Section 3.2.2.4). To date, no ~~proposed action~~Proposed Action has been identified by PacifiCorp to achieve the temperature allocations assigned to Copco 1 and Iron Gate reservoirs.

The Klamath TMDL model (see Appendix D) indicates that under the No Action/No Project Alternative (similar to the TMDL T4BSRN scenario) water temperatures in the reach from Link River Dam to just upstream of J.C. Boyle Reservoir (including Keno Impoundment~~ and ~~/Lake Ewauna~~)~~ and in the Hydroelectric Reach would be very similar to modeled natural conditions temperatures (TMDL T1BSR scenario) (NCRWQCB 2010a). While the Klamath TMDL model output also indicates that natural conditions

would exceed the ~~16~~20°C (6~~0.~~8°F) numeric water quality objective for the support of ~~core coldwater habitat~~Redband and Lahonton cutthroat trout in Oregon during June–~~October~~August (see Table 3.2-3), the narrative Oregon standard stipulates that the natural conditions criterion would supersede the numeric criterion. Thus, assuming eventual full attainment of the Oregon and California TMDLs, water temperature objectives in the Klamath Hydropower Reach can be met; however, the timeframes for achieving water temperature allocations required under the TMDLs will depend on the measures taken to improve water quality conditions. Full attainment could require decades to achieve.

The TMDL models do not address the potential effects of global climate change on ~~water~~ water temperatures in the Klamath Basin (Appendix D).Within the period of analysis (i.e., 50 years), climate change models for the region suggest that as the western United States warms, air temperatures will increase, there will be a slight increase in overall precipitation, winter snowfall will likely shift to higher elevations, and snowpack will be diminished as more precipitation falls as rain (Oregon Climate Change Research Institute [OCCRI] 2010; see also Section 3.10.3.1). For the Sprague River watershed, increased flooding earlier in the spring and decreased summer baseflow would occur as a consequence of increased and decreased proportions of rainfall and snowfall, respectively, given climate change projections (Risley 2010). ~~In~~Bartholow (2005) predicted that in the Klamath Basin as a whole, increasing air temperatures and decreasing flows in the summer months would be expected to cause general increases ~~in~~ in summer and fall water temperatures on the order of 2–3°C (3.6–5.4°F) (~~Bartholow 2005) (~~see also discussion under Lower Klamath Basin).

As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change were included in model projections for future water temperatures under the No Action/No Project Alternative and the Proposed Action. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures under the No Action/No Project Alternative (where simulated flows are subject to the 2010 Biological Opinion mandatory flow regime [NOAA Fisheries Service 2010]) would be 1–2.3~~-~~°C (1.8–4.1~~-~~°F) warmer than historical temperatures in the Klamath Basin (Perry et al. 2011). While this temperature range is slightly lower than that suggested using the Bartholow (2005) historical estimates, within the general uncertainty of climate change projections, the two modeling efforts correspond reasonably well and indicate that water temperatures in the Upper Klamath Basin are expected to increase ~~with~~within the period of analysis on the order of 1–3°C (1.8–5.4°F).

The anticipated increases in water temperatures due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Upper Klamath Basin. The magnitude of the opposition would be slightly less than, but within the general range of, late summer/fall improvements (2–10°C [3.6–18°F]) expected by the TMDLs immediately downstream ~~of~~from Iron Gate Dam (see discussion under Lower Klamath Basin), such that climate change would partially offset the anticipated TMDL-related improvements.

Existing late summer/fall water temperatures in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanisms and timing unknown) would significantly improve conditions in the Hydroelectric Reach, but climate change would partially offset TMDL-related improvements in the late summer/fall. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal water temperatures and diel temperature variation that are shifted from the natural thermal regime of the river and do not meet applicable California North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the Klamath River downstream ~~of~~ from Iron Gate Dam. Under existing conditions, the Four Facilities ~~alter~~ shift the natural thermal regime of the river by approximately 18 days by cooling springtime water temperatures 1–2.5ºC (1.8–4.5°F) and warming late summer/fall water temperatures 2–10ºC (3.6–18°F) in the ~~lower~~Lower Klamath River, with the largest effects occurring just downstream ~~of~~from Iron Gate Dam (RM 190.1) (PacifiCorp 2004a, Bartholow 2005, Dunsmoor and Huntington 2006, NCRWQCB 2010a, Perry et al. 2011). The warming effect, which can be stressful to rearing salmonids, lasts for the majority of late summer and fall months and is of larger magnitude than the cooling effect in spring (PacifiCorp 2004a). Effects diminish with distance downstream such that they are not discernable ~~by~~ downstream from the Salmon River (RM 66) (see Section 3.2.3.2~~ and Appendix C for more detail~~). Summer MWMTs in the Klamath River downstream ~~of~~ from Iron Gate Dam to the Salmon River regularly exceed the range of chronic effects temperature thresholds (13–20°C [55.4–68°F]) for full salmonid support in California (NCRWQCB 2010a) and result in non-attainment of designated COLD and WARM beneficial uses (see Table 3.2-4). Although not an effect of the reservoirs at the Four Facilities, MWMTs in the mainstem from the Salmon River to the Klamath Estuary also regularly exceed these thresholds and result in non-attainment of these beneficial uses (see Section 3.2.3.2 and Appendix C for more detail).

Reservoir thermal regimes also act to reduce the magnitude of diel temperature variation in the reservoir reaches and the riverine reaches immediately downstream from Iron Gate Reservoir (RM 190.1; see Section 3.2.4.3.2, Figure 3.2-5) (Deas and Orlob 1999, PacifiCorp 2005). As discussed in Section 3.3.4.3 Alternative 1: No Action/No Project, when average temperatures are high, diel variability provides salmonids opportunities for regenerative healing and foraging during the cool hours (NRC 2004). During these periods, decreased diel temperature variation in the Klamath River downstream from Iron Gate Dam is deleterious for salmonids. As with the seasonal temperature effect, the dampening influence of the reservoirs on diel temperature variation is considerably diminished farther downstream, at the confluence with the Scott River (RM 143.9; see Section 3.2.4.3.2, Figure 3.2-6). The KRWQM indicates that the temperature influence of the Hydroelectric Reach is mostly ameliorated by RM 66 at the confluence with the Salmon River (see Section 3.2.4.3.2, Figure 3.2-7).

Within the period of analysis (i.e., 50 years), implementation of NOAA Fisheries Service 2010 Biological Opinion mandatory flows and CDFG Code Section 5937 instream flow mandate for tributaries to the mainstem Klamath River (see Section 2.3.1 and Section 3.2.4.1, No Action/No Project Alternative) would increase seasonal stream flow and ~~would be expected to moderately decrease~~may result in minor increases in water temperatures in the Klamath River downstream ~~of~~from Iron Gate Dam~~, particularly~~ during summer and fall months[8]. The California Klamath River TMDLs were developed based on compliance with water quality objectives at the Oregon-California ~~state~~State line, meaning that successful implementation of water quality improvement measures under the Oregon TMDLs will improve water temperatures in the Lower Klamath Basin as well. General implementation measures under the California Klamath TMDLs associated with water temperature improvements are described in the prior section for the Upper Klamath Basin and in Section 3.2.2.4. Additionally, the Shasta, Scott, and Salmon Rivers, tributaries to the ~~lower~~Lower Klamath River within California, have TMDLs addressing temperature (see Section 3.2.2.4).

The Klamath TMDL model indicates that as implementation of the TMDL progresses under the No Action/No Project Alternative (similar to TMDL T4BSRN scenario), water temperatures from Iron Gate Dam (RM 190.1) to the Klamath Estuary (RM 0-2) would improve towards modeled natural conditions (similar to the TMDL T1BSR scenario) (NCRWQCB 2010a). Some delayed warming of springtime water temperatures (February-March) and delayed cooling of late summer/fall (August-November) water temperatures would still occur under the No Action/No Project Alternative due to the large thermal mass of Copco 1 and Iron Gate reservoirs. This temporal shift may continue to occur under the No Action/No Project Alternative from downstream ~~of~~from Iron Gate Dam to approximately ~~Seiad Valley~~the Salmon River (RM ~~129.4~~66) because while full attainment of the California Klamath TMDLs would improve water temperature, the model is unable to demonstrate full temperature compliance in the spring and fall downstream ~~of~~from Iron Gate Dam to ~~Seiad Valley~~the Salmon River with the Four Facilities in place. ~~Based on TMDL model results, water temperature from Seiad Valley (RM 129.4) to the Salmon River (RM 66.0) (the approximate location at which the reservoir temperature signal no longer persists under existing conditions), would meet water quality objectives.~~ The model-predicted lack of compliance from Iron Gate Dam to ~~Seaid Valley~~ the Salmon River underlies the TMDL requirement for PacifiCorp to ~~develop a Reservoir Management Plan that specifically addresses~~address water temperature and dissolved oxygen improvements ~~that would allow the Four Facilities to meet water quality objectives~~ (NCRWQCB 2010a). The timeframes for achieving water temperature allocations required under these TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full attainment of the TMDLs would require decades to achieve.

[8] The effects of increased tributary flows on Lower Klamath River temperatures were evaluated as part of the analyses conducted for the California Klamath River TMDL development. The evaluation indicated little temperature effect on the Klamath River, and only when the tributaries were assumed to have full natural flows (see Section 4.2.4 of NCRWQCB 2010a).

The Klamath TMDL model also predicts that, with full implementation, reduced diel variation in water temperature would continue to occur under the No Action/No Project Alternative immediately downstream from Iron Gate Dam due to the thermal mass of the upstream reservoirs, with the magnitude of diel variation increasing with distance downstream from Iron Gate Dam as the river approaches equilibrium with ambient air temperatures (NCRWQCB 2010a, Dunsmoor and Huntington 2006). As discussed in Section 3.3.4.3 Alternative 1: No Action/No Project – Key Ecological Attributes – Water Temperature, the decrease in diel temperature variation compared with historical conditions in the Klamath River downstream from Iron Gate Dam is deleterious for salmonids. General climate change effects are discussed in Section 3.10.3.1. With respect to water temperatures in the Lower Klamath Basin, the historical data record indicates that mainstem water temperatures have increased approximately 0.05ºC (0.09ºF) per year between 1962 and 2001 (Bartholow 2005) such that climate change may already be affecting Klamath River water temperatures. Projecting the Bartholow (2005) estimate of an average annual temperature increase 50 years into the future, water temperatures would increase 2–3°C (3.6–5.4°F) by the end of the analysis period. As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change were included in model projections for future water temperatures under the No Action/No Project Alternative and the Proposed Action. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures under the No Action/No Project Alternative (where simulated flows are subject to the 2010 Biological Opinion mandatory flow regime [NOAA Fisheries Service 2010]) would be 1–2.3 °°C (1.8–4.1 °F°F) warmer than historical temperatures at the end of the analysis period (Perry et al. 2011). While this temperature range is slightly lower than that suggested using the Bartholow (2005) historical estimates, within the general uncertainty of climate change projections, the two projections correspond reasonably well and indicate that. Considering together the available sources for climate change predictions, annual average water temperatures in the Lower Klamath Basin are expected to increase withwithin the period of analysis on the order of 1–3 °C (1.8–5.4 °F).

The anticipated increases in water temperatures due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin. Within the range of late summer/fall improvements expected by the TMDLs (2–10 °C [3.6–18 °F] immediately downstream offfrom Iron Gate Dam and 2–5 °C [3.6–9 °F] just upstream of the Scott River), climate change would partially offset the anticipated TMDL-related improvements. Climate change would also completely offset the existing 1–2 °C springtime cooling effect of the reservoirs; the cooling effect in spring is potentially beneficial to rearing salmonids by reducing stress and disease for late outmigrants.see Section 3.3.4.3. Water Temperature for a discussion of the effect of the spring cooling on fish in the Lower Klamath River.

Existing late summer/fall water temperatures and reduced diel temperature variation in the Klamath River from immediately downstream offfrom Iron Gate

Dam to the Salmon River (RM 66) are adverse[9]~~.~~.[10] Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve conditions but water temperatures from Iron Gate Dam to approximately Seiad Valley (RM 129.4) would remain adverse. Climate change would partially offset TMDL-related improvements in the late summer/fall. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

~~**3.2.4.3.1.2**~~

[9] ~~Water temperatures from the Salmon River to the Klamath Estuary are also adverse but this condition is not a result of the impoundment of water in the reservoirs at the Four Facilities.~~

[10] Water temperatures from the Salmon River to the Klamath Estuary are also adverse but this condition is not a result of the impoundment of water in the reservoirs at the Four Facilities.

Suspended Sediments

Upper Klamath Basin

Continued impoundment of water at the Four Facilities could result in short-term and long-term interception and retention of mineral (inorganic) suspended material by the KHP dams. Under existing conditions, peak concentrations of ~~this~~mineral (inorganic) suspended material occur during winter and spring (November through April) due to runoff and tributary flows to the Hydroelectric Reach associated with high-flow events. The KHP dams mostly intercept and trap suspended materials (silts, clays with diameters < 0.063 mm) such that water column concentrations generally decrease with distance downstream in the Hydroelectric Reach (see Section 3.2.3.3~~).~~ and Appendix C, Section C.2.1). Likewise, the reservoirs trap bedload or fluvial sediment (coarse sand, gravels, and larger materials with diameters > 0.063 mm) from the tributaries in the Hydroelectric Reach. While ~~this~~ trapping of the suspended materials may be potentially beneficial for downstream reaches by decreasing TSS concentrations and turbidity, trapping of bedload may reduce habitat suitability below Iron Gate Dam for anadromous fish (see Section 3.3.3.3.2 Bedload for discussion of the effect of this trapping of bedload under existing conditions).

On the scale of the entire Klamath Basin, the trapping of fine sediments and suspended materials does not appear to be a critical function with respect to the overall cumulative sediment delivery ~~for the Klamath Basin~~including downstream tributaries (see also Section 3.11.3.3 for a discussion of basin sediment supply and transport~~). A~~), since a relatively small (3.4 percent) fraction of total sediment supplied to the Klamath River on an annual basis originates from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (see Section 3.2.3.3~~) and beneficial~~). Beneficial uses in the upper Klamath River are currently not impaired due to mineral (inorganic) suspended material (see Table 3.2-8).

Under the No Action/No Project Alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project would contribute to reduced mineral (inorganic) fine sediment inputs to Upper Klamath Lake. In the tributaries to Upper Klamath Lake, additional resource management actions for fish habitat restoration (see Section 2.4.2) related to mineral (inorganic) sediment are ongoing, including the following:

- Floodplain rehabilitation
- Large woody debris replacement
- Cattle exclusion [fencing]
- Riparian vegetation planting
- Mechanical thinning of upland areas and fire treatment
- Purchase of conservation easements/land
- Road decommissioning
- Reduction of fine sediment sources

These resource management actions are also discussed with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

Anticipated climate change effects within the period of analysis (i.e., 50 years) include increased fine sediment delivery to streams due to more intense and frequent precipitation events and elevated stormwater runoff (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections). The anticipated increases would occur over a timescale of decades and may reduce anticipated improvements expected from successful implementation of the aforementioned resource management actions; however, the magnitude of the increased sediment delivery relative to the currently low levels of fine sediment production has not been assessed.

Existing interception and retention of mineral (inorganic) suspended material in the reservoirs in the Hydroelectric Reach is potentially beneficial. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in short-term (~~one~~1 year) increases in mineral (inorganic) suspended material in the Hydroelectric Reach. Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches in the fall of 2011 using a passive approach before high flow periods, or to provide for other habitat enhancement in the Klamath River upstream of Copco 1 Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal (for effects on aquatic species, see Section 3.3.4.3.2.3). Work on IM 7 began in fall 2010 with the contracting, planning, and permitting phase. Passive gravel placement is specified by IM 7, which would avoid in-stream placement of gravel and would limit turbidity increases to periods of high river flow when turbidity is naturally elevated. Under the No Action/No Project Alternative, the duration of IM 7 would only be one year and the amount of gravel to be added is therefore limited. The potential for sediments to enter the water during gravel placement along the river banks can be minimized or eliminated downstream ~~of~~ from the enhancement sites through the implementation of BMPs for construction activities (Appendix B) (BLM 2011). Any disturbed sediments would be trapped by Iron Gate Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the *No Action/No Project Alternative*, the effect of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, on SSCs in the Hydroelectric Reach would be a less-than-significant impact.**

Implementation of IM 8, J.C. Boyle Bypass Barrier Removal, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach due to deconstruction activities. Under this IM, the sidecast rock barrier located approximately three miles upstream of the J.C. Boyle Powerhouse in the J.C. Boyle Bypass Reach would be removed. The objective of IM 8 is to provide for the safe, timely, and effective

upstream passage of Chinook and coho salmon, steelhead, Pacific lamprey, and redband trout. The potential for sediments to enter the water during in-stream work associated with barrier removal and from construction site runoff could be minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Any disturbed sediments would be trapped by Copco 1 Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the *No Action/No Project Alternative*, the effect of IM 8, J.C. Boyle Bypass Barrier Removal, on SSCs in the Hydroelectric Reach in the J.C. Boyle ~~bypass reach~~Bypass Reach would be a less-than-significant impact.**

Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the Hydroelectric Reach due to in-situ algal blooms. Under existing conditions, episodic increases in suspended material occur in the KHP reservoirs during summer months as a result of *in*-situ algal productivity. These concentrations typically range 10–20 mg/L, but can be greater than 200 mg/L (see Section 3.2.3.3) and cause nuisance or adversely affect beneficial uses during intense blooms. While some settling of algal-derived (organic) suspended materials from Upper Klamath Lake may occur in the reservoirs at the Four Facilities, the majority of removal occurs further upstream in the Keno Impoundment/Lake Ewauna, with some additional decreases in concentration due to mechanical breakdown of algal remains in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, and dilution from the springs downstream ~~of~~from J.C. Boyle Dam (see Appendix C for more detail). The high levels of seasonal suspended material caused by algal blooms in the reservoirs in the Hydroelectric Reach would continue to occur under the No Action/No Project Alternative.

Also under this alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project would contribute to reduced fine sediment inputs to Upper Klamath Lake. At a programmatic level, the fine sediment reductions may decrease overall sediment-associated phosphorus inputs to the lake and downstream reaches. The effects would be mostly local, but may indirectly reduce nutrient concentrations in the Hydroelectric Reach by decreasing concentrations in upstream Upper Klamath Lake. In the tributaries to Upper Klamath Lake, additional resource management actions for fish habitat restoration (see Section 2.4.2) related to sediment-associated phosphorus are ongoing, including the following:

- Floodplain rehabilitation
- Cattle exclusion [fencing]
- Riparian vegetation planting
- Mechanical thinning of upland areas and fire treatment
- Purchase of conservation easements/land
- Road decommissioning

These resource management actions are also discussed with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

Full attainment of the measures in Oregon's Upper Klamath River and Lost River TMDLs may indirectly decrease algal-derived suspended material in the Link River and Klamath River upstream of the Oregon-California ~~state~~State line within the period of analysis (i.e., 50 years). The Oregon draft TMDLs require reductions in phosphorus and nitrogen loading from both point sources and nonpoint sources in the Upper Klamath River to address chlorophyll-*a* impairments (see Section 3.2.2.4, Upper Klamath River and Lost River TMDLs). Decreases in nutrient inputs to the upper Klamath River would decrease algal blooms and decrease algal-derived suspended material in this reach. Full attainment of the California Lower Lost River for pH and nutrients and the Klamath River TMDLs for organic enrichment/low dissolved oxygen, nutrients, and microcystin water quality impairments would decrease algal-derived suspended material in the Klamath River downstream ~~of~~from the Oregon-California ~~state~~State line to Iron Gate Reservoir and would, in the long~~-~~ term, be beneficial to water quality. It is anticipated that full attainment of the Oregon and California TMDLs would require decades to achieve.

Anticipated climate change effects within the period of analysis (i.e., 50 years) include longer and more intense algal blooms due to increased air temperatures (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections) and higher overall rates of photosynthesis during summer months. This may increase levels of algal-derived (organic) suspended material. The anticipated increases in suspended material due to climate change would also occur over a timescale of decades and may reduce anticipated improvements expected from successful TMDL implementation throughout the Upper Klamath Basin; however, the magnitude of the increased algal productivity with increasing temperature has not been assessed.

Existing seasonal increases in algal-derived (organic) suspended material in the reservoirs in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease algal blooms and associated suspended material in the reservoirs in this reach. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

Continued impoundment of water at the Four Facilities could result in short-term and long-term interception and retention of mineral (inorganic) sediments by the dams and correspondingly low levels of suspended material immediately downstream ~~of~~ from Iron Gate Dam. Under existing conditions, during November–April, mineral (inorganic) suspended sediments tend to be <100 mg/L in the Klamath River immediately downstream ~~of~~ from Iron Gate Dam, increasing to levels greater than 150 mg/L in the

mainstem downstream ~~of~~from the confluence with the Trinity River during storm events (see Section 3.2.3.3). While the interception and retention of mineral (inorganic) suspended sediments may be moderately beneficial for the Klamath River immediately downstream ~~of~~ from Iron Gate Dam, this represents a very minor portion of the load with respect to overall sediment delivery for the Klamath Basin. A relatively small (3.4 percent) fraction of total sediment supplied to the Klamath River on an annual basis, originates from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (see Section 3.2.3.3) and beneficial uses in the Klamath River immediately downstream ~~of~~from Iron Gate Dam are currently not impaired due to mineral (inorganic) suspended material (see Table 3.2-8).

The Klamath River from the Trinity River (RM 42.5) to the mouth (RM 0) is listed as sediment impaired (see Table 3.2-8), and while the California Klamath River TMDLs do not explicitly address sediment impairments, they do identify allocations to address temperature impairments caused by excessive (primarily inorganic) sedimentation (see Section 3.2.2.4, Klamath River TMDLs). Additionally, the Trinity River and South Fork Trinity River TMDLs, which are outside of the area of analysis for the Proposed Action and alternatives, are expected to affect water quality in the ~~lower~~Lower Klamath River. These TMDLs include a specific focus on sediment improvements. Further, the Scott River TMDL addresses sediment. General measures under the Trinity, South Fork Trinity, and Scott Rivers' TMDLs that can be associated with (primarily mineral) suspended sediment loads are described briefly in Section 3.2.2.4.

Full attainment of the measures in the Trinity River, South Fork Trinity River, and Scott River TMDLs would decrease (primarily mineral) suspended sediment loads in the sediment impaired reach of the ~~lower~~Lower Klamath River from the Trinity River (RM 40) to the mouth (RM 0) and would, in the long~~-~~ term, be beneficial to water quality. Full attainment could require decades to achieve. These implementation measures would occur downstream ~~of~~from the Four Facilities and are not related to the KHP reservoirs under the No Action/No Project Alternative.

Anticipated climate change effects within the period of analysis (i.e., 50 years) include increased fine sediment delivery to streams due to more intense and frequent precipitation events and elevated stormwater runoff (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections). The anticipated increases would occur over a timescale of decades and may reduce improvements expected from successful implementation of the aforementioned TMDL implementation actions; however, the magnitude of the increased sediment delivery relative to the currently low levels of fine sediment production has not been assessed.

Existing interception and retention of mineral (inorganic) sediments by the dams is potentially beneficial. Continued impoundment of water in the reservoirs at the Four Facilities under the No *Action/No Project Alternative* would result in no change from existing conditions.

Continued impoundment of water at the Four Facilities could result in short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the reservoirs in the Hydroelectric Reach and transport into the Klamath River downstream ~~of~~ from Iron Gate Dam. Under existing conditions, concentrations of summer and fall (June–October) algal-derived (organic) suspended material in the Klamath immediately downstream ~~of~~from Iron Gate Dam tend to be less than 5–8 mg/L, reflecting the dams' capacity to intercept and retain suspended material. Much of the algal-derived (organic) suspended material retained behind the Project dams is a result of in-reservoir algal production, as the majority ~~(although not all)~~ of the algal material transported downstream from Upper Klamath Lake appears to be intercepted in the Keno Impoundment/Lake Ewauna (see Appendix C for more detail). However, some of the seasonal algal production that occurs in Copco 1 and Iron Gate Reservoirs is transported downstream to the Klamath River, as evidenced by chlorophyll-*a* patterns, and to a lesser degree TSS patterns, in the river from Iron Gate Dam to the Klamath Estuary (see Appendix C for more detail). While the transport occurs, TSS levels are still relatively low. This pattern would continue to occur under the No Action/No Project Alternative.

Full attainment of the measures in Oregon's Upper Klamath River and Lost River TMDLs would decrease algal blooms and decrease algal-derived suspended material ~~in~~ in the KHP reservoirs due to ~~decreasing~~decreased nutrient availability. Full attainment of the measures in California's Lower Lost River TMDLs and Klamath River TMDLs for organic enrichment/low dissolved oxygen, nutrients, and microcystin water quality impairments, would also decrease algal-derived suspended material KHP reservoirs ~~and~~ and would, in the long~~-~~ term, be beneficial to water quality. It is anticipated that full attainment of the Oregon and California TMDLs would require decades to achieve.

Anticipated climate change effects within the period of analysis (i.e., 50 years) include increased fine sediment delivery to streams and earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase levels of both mineral (inorganic) and algal-derived (organic) suspended material, the latter due to higher overall rates of photosynthesis during summer months. The anticipated increases in suspended sediments due to climate change would also occur over a timescale of decades and may ~~reduce~~offset improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the ~~opposition~~offset is unknown.

Existing transport of seasonally high algal-derived (organic) suspended material from the reservoirs to the Klamath River downstream ~~of~~ from Iron Gate Dam is adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve conditions. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

~~3.2.4.3.1.3~~ Nutrients

Upper Klamath Basin

Continued impoundment of water at the Four Facilities could result in long-term interception and retention of TN and TP in the Hydroelectric Reach on an annual basis but release ~~(export)~~ of TP and, to a lesser degree, TN ~~-~~from reservoir sediments on a seasonal basis. Under existing conditions, TN and TP decrease longitudinally through the Hydroelectric Reach on an annual basis due to dilution from the springs downstream ~~of~~from J.C. Boyle Dam and the settling of algal-derived (organic) material and associated nutrients in Copco 1 and Iron Gate reservoirs. On a seasonal basis, reservoir sediments can release bioavailable TP (as ortho-phosphorus), and to a lesser degree, bioavailable TN (as ammonium), to the water column during periods of seasonal hypolimnetic anoxia (see Section 3.2.3.4). While much of the TP released from anoxic reservoir sediments appears to remain within the hypolimnion until the reservoirs begin to turn over in the fall, some release ~~does~~can occur during late summer and fall months when it could stimulate in-reservoir algal blooms. Nutrients infrequently meet narrative ~~Oregon water quality objectives for nuisance algae growth (Oregon Administrative Rule [OAR] 340-041-0019), or the narrative~~ California North Coast Basin Plan water quality objective for biostimulatory substances (see Table 3.2-4) in the Hydroelectric Reach.

Under the No Action/No Project Alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project (see above water temperature and suspended sediment discussions) would provide long-term reductions in nutrients transported from the Agency Lake subbasin to Upper Klamath Lake. While short-term releases of nutrients are possible during the establishment of project equilibrium, at a programmatic level, these activities may decrease overall nutrient inputs to Upper Klamath Lake by inundating wetland (peat) soils and creating anaerobic conditions ~~that~~ that support nutrient retention, particularly in the case of phosphorus (Snyder and ~~Morace~~ Morace 1997). The effects would be mostly local, but may indirectly reduce nutrient concentrations in the Hydroelectric Reach by decreasing upstream nutrient concentrations in Upper Klamath Lake. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3.2, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of water quality improvement measures addressing nutrients in the Upper Klamath Lake Drainage TMDL and Water Quality Management Plan (WQMP) (ODEQ 2002) and the Upper Klamath River and Lost River Sub-basins TMDL and WQMP (see Section 3.2.2.4), include the following:

- Achievement of TMDL targets for TP loading as the primary method of improving dissolved oxygen (and pH) conditions in Upper Klamath and Agency lakes
- Reductions in phosphorus, nitrogen, and BOD loading from both point and nonpoint (e.g., agricultural returns) sources in the Upper Klamath River

In addition to the Oregon upstream improvements, California ~~possesses~~has promulgated load allocations for the Lower Lost River TMDLs for pH and nutrients and specific

TMDL load allocations for TN and TP assigned to the KHP facilities for the Klamath River TMDLs. The California Klamath River TMDL also indicates that "alternative pollutant load reductions and/or management measures or offsets that achieve the in-reservoir targets" are possible (NCRWQCB 2010a).

The Oregon and California TMDLs in the Upper Klamath Basin are designed to meet water quality objectives; however, the timeframes for achieving nutrient allocations required under these TMDLs will depend on the measures taken to improve water quality conditions. Klamath TMDL model results for nutrient species (i.e., ortho-phosphorus, nitrate, and ammonium) are highly variable depending on location and season, likely due to rapid uptake and release of these chemical species during and following seasonal algal blooms (see Section 3.2.3.1) and potentially due to peaking operations at the J.C. Boyle Powerhouse. Nonetheless, TMDL modeling results tend to suggest that concentrations under the No Action/No Project Alternative would be similar to modeled natural conditions in the Hydroelectric Reach in spring and summer assuming full attainment ~~of~~ of the TMDLs. Full attainment could require decades to achieve and is highly dependent on reducing nutrient loads exiting Upper Klamath Lake and ~~on~~ the agricultural return flows (including the Klamath Straits Drain) along the Keno Reach.

In summary, despite beneficial annual decreases in TP and TN through the Hydroelectric Reach, on a seasonal basis, internal release ~~and export~~ of TP, and to a lesser degree TN, from anoxic reservoir sediments during the summer and late fall may contribute to large blooms of toxigenic algae in the reservoirs.

Existing interception and retention of nutrients in the reservoirs on an annual basis is beneficial, but the release (export) of nutrients (particularly TP) from reservoir sediments on a seasonal basis is adverse for the Hydroelectric Reach. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease nutrients. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

Continued impoundment of water at the Four Facilities could result in long-term interception and retention of TP and TN in the KHP reservoirs on an annual basis and release (export) of TP ~~and TN~~ to the Klamath River downstream ~~of~~ from Iron Gate Dam on a seasonal basis. On an annual basis, nutrients in the Klamath River downstream ~~of~~ from Iron Gate Dam currently tend to be lower than those in upstream reaches, due to dilution from the natural springs downstream ~~of~~from J.C. Boyle Dam and settling of particulate matter and associated nutrients in ~~the larger KHP reservoirs~~Copco 1 and Iron Gate Reservoirs (see Section 3.2.3.4). ~~-~~Further decreases in nutrient levels occur with distance downstream ~~of~~from Iron Gate Dam due to a combination of tributary dilution and in-river nutrient removal processes (see Section 3.2.3.4). Although interception and retention of nutrients in ~~the KHP reservoirs~~Copco 1 and Iron Gate Reservoirs on an annual basis may be beneficial to the Klamath River downstream ~~of~~from Iron Gate Dam,

under existing conditions TP and TN concentrations from the dam to the Klamath Estuary during late summer/early fall do not meet the narrative California Basin Plan water quality objective for biostimulatory substances due to the promotion of algal growth at levels that cause nuisance effects or adversely affect beneficial uses (see Table 3.2-4), nor do they meet the Hoopa Valley Tribe numeric criteria for TP (0.035 mg/L) and TN (0.2 mg/L) (see Table 3.2-6). ~~Further, in~~ In late-summer and fall (i.e., August-November), TP ~~and TN~~ concentrations can increase downstream ~~of~~from the KHP reservoirs due to release of TP (as ortho-phosphorus) ~~and, to a lesser degree, TN (as ammonium),~~ which ~~are~~is formed during periods of seasonal hypolimnetic anoxia in Copco 1 and Iron Gate ~~reservoirs~~Reservoirs. This seasonal release ~~occurs~~ during late summer and fall periods ~~that~~ may stimulate periphyton growth in the Klamath River downstream ~~of~~from Iron Gate Dam (see Appendix C, Sections C.3.1.4 and C.3.2.1). This pattern would continue under the No Action/No Project Alternative.

In the Lower Klamath Basin, the California Klamath TMDLs include a specific focus on nutrient (TN and TP) improvements through specific load allocations assigned to the KHP facilities in California – Copco and Iron Gate reservoirs (see Section 3.2.2.4). Although specific nutrient allocations are only assigned to the KHP, the California Klamath TMDLs were developed based on compliance with water quality objectives at the Oregon-California ~~state~~State line, meaning that successful implementation of water quality improvement measures under the Oregon TMDLs will improve nutrients in the Lower Klamath Basin as well. General measures under the California Klamath River TMDLs that are associated with nutrients include the following:

- Developing a conditional waiver by 2012 to control discharges from agricultural activities (e.g., grazing, irrigated agriculture)
- Prohibiting the unauthorized discharge of waste that is in violation of water quality standards

~~The Shasta River TMDLs also address nutrients (see Section 3.2.2.4).~~

Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving nutrient allocations required under these TMDLs will depend on the measures taken to improve water quality conditions. Modeling conducted for development of the California Klamath River TMDLs indicates that under the No Action/No Project Alternative (similar to the T4BSRN scenario) TN and TP in the Klamath River downstream ~~of~~ from Iron Gate Dam would meet or be lower than modeled natural conditions due to the trapping efficiency of sediment- and algal-associated nutrients behind the dams. Nutrient levels would also meet Hoopa Valley Tribe criteria for TP (0.035 mg/L) and TN (0.2 mg/L) (NCRWQCB 2010a). Given full attainment of the measures in the Oregon and California TMDLs, actual TN concentrations under the No Action/No Project Alternative and natural conditions might be slightly lower than the model predicted concentrations, because denitrification is not included as a possible nitrogen removal term in the riverine segments of the Klamath TMDL model (Tetra Tech 2009). ~~Nutrient~~ In contrast,

dissolved nutrient species (i.e., ortho-phosphorus, nitrate, ammonium) concentrations are variable depending on location and season, with particularly high daily variation during summer months, but Klamath TMDL model results tend to suggest that concentrations under the No Action/No Project Alternative would be somewhat higher than modeled natural conditions in the Lower Klamath Basin. Use of adaptive management will be employed to refine efforts toward achieving water quality standards and TMDL targets. It is anticipated that full attainment of the TMDLs would require decades to achieve.

Existing interception and retention of nutrients in the reservoirs on an annual basis is beneficial, but the release (export) of nutrients (particularly TP) on a seasonal basis is adverse for the Klamath River downstream ~~of~~ from Iron Gate Dam. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease nutrients. Continued impoundment of water in the reservoirs at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

~~3.2.4.3.1.4~~

Dissolved Oxygen

Upper Klamath Basin

Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in dissolved oxygen concentrations in the Hydroelectric Reach, such that levels do not meet ODEQ and California North Coast Basin Plan water quality objectives and adversely affect beneficial uses. Under existing conditions, dissolved oxygen ~~levels exhibit~~ concentrations in summer and fall ~~levels~~ are substantially below (i.e., do not meet) water quality objectives and infrequently support designated beneficial uses in Oregon for ~~coldwater aquatic life,~~ cool water aquatic life~~, warm water aquatic life,~~ and ~~spawning (including bull trout spawning and juvenile rearing, core cold-water habitat,~~ redband ~~trout, and cool water species [no salmonid use]~~ or Lahonton cutthroat trout; see ~~Table~~ Table 3.2-3), and in California for COLD, WARM, and SPWN beneficial uses (see ~~Table~~ Table 3.2-4). Dissolved oxygen levels are particularly low during the summer in the reach from Link River Dam to upstream of J.C. Boyle Reservoir (including Keno Impoundment~~ and~~ /Lake Ewauna), with typical levels ranging from <1 mg/L to 5 mg/L. The primary cause of low summertime dissolved oxygen in the Keno Impoundment~~ (including~~ /Lake Ewauna~~)~~ is settling and decomposition of algae exported from Upper Klamath Lake (see Section 3.2.~~2~~3.5), in combination with warm water temperatures that support lower dissolved oxygen concentrations than cold water, including when saturated. Organic matter and nutrient inputs from the Lost River Basin via Klamath Straits Drain and the Lost River Diversion Channel also contribute to low dissolved oxygen levels in this reach (see Appendix C, Section C.4.1.3 for additional detail). In the Hydroelectric Reach, the seasonal variability in dissolved oxygen concentrations in J.C. Boyle Reservoir ~~is~~ can be highly influenced by the ~~adverse dissolved oxygen conditions in~~ high oxygen demand of water flowing downstream from the upstream Keno Impoundment/Lake Ewauna. Dissolved oxygen in hypolimnetic waters of Copco 1 and Iron Gate reservoirs reach minimum values near 0 mg/L during the summer (see Section 3.2.~~2.~~3.5).

Under the No Action/No Project Alternative, the ongoing Williamson River Delta Project and Agency Lake and Barnes Ranches Project may contribute to long-term improvements in seasonally low dissolved oxygen in Upper Klamath Lake. These resource management actions may decrease overall suspended sediment and nutrient inputs ~~to~~ to Upper Klamath Lake and downstream reaches. These resource management actions are discussed again with respect to water quality effects under the KBRA (see ~~Section~~ Section 3.2.4.3~~, Full Facilities Removal of Four Dams – KBRA~~.2.11).

In Oregon, implementation of TMDL water quality improvement measures focus on dissolved oxygen through reductions in water temperature and nutrient concentrations. The Upper Klamath Lake Drainage TMDL (see Section 3.2.2.4) include the following recommended measures for working toward achievement of TMDL targets for TP loading as the primary method of improving dissolved oxygen (and pH) conditions in Upper Klamath River along with Upper Klamath Lake and Agency lakes:

- Implementation of BMPs for improving dissolved oxygen in the Sprague River

- Reductions in phosphorus, nitrogen, and BOD loading from both point and nonpoint sources in the Upper Klamath River

Additionally, the Upper Klamath River and Lost River Sub-basins TMDLs require dissolved oxygen augmentation to J.C. Boyle Reservoir and several impoundments on the Lost River (the latter is not included in the area of analysis). The Lower Lost River pH and nutrient TMDLs were designed to ensure that California's numeric dissolved oxygen water quality standard would be attained. In California, one of the three TMDL load allocations assigned to the KHP is to create sufficient dissolved oxygen in Copco 1 and Iron Gate Reservoirs through a compliance lens, such that water temperature and dissolved oxygen conditions would be suitable for cold water fish during the critical summer period (see Section 3.2.2.4).

Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving dissolved oxygen (DO) allocations required under these TMDLs will depend on the measures taken to improve water quality conditions, especially reductions in nutrients. Based on Oregon numeric water quality standards, dissolved oxygen levels in the Upper Klamath Basin would need to meet natural conditions or attain 5.5 mg/L (year-round minimum for warm water aquatic life), 6.5 mg/L (year-round minimum for cool water aquatic life), 8.0 mg/L (year-round minimum for coldwater aquatic life), or 11.0 mg/L (January 1–April 15 minimum for spawning) (see Table 3.2-3). As with water temperature, the narrative Oregon standard stipulates that the natural conditions criterion supersedes the numeric criterion and is the standard for that water body (see Table 3.2-3). For California, dissolved oxygen would need to achieve 90 percent saturation based on natural receiving water temperatures during October–March and 85 percent saturation during April–September (see Table 3.2-4). The Klamath TMDL model (see Appendix D) indicates that under the No Action/No Project Alternative with full attainment of the TMDLs (similar to the T4BSRN scenario) dissolved oxygen in the riverine portions of the reach from Link River Dam to the Oregon-California ~~state~~State line would meet Oregon's 6.5 mg/L numeric objective for supporting the cool water aquatic life beneficial use~~ (see Figure 3.2-16)~~. Dissolved oxygen predicted levels would be similar to the modeled natural conditions baseline (TMDL T1BSR scenario) (NCRWQCB 2010a).

Klamath TMDL model results for riverine conditions at the Oregon-California ~~state~~State line indicate a similar pattern, whereby predicted dissolved oxygen concentrations meet the 6.5 mg/L objective year round and achieve the modeled natural conditions baseline during the warm summer and fall months (Figure 3.2-17). Under full TMDL compliant conditions, the California 85 percent saturation objective (based on natural receiving water temperatures) is met at ~~state~~State line under the No Action/No Project Alternative (Figure 3.2-17). Thus, full attainment of the Oregon and California TMDLs would eventually be beneficial for dissolved oxygen in the Hydroelectric Reach. Full attainment could require decades to achieve and ~~it~~ is highly dependent on improvements ~~in~~ in dissolved oxygen~~ in~~, nutrients, and organic matter export from Upper Klamath Lake

~~and~~ and the upstream reach from Link River Dam to J.C. Boyle Dam (particularly Keno Impoundment ~~and~~ /Lake Ewauna).

Climate change is expected to cause a small ~~anticipated~~ decrease in dissolved oxygen due to general increases in water temperature in the Klamath Basin on the order of 2–3 °C (3.6–5.4 °F) over the period of analysis (i.e., 50 years) (Bartholow 2005; see also ~~Section~~ the subsection, Upper Klamath Basin, in Section 3.2.4.3.~~2.4.3, Alternative~~ 1~~: No Action/No Project Alternative: Water Temperature: Upper Klamath Basin~~). This would decrease the 100 percent saturation level for dissolved oxygen by an estimated 0.3–0.4 mg/L, using general assumptions for water temperature (20–24 °C [68–75.~~2º~~2 °F]), salinity (0 ppt) and elevation (1,433 m [4,700 ft]), where the elevation of Upper Klamath Lake is used as a simplifying assumption for the calculation. Climate change would also occur over a timescale of decades and would ~~act~~ act in opposition to improvements expected from successful TMDL implementation throughout the Upper Klamath Basin. Alternately, increased levels of algal growth and photosynthesis anticipated under climate change (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections) may increase daytime dissolved oxygen concentrations during summer months, along with the severity of bloom crashes and their negative effect on dissolved oxygen.. The magnitude of ~~this increase~~these changes is unknown.

Existing seasonal dissolved oxygen levels in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly increase dissolved oxygen. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

Continued impoundment of water at the Four Facilities could result in ~~long-term seasonal and daily variability in~~the continued release of seasonally low dissolved oxygen concentrations ~~in~~from Iron Gate Reservoir into the Klamath River ~~downstream of Iron Gate Dam~~, such that levels immediately downstream from the dam do not meet California North Coast Basin Plan ~~and Hoopa Valley Tribe~~ water quality objectives and adversely affect beneficial uses. Under existing conditions, dissolved oxygen in the Klamath River exhibits seasonal ~~and daily variability~~ low levels immediately downstream ~~of~~from Iron Gate Reservoir with frequent violations of the California water quality objective (expressed as percent saturation, see Table 3.2-5) during late summer/early fall (July–September) (see ~~Section~~ Section 3.2.3.5). Dissolved oxygen levels generally recover with distance downstream, but they still exhibit occasional minimum values below objectives during late summer/early fall downstream ~~of~~ from the confluence with the Trinity River (RM 40). The Hoopa Valley Tribe (8 mg/L) water quality objective for dissolved oxygen, which applies at ≈RM 45–46, is also infrequently met during late summer/early fall months (see Section 3.2.3.5). Thus, dissolved oxygen conditions currently do not fully support designated beneficial uses COLD and WARM beneficial uses (see Table 3.2-4) in the Klamath River downstream ~~of~~ from Iron Gate Dam.

Under the No Action/No Project Alternative, IM 3, Iron Gate Turbine Venting, as part of ongoing KHSA IM studies (see also Section 3.2.4.1), may be used to augment dissolved oxygen in the river ~~for a short distance (approximately one-quarter mile)~~ downstream ~~of~~ from the dam prior to 2020~~ (see Section 3.2.3.1, Upper Klamath Basin – Dissolved Oxygen – Hydroelectric Reach). However, pilot studies to date have not~~. Pilot study results from 2008 indicated that dissolved oxygen levels immediately downstream from Iron Gate Dam can be increased through the mechanical introduction of oxygen as water passes through the turbines (i.e., turbine venting). PacifiCorp reported an increase of approximately 0.5 to 2 mg/L dissolved oxygen (approximately 7 to 20 percent saturation) observed across separate tests in August and October 2008 (Carlson and Foster 2008, PacifiCorp 2008). However, during the October 2008 test, when the upstream reservoirs were de-stratifying and dissolved oxygen concentrations in the river immediately downstream from Iron Gate Powerhouse were decreasing to levels of approximately 6.5 mg/L, turbine venting only increased concentrations at this location by approximately 0.5 mg/L and 7 percent saturation (Carlson and Foster 2008). As part of their review of PacifiCorp's requested "Authorization for Incidental Take and Implementation of KHP Interim Operations Habitat Conservation Plan for Coho Salmon", USEPA indicated that the 2008 study did not demonstrate the efficacy of the proposed turbine venting to significantly improve dissolved oxygen downstream from Iron Gate Dam (USEPA 2011). Further testing conducted in 2010 indicated that turbine venting in combination with a forced air blower was the most effective of three methods tested (i.e., turbine venting, blower, turbine venting plus blower), resulting in an initial increase in dissolved oxygen percent saturation from approximately 50 percent to just over 70 percent immediately downstream from the Iron Gate Powerhouse (PacifiCorp 2011). Throughout the 6-mile test reach downstream from the powerhouse, dissolved oxygen concentrations continued to increase for all tested methods, as well as for ambient (i.e., no treatment) conditions, due to river re-aeration. For the turbine venting plus blower treatment, dissolved oxygen concentrations achieved the reach-specific Basin Plan water quality objective of 90 percent saturation (i.e., October 1 through March 31 from Stateline to Scott River) at the end of the 6-mile test reach. Ambient conditions (i.e., no treatment) achieved approximately 88 percent saturation at the end of the 6-mile reach (PacifiCorp 2011). Although turbine venting treatments considerably improved dissolved oxygen concentrations in the 6-mile test reach, particularly in the first 1 to 3 miles downstream from the dam, the full compliance point in the river with turbine venting did not shift considerably further upstream as compared with that of ambient conditions (i.e., no treatment). Thus, although there have been improvements from the initial tests,~~ turbine venting efforts ~~would~~have not yet been demonstrated to be a viable long-term solution for dissolved oxygen impairment from the reservoirs~~.~~

In the Lower Klamath Basin, the California Klamath River TMDLs include a specific focus on dissolved oxygen improvements. Full attainment of water quality improvement measures under the Oregon TMDLs would improve dissolved oxygen in the California portions of the Klamath River as well, particularly since California Klamath River TMDLs were developed based on compliance with water quality objectives at the Oregon-California ~~state~~State line. Specific dissolved oxygen allocations are assigned to

the KHP and TN, TP, and CBOD allocations are assigned to the mainstem river and tributaries to support improvement toward dissolved oxygen targets (i.e., water quality objectives for dissolved oxygen). Specific monthly dissolved oxygen numeric targets are also assigned to the Copco and Iron Gate tailraces, based on percent saturation (see Section 3.2.2.4). General measures under the California Klamath River TMDLs associated with dissolved oxygen in the Klamath River include the following:

- A conditional waiver (developed by 2012) for discharges from agricultural activities (e.g., grazing, irrigated agriculture)
- Prohibiting the unauthorized discharge of waste that is in violation of water quality standards

The Shasta River TMDLs also address dissolved oxygen. Dissolved oxygen improvements in the Shasta River would be expected to improve concentrations in the Klamath River mainstem at or downstream ~~of~~from the confluence with the Shasta River (~~RM~~ RM 176.7). Multiple water quality improvement measures in the Shasta River TMDL focus on dissolved oxygen (see Section 3.2.2.4).

Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving dissolved oxygen allocations and targets required under these TMDLs will depend on the measures taken to improve water quality conditions, especially reductions in nutrients in upstream reaches. The Oregon and California with-dam TMDL scenario (T4BSRN - see ~~Appendix~~ Appendix D) was run in order to quantify the impacts of the dams on water quality and to determine appropriate allocations and targets. The Klamath with-dam TMDL modeling scenario indicates that, with full compliance of the TMDLs, under the No Action/No Project Alternative (similar to the TMDL T4BSRN scenario), dissolved oxygen concentrations immediately downstream ~~of~~ from Iron Gate Dam ~~to the Shasta River (RM 176.7)~~, without additional mitigation, would not meet the North Coast Basin Plan water quality objective of 85 percent saturation (see Tables 3.2-4 and 3.2-5) during ~~July~~August–September, and ~~from the Shasta River to approximately the Scott River (RM 143) from September–November (see Figures 3.2-19 and~~the 90 percent saturation objective would not be met from October–November (Figure 3.2-18). Further downstream, near the confluence with the Shasta River, dissolved oxygen concentrations under the No Action/No Project Alternative would not meet the 90 percent saturation objective from October–November (Figure 3.2-19). In the Klamath River at Seiad Valley, concentrations would be mostly in compliance with the exception of modeled values in November that are just above the 90 percent saturation objective (Figure 3.2-20). The inability to achieve the water quality ~~objective of 85% saturation~~objectives under TMDL compliance conditions immediately downstream from Iron Gate Dam ~~to the Shasta River~~ is due to the release of low dissolved oxygen water from the hypolimnion of the reservoir. This result indicates that while full attainment of the California Klamath TMDLs would result in dramatic improvements in dissolved oxygen both upstream and downstream ~~of~~ from Iron Gate Dam, release of low dissolved oxygen water from the hypolimnion (i.e., the bottom layer within stratified reservoir)

inhibits compliance immediately downstream from ~~the~~ Iron Gate ~~tailrace to the Scott River~~Dam with the dams in place. The TMDL does include dissolved oxygen targets for the Iron Gate Dam tailrace that meet water quality objectives. It is possible that there are management practices that PacifiCorp could use to meet the TMDL dissolved oxygen targets. However, these practices have not been demonstrated to date and the NCRWQCB could not make presumptions regarding what these practices might be. Therefore, these enhancements were not included in the with-dams TMDL modeling scenario. ~~Therefore, the~~ The TMDL Action Plan includes a requirement for PacifiCorp to ~~develop~~submit a ~~Reservoir Management~~proposed Implementation Plan that ~~specifically addresses water temperature and dissolved oxygen improvements that would allow the KHP facilities and downstream reaches to meet water quality objectives~~incorporates timelines and contingencies pursuant to the KHSA. PacifiCorp may propose the use of off-site pollutant reduction measures (i.e., offsets or "trades") to meet the allocations and targets in the context of the Interim Measures 10 and 11 of the KHSA (NCRWQCB 2010a).

~~Farther downstream~~By the Salmon River (RM 66.0) confluence, with full attainment of TMDL allocations, predicted dissolved oxygen concentrations would remain at or above the 85 percent saturation objective (as well as the 90 percent saturation objective, where applicable), meeting the North Coast Region Basin Plan ~~water quality objective from Seiad Valley (RM 129.4) to the Klamath Estuary. Despite this, predicted~~requirements. Predicted dissolved oxygen would infrequently meet the Hoopa Valley Tribe numeric dissolved oxygen objective ~~of~~ of 8 mg/L (see Table 3.2-6), which applies at ≈~~RM~~RM 45–46, because warm water temperatures during July–October would decrease the saturation level of oxygen in the water column to less than 8 mg/L (see Figure 3.2-20 and 3.2-21). However, Hoopa Valley Tribe has a natural conditions clause requiring dissolved oxygen to achieve 90% saturation if numeric values are not met; predicted dissolved oxygen concentrations would meet this natural condition clause. The Hoopa Valley Tribe's Water Quality Control Plan (HVTEPA 2008) has been approved by USEPA; however, this natural conditions clause has not yet been approved (as of July 2012). USEPA requires that a method be developed for determining that the dissolved oxygen objectives are not achievable due to natural conditions and presented for approval. Throughout the ~~lower~~Lower Klamath River, daily fluctuations in dissolved oxygen during July–October would occur due to colonization of periphyton mats in the river and the associated ~~photosynthetic swings in oxygen production.~~

photosynthesis.

As described for the Upper Klamath Basin, climate change would decrease the 100 percent saturation level for dissolved oxygen in the lower basin by increasing water temperatures. In the lower basin, this would result in an estimated 0.3–0.5 mg/L decrease in dissolved oxygen, using general assumptions for water temperature (20–24°C [68-75.2ºF]), salinity (0 ppt) and elevation at sea level as a simplifying assumption for ~~the~~ the calculation. The small anticipated decreases in dissolved oxygen due to climate change would also occur over a timescale of decades and would act in opposition to

improvements expected from successful TMDL implementation throughout the Lower Klamath Basin. As with the ~~upper basin~~Upper Basin, increased levels of algal growth and photosynthesis anticipated under climate change (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections) may increase daytime dissolved oxygen concentrations during summer months but could increase the severity of subsequent bloom crashes and their negative effect on dissolved oxygen. The magnitude of ~~this increase~~ these changes is unknown.

Existing seasonal dissolved oxygen levels immediately downstream ~~of~~from Iron Gate Dam are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly increase dissolved oxygen, although seasonal concentrations from Iron Gate Dam to the Shasta River would remain adverse. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

~~3.2.4.3.1.5~~ pH

Upper Klamath Basin

Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in pH in the Hydroelectric Reach. Under existing conditions, pH values in the Hydroelectric Reach range from just above neutral to greater than 9, with large (0.5–1.5 pH units) daily fluctuations occurring in reservoir surface waters during periods of intense algal blooms (see Section 3.2.6). During these periods, pH levels infrequently meet applicable ODEQ and California North Coast Basin Plan water quality objectives (see Table 3.2-3 and Table 3.2-4), and adversely affect beneficial uses.

Several ongoing resource management actions represent reasonably foreseeable actions within the period of analysis that may affect pH. Although initially resulting in increased nutrient release, the ongoing Williamson River Delta Project and Wood River Wetland Restoration are expected to eventually reduce nutrient inputs to Upper Klamath Lake which may decrease algal bloom populations and rates of photosynthesis, and correspondingly decreasing observed pH maximums in the lake and its tributaries. Additional resource management actions such as floodplain rehabilitation, riparian vegetation planting, and purchase of conservation easements/land ~~related to~~, and which could affect nutrients, are currently ongoing in the Upper Klamath Basin (see Section 2.3.1) and are expected to continue to improve long-term pH in the Upper Klamath Lake. This may indirectly decrease pH maximums in the Hydroelectric Reach. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of TMDL measures focused on pH in the Upper Klamath Lake Drainage TMDL and WQMP and those in the draft Upper Klamath River and Lost River Sub-basins TMDL and WQMP (see Section 3.2.2.4) include decreased loading of total phosphorous as the primary method for decreasing pH in Upper Klamath and

Agency lakes and in the Sprague River. While the California Klamath River TMDLs do not include specific allocations or targets for pH, load allocations and targets for TN and TP, which include pH under the allocations for nutrients as biostimulatory substances (NCRWQCB, 2010a), are assigned to the KHP and are designed to limit algal photosynthesis~~, which~~. This will decrease maximum pH levels and daily variability in the Hydroelectric Reach. The California Lower Lost River TMDLs also include pH allocations.

The Oregon and California TMDLs in the Upper Klamath Basin are designed to achieve water quality objectives; however, the timeframes for achieving pH objectives will depend on the measures taken to improve water quality conditions, especially reductions in nutrients. To consistently support beneficial uses, pH cannot be below 6.5 units or above 9.0 units in Oregon (see Table 3.2-3) and cannot be depressed below 7.0 units nor raised above 8.5 units in California upstream or downstream ~~of~~from Iron Gate Dam (see Table 3.2-4). The pH in the reach from Link River Dam to just upstream of J.C. Boyle Reservoir, and to the Oregon-California ~~state~~State line in the Hydroelectric Reach, would meet water quality objectives for Oregon. Similarly, in California from the ~~state~~State line to Iron Gate Dam, pH is expected to trend toward achievement of water quality objectives given full attainment of the TMDLs within the period of analysis (NCRWQCB 2010a). Full attainment could require decades to achieve.

Anticipated climate change effects on pH include earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase pH maximums due to higher overall rates of photosynthesis during summer months. The anticipated increases in pH due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Upper Klamath Basin; however, the magnitude of the opposition is unknown.

Existing seasonal fluctuations in pH occurring during periods of intense algal blooms in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve pH. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in pH in the Klamath River downstream ~~of~~ from Iron Gate Dam. Under existing conditions, pH during late-summer and early-fall months (August–September) in the Klamath River downstream ~~of~~ from Iron Gate Dam ranges from just above neutral to greater than 9, with large (0.5–1.5 pH units) daily fluctuations occurring in the ~~lower~~ river during periods of high photosynthesis (see Section 3.2.3.6). In California, to consistently support beneficial uses in the Klamath, pH cannot be depressed below 7.0 units nor raised above 8.5 units (see Table 3.2-4).

While the California Klamath River TMDLs do not include specific allocations or targets for pH, load allocations and targets for TN and TP, which include pH under the allocations for nutrients as biostimulatory substances (NCRWQCB, 2010a), are assigned to the KHP and are designed to limit algal photosynthesis, which will decrease maximum pH levels and daily variability in the Klamath River downstream ~~of~~from Iron Gate Dam.

The timeframes for achieving pH objectives will depend on the measures taken to improve water quality conditions, especially reductions in nutrients. The Klamath TMDL model (see Appendix D) indicates that under the No Action/No Project Alternative (similar to TMDL T4BSRN scenario) pH in the reach from Seiad Valley *(*RM 129.4*)* to downstream ~~of~~from the mainstem confluence with Indian Creek (RM 108) would meet water quality objectives. While model results indicate that daily maximum values in some stretches of the Klamath River downstream ~~of~~from Iron Gate Dam may not meet the Basin Plan water quality objective of 8.5 pH units (see Table 3.2-4), within the resolution of the Klamath TMDL model these potentially occasional exceedances of the pH objective would not be expected to substantially adversely affect beneficial uses. The Hoopa Valley Tribe water quality objective for pH (7.0–8.5) (see Table 3.2-6) is met at the location that it is applicable (≈RM 45–6) (NCRWQCB 2010a). Therefore, pH under the No Action/No Project Alternative would meet pH water quality objectives for

California within the period of analysis due to full attainment of the California TMDLs (NCRWQCB 2010a). It is anticipated that full attainment of the TMDLs would require decades to achieve.

Anticipated climate change effects on pH include earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase pH maximums due to higher overall rates of photosynthesis during summer months. The anticipated increases in pH due to climate change would also occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the opposition is unknown.

Existing seasonal fluctuations in pH downstream ~~of~~ from Iron Gate Dam, which occur during periods of intense algal blooms in the upstream reservoirs, are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve pH. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

~~3.2.4.3.1.6~~ Chlorophyll-a and Algal Toxins

Upper Klamath Basin

Continued impoundment of water at the Four Facilities could support long-term growth conditions for toxin-producing nuisance algal species such as M. aeruginosa, resulting in high seasonal concentrations of chlorophyll-a and algal toxins in the Hydroelectric Reach. Under existing conditions, chlorophyll-*a* samples during summer and fall in Upper Klamath Lake and the two largest reservoirs at the Four Facilities (Copco 1 and Iron Gate Reservoirs) exhibit annual mean values >10 µg/L (measured May through October) with the highest values (> 100 mg/L) occurring in surface waters during late summer periods of intense algal blooms (see Section 3.2.3.~~1~~7). High (>8 µg/L) seasonal levels of algal toxins (microcystin) are linked to intense blue-green algae blooms and exceed applicable ODEQ water quality objectives for toxic substances (see Table 3.2-3) and the North Coast Basin Plan water quality objectives for toxicity (see Table 3.2-4). This adversely affects beneficial uses, particularly the human health water contact recreational use (REC-1) and the cultural use (CUL).

As with other water quality parameters analyzed in this EIS/EIR (i.e., water temperature, sediment, nutrients, dissolved oxygen, pH), several ongoing resource management actions represent reasonably foreseeable actions within the period of analysis that may affect algal toxins and chlorophyll-*a* concentrations in the Upper Klamath Basin. The ongoing Williamson River Delta Project and Wood River Wetland Restoration are intended to eventually reduce nutrient inputs to Upper Klamath Lake, which may help decrease the incidence of toxic cyanobacterial algal blooms and high chlorophyll-*a* levels and algal toxins in Upper Klamath Lake and reduce those transported downstream to the Hydroelectric Reach. Additional resource management actions such as floodplain rehabilitation, riparian vegetation planting, and purchase of conservation easements/land

~~related to~~, and which could affect nutrients, are ongoing in the Upper Klamath Basin (see ~~Section~~ Section 2.3.1) and are expected to continue to decrease long-term levels of algal toxins and chlorophyll-*a* in Upper Klamath Lake. This may slightly decrease concentrations in the Hydroelectric Reach. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3, Full Facilities Removal of Four Dams - KBRA).

In Oregon, implementation of measures related to chlorophyll-*a* and algal toxins in the Upper Klamath Lake Drainage TMDL and WQMP and those in the Upper Klamath River and Lost River Sub-basins TMDL and WQMP (see Section 3.2.2.4) include decreased loading of TP as the primary method for decreasing the magnitude of algal productivity (blooms) affecting the high rates of photosynthesis and the related water quality problems (e.g., pH, dissolved oxygen) in the Sprague River, Upper Klamath and Agency lakes, and the Keno Reach. Decreases in upstream algal blooms would result in corresponding decreases in chlorophyll-*a* concentrations and, for toxin-producing algal species, levels of microcystin in the Hydroelectric Reach.

Additionally, the Oregon and California TMDLs include specific load allocations for TN and TP upstream of the Klamath Hydropower Facilities (see Section 3.2.2.4), which are intended to eventually limit the extensive algal blooms in Copco 1 and Iron Gate Reservoirs and thus decrease chlorophyll-*a* and algal toxin levels toward the TMDL targets of 10 µg/L chlorophyll-*a* (growing season average), *M. aeruginosa* cell density ≤20,000 cells/L, and microcystin toxin <4 µg/L (see Table 3.2-10). Full attainment of the measures in the Oregon and California TMDLs would result in waters meeting water quality standards; however, the timeframes for achieving water quality objectives with respect to algal toxins and chlorophyll-*a* will depend on the measures taken to improve water quality conditions. This would require decades to achieve and it is highly dependent on nutrient improvements in ~~nutrients in the upstream reach from~~Upper Klamath Lake, Link River ~~Dam to J.C. Boyle Dam (particularly~~ , and the Keno Impoundment ~~including~~ /Lake Ewauna~~).~~

.

Anticipated climate change effects include earlier, longer, and more intense algal blooms (Barr et al. 2010) (see Section 3.10.3.1, Existing Conditions – Climate Change Projections), which may increase algal toxin and chlorophyll-*a* concentrations due to higher overall rates of photosynthesis and algal primary production during summer months. The anticipated effects of climate change would also occur over a timescale of decades and may slightly offset improvements expected from successful TMDL implementation throughout the Upper Klamath Basin.

Existing seasonal blooms of toxin-producing nuisance algal species and corresponding levels of chlorophyll-*a* and algal toxins in the Hydroelectric Reach are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease chlorophyll-*a* and

algal toxins. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

Continued impoundment of water at the Four Facilities could support long-term growth conditions for toxin-producing nuisance algal species such as M. aeruginosa, resulting in high seasonal concentrations of chlorophyll-a and algal toxins (i.e.g., microcystin) transported into the Lower Klamath River from downstream of Iron Gate Dam toand likely the Klamath Estuary, and potentially the marine nearshore environment. Under existing conditions, chlorophyll-*a* concentrations during summer through fall in the Klamath River downstream of from Iron Gate Dam are lowercan be greater than those in Upper Klamath Lake and the KHP reservoirsthe river directly upstream of Copco 1 Reservoir due to interception of algae by the KHP dams. However, concentrations are variable by location and increase as a result of periodic seasonal (i.e., summer, fall) in reservoir algal blooms that are transported into the lower river (see Appendix C, Section 3.2.3.7C.4.1.4 and Figure C-28). These algal blooms can be toxic and can exceed numeric thresholds for microcystin (i.e., SWRCB/OEHHA Public Health Threshold of 8 µg/L, WHO guidelines of 4 ug/L) posing a human health risk and substantially adversely affecting recreational beneficial uses, particularly water contact (REC-1) and CUL uses. Although the The CUL beneficial use has only been approved for the Hoopa Valley Tribe thus faris applicable in the Klamath River from State line to the Klamath River Estuary (see Table 3.2-2), known). Known or perceived risks of exposure to degraded water quality conditions due to algal toxins during ceremonial bathing and traditional cultural activities have resulted in impairment of this beneficial use for the Karuk Tribe as well (see also Section 3.12.3.3). Additionally, Hoopa Valley Tribe water quality objectives for toxigenic cyanobacteria species and cyanobacterial scums are not consistently met during summer months (see Section 3.2.3.7 and Appendix C for more detail). Microcystin can also bioaccumulate in aquatic biota in the Lower Klamath River, including filter feeders and fish. A discussion of algal toxins as related to fish health is presented in Section 3.3.3.2, Physical Habitat Descriptions - Water Quality - Algal Toxins.

Existing information indicates that instances of elevated levels of *M. aeruginosa* and microcystin toxin in the Klamath Estuary correspond with elevated levels measured at upstream locations in the Lower Klamath River (see also Section 3.4.3.6). Continued occurrence of *M. aeruginosa* and microcystin toxin in the Lower Klamath River under the No Action/No Project Alternative would also likely result in the continued occurrence of this toxic blue-green algae and the associated toxin in the Klamath Estuary. Lastly, there is emerging evidence that cyanotoxins flushing from coastal rivers into Monterey Bay, California were responsible for numerous sea otter deaths in 2007 (Miller et al. 2010). While it is not known if conditions in Monterey Bay are similar to those in the Klamath River marine nearshore environment, there may be potential for microcystin to adversely impact marine organisms under the No Action/No Project Alternative.

TheAdditionally, the Oregon and California Klamath River TMDLs include specific load allocations for TN and TP upstream of the FourKlamath Hydropower Facilities to offset the reduced nutrient assimilative capacity in the reservoirs (see Section 3.2.2.4, Klamath River TMDLs); the decreased nutrient loads would (see Section 3.2.2.4), which are

intended to eventually limit the extensive algal ~~growth~~blooms in Copco 1 and Iron Gate Reservoirs and thus decrease chlorophyll-*a* and algal toxin levels ~~in the KHP reservoirs~~ toward the TMDL targets of 10 µg/L chlorophyll-*a* (growing season average), *M. aeruginosa* cell density 20,000 cells/L, and microcystin toxin <4 µg/L (~~NCRWQCB 2010a~~see Table 3.2-10). This would subsequently decrease levels of chlorophyll-*a* and algal toxins transported into the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. This would require decades to achieve and it is highly dependent on upstream nutrient improvements.

As with the Upper Klamath Basin, anticipated effects of climate change on chlorophyll-*a* and algal toxins would occur over a timescale of decades and would act in opposition to improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the opposition is unknown.

Existing transport of seasonal blooms of toxin-producing nuisance algal species, chlorophyll-*a*, and algal toxins into the Lower Klamath River ~~from downstream of Iron Gate Dam to~~and likely the Klamath Estuary are adverse. Transport to the marine nearshore environment is potentially adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease chlorophyll-*a* and algal toxins. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

~~3.2.4.3.1.7~~ Inorganic and Organic Contaminants

Upper Klamath Basin

Freshwater Aquatic Life Toxicity and/or Bioaccumulation

Effects of the No Action/No Project Alternative on potential inorganic and organic contaminants in Upper Klamath Lake and its major tributaries cannot be assessed directly due to a lack of information for these parameters (see Section 3.2.3.8, Upper Klamath Lake – Inorganic and Organic Contaminants). However, under the No Action/No Project Alternative, ongoing resource management actions (i.e., Williamson River Delta Project, Agency Lake and Barnes Ranches Project) may reduce transport of inorganic and organic contaminants into Upper Klamath Lake and downstream reaches. While Oregon and California TMDLs do not address inorganic and organic contaminants, under the No Action/No Project Alternative TMDL implementation may indirectly limit transport of inorganic and organic contaminants through mechanisms expected to reduce suspended sediments and nutrients.

Low levels of organic and inorganic contaminants have been identified in the sediment deposits trapped behind the dams in the Hydroelectric Reach (see Section 3.2.3.8). Benthic uptake and subsequent transfer through the food web is one potential pathway of contaminant exposure for aquatic organisms in the Hydroelectric Reach; exposure to water column contaminants is also a possible pathway. Sediment contaminants influenced by pH or dissolved oxygen, such as methylmercury, may flux into the water column via the low redox conditions supported by reservoir stratification and seasonal

anoxia. Human exposure to methylmercury, inorganic contaminants (e.g., arsenic), and organic contaminants (e.g., pesticides, PCBs, PAHs) associated with reservoir sediments may occur through consumption of contaminated reservoir fish or shellfish. Potential effects of the No Action/No Project Alternative are further discussed below using available water column, sediment, and aquatic biota contaminant data.

Continued impoundment of water at the Four Facilities and associated interception and retention of sediments behind the dams could result in long-term low-level exposure to inorganic and organic contaminants for freshwater aquatic species in the Hydroelectric Reach.

Water Column Contaminants~~.~~ Water quality data collected during in Copco 1 and Iron Gate reservoirs during 2001–2005 under the SWAMP indicate that concentrations of numerous inorganic compounds (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) and organic compounds (i.e., pesticides, PCBs, phenols) were in compliance with water quality objectives (NCRWQCB 2008; see Section 3.2.3.1 and Appendix C, Section C.7.1.1 for more detail).

Sediment Contaminants~~.~~ Two studies provide data for the evaluation of sediment toxicity and bioaccumulation potential under the No Action/No Project Alternative:

- Sediment chemistry data collected during 2004–2005 from 26 cores in J.C. Boyle, Copco 1, and Iron Gate Reservoirs (Shannon & Wilson, Inc. 2006). The 2004–2005 sediment chemistry data indicate generally low levels of metals, pesticides, chlorinated acid herbicides, PCBs, VOCs, SVOCs, cyanide, and dioxins (Shannon & Wilson, Inc. 2006; see Section 3.2.3.1).
- Sediment chemistry and toxicity data collected during 2009-2010 as part of the Secretarial Determination process, including samples from J.C. Boyle, Copco 1, and Iron Gate Reservoirs, and the Klamath Estuary (Department of the Interior 2010a and ~~exposure "Scenario~~"Exposure Pathway 1" in CDM [2011]). Based on comparison to appropriate freshwater sediment screening levels (see Section 3.2.3.8 and Appendix C for more detail), ~~no exceedances of detected chemicals were found in~~ a limited number of COPCs were detected in reservoir sediment samples (i.e., nickel, iron, dieldrin, 4,4'-DDT, 4,4'-DDD, 4,4'-DDE, 2,3,4,7,8-PECDF, and 2,3,7,8-TCDD; see Appendix C, Section C.7.1.1 and Table 2 in CDM [2011]), indicating a low risk of toxicity to or bioaccumulation in freshwater sediment-dwelling organisms in the Hydroelectric Reach under the No Action/No Project Alternative. Based on additional lines of evidence (i.e., toxicity tests, calculation of TEQs), there does not appear to be a substantial sediment toxicity concern for national benchmark benthic indicator species from Copco 1 and Iron Gate Reservoir under the No Action/No Project Alternative. The exception to this occurred in a single sample from J.C. Boyle Reservoir, where survival of the benthic amphipod *Hyalella azteca* indicated a moderate potential for toxicity. TEQs for dioxin, furan, and dioxin-like PCBs in reservoir and estuary sediment samples were within the range of local background values and suggest a limited potential for adverse effects for fish exposed to reservoir

sediments under the No Action/No Project Alternative (CDM 2011). ~~Lastly, sediment samples were also evaluated for levels of known bioaccumulative compounds; ODEQ bioaccumulation~~ Similarly, based on comparison to appropriate human health sediment screening ~~values were not exceeded in J.C. Boyle Reservoir sediments, with the exception of a small number of samples for DDTs (i.e., 4,4'-DDT, 4,4'-DDD, 4,4'-DDE) (CDM 2011~~levels, a limited number of COPCs were detected in reservoir sediment samples (i.e., arsenic, nickel, dieldrin, 4,4'-DDT, 4,4'-DDD, 4,4'-DDE, dioxin-like compounds, and pentachlorophenol) (see Appendix C, Section C.7.1.1 and Table 3 in CDM [2011]).

Contaminants in Aquatic Biota~~.~~ The potential for bioaccumulation under the No Action/No Project Alternative can also evaluated using fish tissue concentrations. Two studies provide data for the evaluation of bioaccumulation potential in freshwater fish:

- PacifiCorp (2004c) conducted a screening-level analysis looking at metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine pesticides, and PCBs in the Hydroelectric Reach and Upper Klamath Lake. The PacifiCorp data suggest that, with two exceptions, fish in the KHP reservoirs do not appear to be exposed to levels of contaminants that may adversely affect beneficial uses or that are toxic or detrimental to aquatic life. The exceptions include exceedances of the total mercury wildlife screening level (0.00227 ug/g) for all tissue samples in Keno, J.C. Boyle, Copco 1, and Iron Gate Reservoirs (see Appendix C for more detail), suggesting that localized mercury methylation may be occurring during periods of stratification and anoxia in the reservoirs (see Table ~~3.2-5~~C-1). Another exception is that exceedances of recommended wildlife screening levels for total DDTs based on p,p'-DDE found in fish tissue samples from Upper Klamath Lake, the Keno Impoundment/Lake Ewauna, J.C~~.~~. Boyle Reservoir, and Copco 1 Reservoir (see Section 3.2.3.1, Inorganic and Organic Contaminants – Hydroelectric Reach), may suggest a possible broader~~-~~-scale bioaccumulation effect (see Appendix C, Table C-7).
- Results from the 2009-2010 Secretarial Determination fish tissue sampling (~~exposure "Scenario~~"Exposure Pathway 1" in CDM [2011]) indicate that mercury is present in fish tissue at levels with potential to cause minor or limited adverse effects to fish; multiple other chemicals are not present at such levels, or they are present but do not possess tissue-based TRVs for comparison (see Section 3.2.3.8 and Appendix C for more detail). Fish tissue results were also below dioxin, furan, and dioxin~~-~~-like PCB TEQs, indicating no adverse effect (CDM 2011). Combined with the sediment contaminant data (see above), inorganic and organic contaminants are present in reservoir sediments at levels that have the potential ~~to~~ to cause minor or limited adverse effects (i.e., toxicity or bioaccumulation) to freshwater aquatic species (Figure 3.2-2).

	Exposure Scenario	Freshwater biota	Marine biota	Terrestrial biota	Humans
Scenario 1 (No Action Alternative)	Long-term exposure to reservoir sediments	●			●
Scenario 2 (Proposed Action)	Short-term exposure to sediments flushed downstream	●	●		
Scenario 3 (Proposed Action)	Long-term exposure to exposed reservoir terrace and or river bank deposits			● (1)	● (1)
Scenario 4 (Proposed Action)	Long-term exposure to river bed deposits	●			●
Scenario 5 (Proposed Action)	Long-term exposure to marine / near shore deposits		●		

●	No adverse effects based on lines of evidence
●	One or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence
●	One or more chemicals present at levels with potential to cause minor or limited adverse effects based on the lines of evidence
●	At least one chemical detected at a level with potential for significant adverse effects based on the lines of evidence
	This exposure pathway is incomplete or unimportant for this receptor group

~~Figure 3.2-2. Summary of Anticipated Effects of Inorganic and Organic Contaminants in Klamath Reservoir and Estuary Sediments Under the No Action/No Project Alternative and the Proposed Action. This does not include an evaluation of the physical effects (e.g., dissolved oxygen, suspended sediment). (1): Qualitative evaluation conducted for this exposure scenario.~~
~~Source: CDM 2011.~~

Existing inorganic and organic contaminant data characterizing reservoir sediments at the Four Facilities indicate that a relatively small number of chemicals (i.e~~.,~~ ., mercury, DDTs, and possibly dioxin-like chemicals) are present in reservoir sediments at levels that have the potential to cause minor or limited adverse effects (i.e., toxicity or bioaccumulation) to freshwater aquatic species in the ~~Hydroelectric~~ Hydroelectric Reach. Continued impoundment of water at the Four Facilities ~~under~~ under the *No Action/No Project Alternative* would result in no change from existing conditions.

	Exposure Pathway	Freshwater biota	Marine biota	Terrestrial biota	Humans
Pathway 1	Short-term exposure to sediments flushed downstream	🟢	🔵	--	--
Pathway 2	Long-term exposure to exposed reservoir terrace and or river bank deposits	--	--	⚫ (1)	🔵 (2)
Pathway 3	Long-term exposure to new river channels and river bed deposits	🔵	--	--	🔵
Pathway 4	Long-term exposure to marine / near shore deposits	--	🔵	--	--
Pathway 5	Long-term exposure to reservoir sediments	🟢	--	--	🟢

⚫	No adverse effects based on lines of evidence
🔵	One or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence
🟢	One or more chemicals present at levels with potential to cause minor or limited adverse effects based on the lines of evidence
🔴	At least one chemical detected at a level with potential for significant adverse effects based on the lines of evidence
--	This exposure pathway is incomplete(3) or insignificant(4) for this receptor group

Note:
This does not include an evaluation of the physical effects (e.g., dissolved oxygen in the water, suspended sediment)
(1) Qualitative evaluation conducted for this exposure pathway
(2) Limited quantitative, along with qualitative evaluations conducted for this exposure pathway
(3) Incomplete - receptor group is unlikely to come in contact with sediment-associated contaminants under this exposure pathway
(4) Insignificant - exposure pathway not considered a major contributor to adverse effects in humans based on best professional judgment

Figure 3.2-2. Summary of Anticipated Effects of Inorganic and Organic Contaminants in Klamath Reservoir and Estuary Sediments Under the No Action/No Project Alternative and the Proposed Action, for Five Exposure Pathways . Source: CDM 2011.

Continued impoundment of water at the Four Facilities and associated interception and retention of sediments behind the dams could result in long-term low-level exposure to inorganic and organic contaminants in the Hydroelectric Reach for humans through the consumption of resident fish tissue. Human health exposure to inorganic or organic chemicals in reservoir sediments under the No Action/No Project Alternative is primarily through consumption of resident fish. Under the No Action/No Project Alternative, direct human exposure to sediments is not considered a reasonable exposure pathway. Three studies provide data for the evaluation of human health exposure through consumption of resident fish:

- Results from California SWAMP fish tissue sampling in Copco 1 and Iron Gate Reservoirs indicate mercury tissue concentrations of ~~0.31~~310 and ~~0.33~~330 ng/g wet weight, respectively (Davis et al. 2010). These data are greater than the advisory tissue levels for 3 and 2 servings per week (70 and 150 ng/g wet weight, respectively) and the fish contaminant goal (220 ng/g wet weight) (see Appendix C, Section ~~3.2.3.1~~C.7), suggesting low-level bioaccumulation potential in the two largest KHP reservoirs.
- PacifiCorp (2004c) reported that, in general, fish in the reservoirs at the Four Facilities are not exposed to levels of contaminants that may adversely affect human health via fish consumption. Exceptions to this include arsenic and total PCBs, which may equal or exceed the toxicity screening level for subsistence fishers (see Appendix C, Section ~~3.2.3.1~~C.7; PacifiCorp 2004c). Additionally, a subsequent a review of the PacifiCorp data and conversion to wet weight values found that mercury levels exceeded the screening level for subsistence fishers (0.049 ug/g) for samples from Keno, J.C. Boyle, Copco 1, and Iron Gate Reservoirs, and exceeded the screening level for recreational fishers (0.4 ug/g) for samples from samples from Copco 1 and Iron Gate Reservoirs (see Appendix C for more detail).
- Results from the 2010 Secretarial Determination fish tissue sampling indicate that a relatively small number of chemicals are present in fish tissue at levels with potential to cause minor or limited adverse effects to humans through fish consumption (Figure 3.2-2). These include arsenic, total PCBs, and dioxins in yellow perch at J.C. Boyle, Copco 1, and Iron Gate reservoirs (CDM 2011). In bullhead, the same chemicals are present, with the addition of mercury for Copco 1 Reservoir (see Section 3.2.3.8.3 and Appendix C for more details).

In summary, existing fish tissue, bioassay, and sediment chemistry data indicate that continued retention of sediments behind the KHP dams under the No Action/No Project Alternative may result in concentrations of inorganic and organic contaminants at levels that adversely affect beneficial uses or are toxic to humans in the Hydroelectric Reach. This includes possible exposure to low-level bioaccumulation of arsenic (which may be naturally elevated in the Upper Klamath Basin [see Section 3.2.~~2~~3.8~~, Inorganic and Organic Contaminants~~]) and mercury in fish residing in the lacustrine environment of the Keno Impoundment~~ (including~~ /Lake Ewauna~~)~~ and J.C. Boyle, Iron Gate, and Copco 1 Reservoirs.

Existing inorganic and organic contaminant data characterizing fish tissue in the reservoirs at the Four Facilities indicate that a relatively small number of chemicals (i.e., mercury, arsenic, total PCBs, and dioxins) are present at levels that have the potential to cause minor or limited adverse effects to humans through fish consumption in the Hydroelectric Reach. Continued impoundment of water at the Four Facilities under the *No Action/No Project Alternative* would result in no change from existing conditions.

Lower Klamath Basin

With the possible exception of compounds (i.e., mercury) that can be released (exported) from reservoir bottom waters under seasonally anoxic conditions, continued impoundment of water at the Four Facilities is not anticipated to result in increased exposure to inorganic and organic contaminants for freshwater aquatic species in the Klamath River downstream ~~of~~ from Iron Gate Dam. This is because contaminants that may be present in reservoir sediments at the Four Facilities would remain in place under the No Action/No Project Alternative. There is currently insufficient information to assess whether the No Action/No Project Alternative would expose downstream aquatic biota ~~to~~ to methylmercury released from bottom waters. Bioaccumulation of algal toxins (i.e~~.,~~ ., microcystin) has been documented in fish and mussel tissue in the Klamath ~~River~~ River downstream ~~of~~ from Iron Gate Dam (Kann et al. 2010) and is discussed further in Section 3.3, Aquatic Resources. Potential for the Proposed Action and alternatives ~~to~~ to affect production and toxicity of algal toxins in discussed in Section 3.4, Algae.

3.2.4.3.2~~–~~ Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

The Full Facilities Removal of Four Dams (Proposed Action) is the removal of four major dams in the Klamath Hydroelectric Project (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) along with the ancillary facilities of each installation in a 20-month period which includes an 8-month period of site preparation and partial drawdown at Copco 1 and a 12-month period for full drawdown and removal of facilities. This includes the entire dam, the powerhouses, spillways, and other infrastructure associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to ~~the DOI~~Reclamation and the implementation of the KBRA. Removal of the Four Facilities would not affect water quality in the following reaches in the Upper Klamath Basin: Wood, Williamson, and Sprague Rivers, Upper Klamath Lake, and Link River to the upstream end of J.C~~.~~. Boyle Reservoir. In the Hydroelectric Reach of the Upper Klamath Basin, removal of the Four Facilities would result in the release of sediments currently trapped behind the dams. This release would have short-term (<2 years following dam removal) effects on suspended sediments, dissolved oxygen, nutrients, and inorganic and organic contaminant concentrations in the Klamath River. Under the Proposed Action, interception and retention of sediments behind the dams at the Four Facilities would no longer occur; this would have long-term (2–50 years following dam removal) effects on suspended sediments. Additionally, elimination of the lacustrine environment of the reservoirs under the Proposed Action would have long-term effects on water temperature, dissolved oxygen, nutrients, pH, algal toxins and chlorophyll-*a* in the river. The following sections provide detail regarding the anticipated effects. KBRA under the Proposed Action is addressed at a programmatic level in the last subsection of the Proposed Action.

~~**3.2.4.3.2.1**~~

Water Temperature

Upper Klamath Basin

Removal of the Four Facilities under the Proposed Action and elimination of hydropower peaking operations at J.C. Boyle Powerhouse could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) alterations in ~~daily~~overall water temperatures and ~~fluctuations~~diel water temperature variation in the J.C. Boyle ~~bypass~~Bypass and ~~peaking reaches~~Peaking Reaches. Klamath TMDL model (see Appendix D) results indicate that under the Proposed Action (similar to the TMDL TOD2RN scenario, which includes Oregon TMDL allocations), water temperatures in the ~~Hydroelectric~~Bypass Reach immediately downstream ~~of~~ from J.C. Boyle Dam would be similar to those under the No Action/No Project Alternative, but there would be relatively ~~*higher* daily fluctuations~~*greater* diel water temperature variation during June through September (similar to the TMDL T4BSRN scenario) due to the absence of the thermal mass in J.C. Boyle Reservoir, which tends to moderate ~~daily~~diel water temperature ~~fluctuations~~variation immediately downstream ~~of~~from the dam under existing conditions (NCRWQCB 2010a). ~~Higher daily fluctuations~~Greater diel variation would also occur further downstream in the J.C. Boyle ~~bypass reach~~ Bypass Reach because it would no longer be dominated by cold groundwater inputs at a relatively constant temperature of 11–~~12~~12 °C (Kirk et al. 2010, data from electronic appendices of Asarian and Kann ~~2006a~~2006b). Water temperatures in this short river reach (i.e., downstream from the cold springs) would increase during summer months~~, moving it away from support of core coldwater habitat~~ due to the elimination of bypass operations and associated increase in streamflows; however, areas adjacent to the coldwater springs in the ~~bypass reach~~Bypass Reach would continue to serve as thermal refugia for aquatic species because the springs themselves would not be affected by the Proposed Action. Further, as described in Section 3.3.4.3 Alternative 2: Proposed Action – Key Ecological Attributes – Water Temperature, a shift in water temperatures toward natural diel variation would increase daily maximum temperatures, but would also increase nighttime cooling providing regular thermal relief, time for repair of proteins damaged by thermal stress, and significant bioenergetic benefits for salmonids.

In the J.C. Boyle ~~peaking reach~~ Peaking Reach model results indicate that water temperatures under the Proposed Action would ~~be~~ exhibit slightly lower ~~(~~daily maximum values (0.0–2 °C [0~~.5–1°C [0.9–1.8°F]) than~~–3.6 °F]) as compared to those predicted under the No Action/No Project and would exhibit *lower* ~~daily fluctuation~~diel water temperature variation during June through September, moving toward the natural thermal regime (Figure 3.2-3) (NCRWQCB 2010a, data from electronic appendices of Asarian and Kann ~~2006a~~2006b). At these locations the relative difference in ~~daily~~diel water temperature ~~fluctuations~~variation between the Proposed Action and the No Action/No Project Alternative is due to the elimination of peaking operations and the associated large ~~daily~~artificial temperature swings.

~~**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in summer/fall water temperatures and daily fluctuations in the J.C. Boyle bypass reach due to the elimination of hydropower peaking operations would be a significant impact. Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial.**~~

~~*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in spring water temperatures and decreases in late summer/fall water temperatures in the Hydroelectric Reach downstream of Copco 1 Reservoir*. In the Klamath River downstream of the J.C. Boyle bypass and peaking reaches, TMDL model results indicate that water temperatures under the Proposed Action would be slightly lower (0.5–1°C [0.9–1.8°F]) than those predicted under the No Action/No Project and would exhibit *lower* daily fluctuation during June through September (NCRWQCB 2010a, Asarian and Kann 2006a; Figure 3.2-3).~~ Overall, the TMDL model results indicate that June through October riverine water temperatures from J.C. Boyle Reservoir to the Oregon-California ~~state~~ State line would meet the Oregon narrative natural conditions criterion that supersedes the numeric objective (i.e., ~~16~~20 °C [~~60.8~~68 °F], see Table 3.2-3) for support of ~~core coldwater~~coolwater habitat.

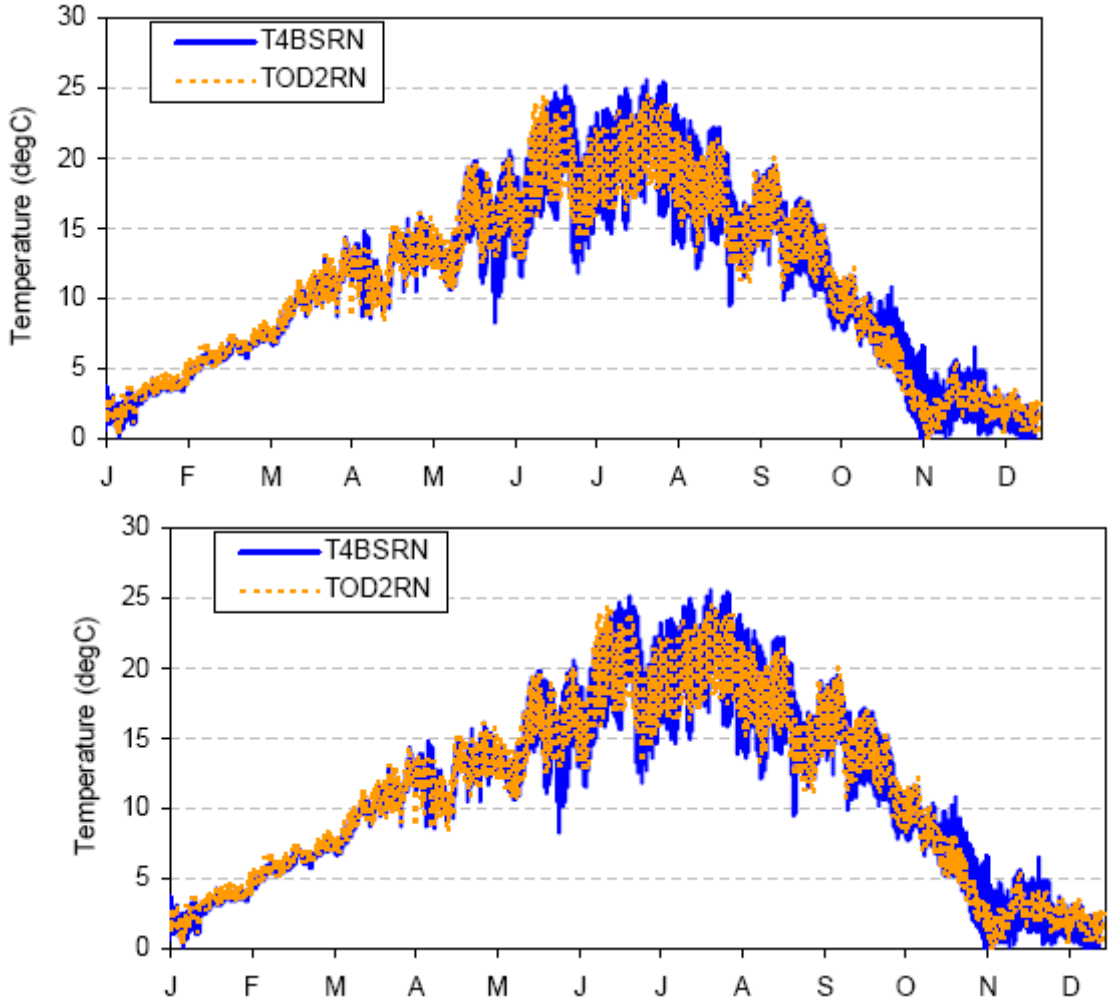


Figure 3.2-3. Predicted Water Temperature at the California-Oregon State ~~Line~~line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in summer/fall water temperatures and diel temperature variation in the J.C. Boyle Bypass Reach due to the removal of J.C. Boyle Reservoir and elimination of bypass operations would be a less than significant impact. Slight decreases in long-term maximum summer/fall water temperatures and less artificial water temperature swings in the J.C. Boyle Peaking Reach would be beneficial.

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in spring water temperatures and decreases in late summer/fall water temperatures in the Hydroelectric Reach downstream from Copco 1 Reservoir.

In the California portion of the Hydroelectric Reach, the TMDL model indicates that removal of the Four Facilities under the Proposed Action would eliminate the seasonal temperature shift caused by the Four Facilities in the Hydroelectric Reach~~ such that spring water temperatures~~ , returning the river to a more natural thermal regime. Removal of the Project reservoirs would ~~increase and late summer/fall temperatures would decrease. Just downstream of~~also result in a slight increase in flow as the evaporative losses would be reduced. Evaporation from the surface of the reservoirs is currently about 11,000 acre-feet/year and after dam removal the evapotranspiration in the same reaches is expected to be approximately 4,800 acre-feet/year, resulting in a gain in flow to the Klamath River of approximately 6,200 acre-feet/year (Reclamation 2012).

The TMDL model indicates that just downstream from Copco 1 and Copco 2 Reservoirs (≈RM 198), ~~this~~removal of the Four Facilities would increase daily maximum temperatures that are currently up to 7°C (13°F) lower than modeled natural conditions in spring (May and June) and decrease temperatures that are up to roughly 4°C (7°F) greater than modeled natural conditions in late summer/fall (August through October), due to the presence of the reservoirs (Figure 3.2-4) (NCRWQCB 2010a). Water temperature modeling conducted for the Klamath Dam Removal Secretarial Determination Studies provides generally similar results, with RBM10 model results showing a projected shift in the annual temperature cycle that would slightly increase river temperatures in the spring, and decrease temperatures in the late summer/fall in the Hydroelectric Reach under the Proposed Action (Perry et al. 2011). Further discussion of RBM10 results is presented below for the Lower Klamath Basin.

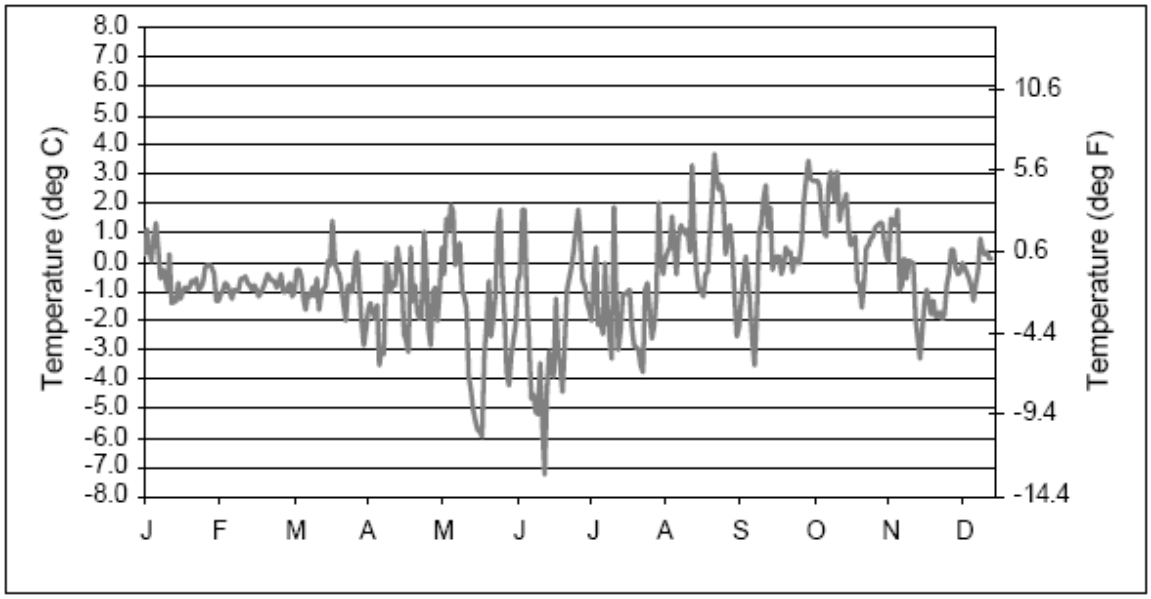


Figure 3.2-4. Estimated Changes in Daily Maximum Klamath River Water Temperatures at ≈RM 198 due to the Presence of Copco 1 and 2 Reservoirs for the 2000 Calendar Year. Positive Values Represent an Increase above Modeled Natural Conditions. Source: NCRWQCB 2010a.

Prior evaluations of the cooling effect of the Project reservoirs in spring have indicated that cooler spring water is potentially beneficial to rearing salmonids because it can reduce stress and disease for late outmigrants (PacifiCorp 2004a). However, as discussed in Section 3.3.4.3 (Alternative 2: Proposed Action), warming of spring water temperatures could lead to earlier fall-run Chinook spawning in the mainstem (reducing pre-spawn mortality) more in sync with historical spawning timing. In addition to earlier spawning, warmer spring temperatures would result in fry emerging earlier and growing faster, which could encourage earlier emigration downstream, reducing stress and disease (Bartholow 2005, FERC 2007). Thus, the projected increase in spring water temperatures under the Proposed Action would be a less than significant effect.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., prior to thermal stratification in the reservoirs), the aforementioned water temperature effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and would, therefore, also be short-term effects.

The Klamath TMDL model does not address the potential long-term effects of global climate change on water temperatures in the Klamath Basin (Appendix D). As described for the No Action/No Project Alternative, climate change is expected to increase summer

and fall water temperatures in the Klamath Basin on the order of 1–3 °C (1.8–5.4 °F) (Bartholow 2005, Perry et al. 2011). The Proposed Action would decrease long-term late summer/fall water temperatures and would therefore increase the likelihood that beneficial uses would be supported under climate change.

Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in springtime water temperatures and diel temperature variation in the Hydroelectric Reach would be ~~potentially~~ less than significant while decreases in late summer/fall water temperatures would be beneficial.

Lower Klamath Basin

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in spring water temperatures ~~and~~, decreases in late summer/fall water temperatures, and increased diel temperature variation in the Lower Klamath River. Water temperature modeling results are available for the Lower Klamath Basin from three separate modeling efforts: the PacifiCorp relicensing efforts (KRWQM; see Appendix D); development of the California Klamath River TMDLs (see Appendix D); and, water temperature modeling conducted for the Secretarial Determination studies (RBM10; see Appendix D). KRWQM results comparing the current condition (all KHP dams in place) to four without-project scenarios (i.e., no KHP dams including Keno Dam; without Iron Gate Dam; without Copco 1, Copco 2, and Iron Gate; and without J.C. Boyle, Copco 1, ~~Copco~~ Copco 2, and Iron Gate Dams) for 2001–2004 indicate that the reservoirs create a temporal shift by releasing generally cooler water from mid-January to April, variably cooler or warmer water from April through early August, and warmer water from August through November (PacifiCorp 2004a, Dunsmoor and Huntington 2006). Just downstream ~~of~~ from Iron Gate Dam (RM 190.1), this translates to a 1–2.5°C (1.8–4.5 °F) cooling during spring and a 2–10 °C (3.6–18 °F) warming during summer and fall (Figure 3.2-5). Immediately upstream of the confluence with the Scott River (~~RM~~ RM 143.9), the difference between existing conditions and without-project scenarios indicates a lesser, albeit still measurable, warming of 2–5 °C (3.6–9 °F) for most of October and November (Figure 3.2-6). Because patterns in reservoir thermal structure for Iron Gate and Copco 1 indicate that stratification generally commences in April and ends in November, the effect of reservoir thermal regime on downstream water temperatures appears to be cooling during non-stratified periods and warming during stratified periods. The cooling effect in spring is potentially beneficial to rearing salmonids by reducing stress and disease for late outmigrants, although it may also have adverse effects such as a delay in emergence or outmigration (see Section 3.3.4.3.2.1.4 Water Temperature). The fall warming effect, which can be stressful to rearing salmonids, lasts for the majority of late summer and fall months and is of larger magnitude (PacifiCorp 2004a).

Reservoir thermal regimes also act to reduce the magnitude of ~~daily~~diel temperature ~~fluctuations~~variation in the reservoir reaches and the riverine reaches immediately downstream ~~of~~ from Iron Gate Reservoir (RM 190.1; see Figure 3.2-5) (Deas and Orlob 1999, PacifiCorp ~~2004b~~2005). As with the seasonal temperature effect, the dampening influence on ~~daily~~diel temperature ~~fluctuations~~variation is ~~generally absent~~considerably diminished farther downstream, at the confluence with the Scott River (RM 143.9; see Figure 3.2-6). The KRWQM indicates that the temperature influence of the Hydroelectric Reach is mostly ameliorated by RM 66 at the confluence with the Salmon River (see Figure 3.2-7).

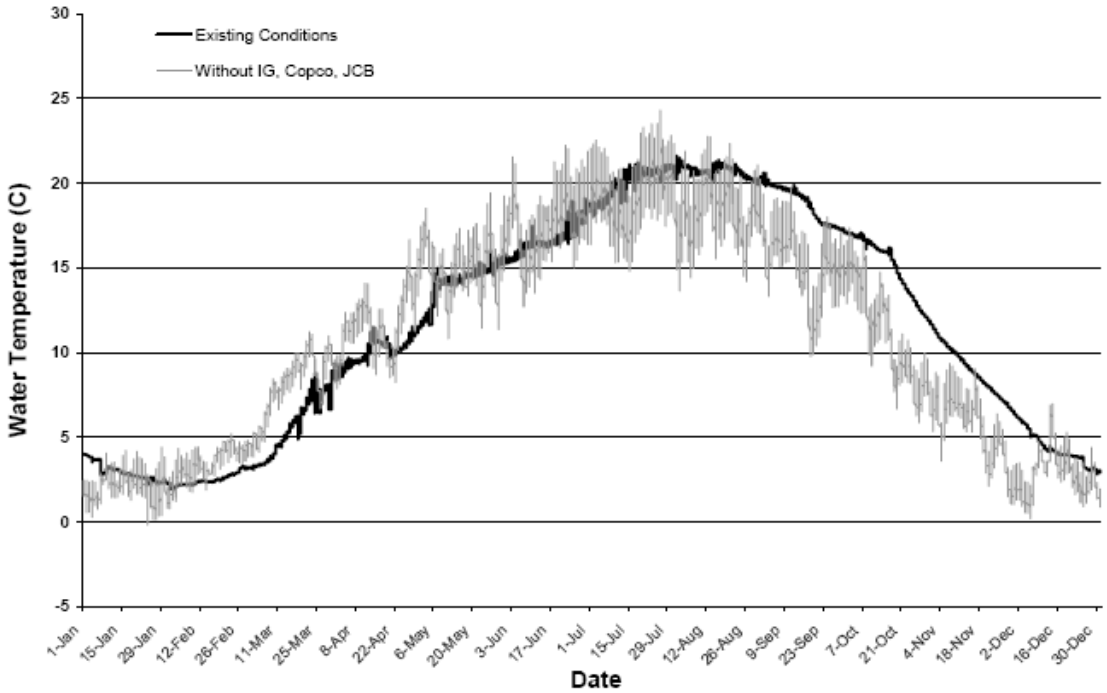


Figure 3.2-5. Simulated Hourly Water Temperature Downstream ~~of~~ from Iron Gate Dam (RM 190.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp ~~2004a~~2005.

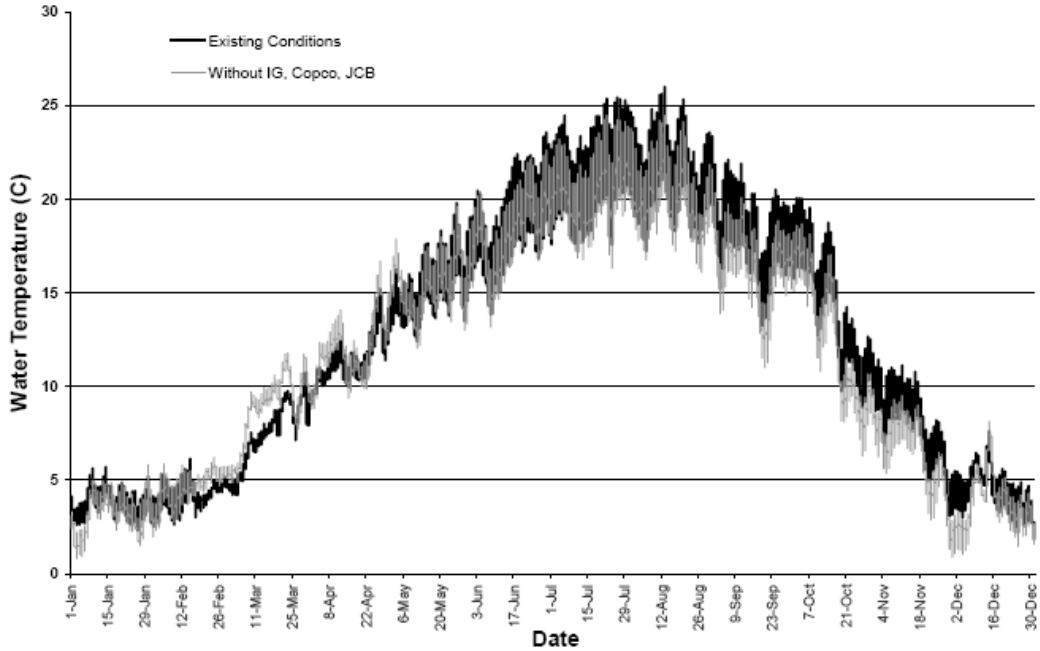


Figure 3.2-6. Simulated Hourly Water Temperature Immediately Upstream of the Scott River Confluence (RM 143.9) Based on Year

2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp ~~2004a.~~2005.

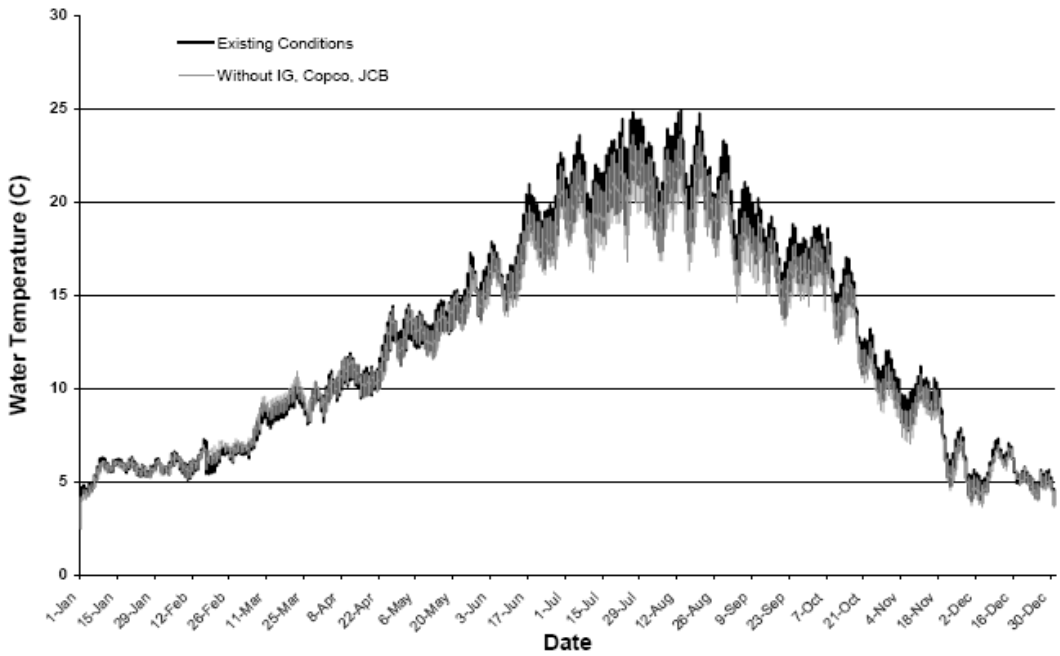


Figure 3.2-7. Simulated Hourly Water Temperature Downstream ~~of~~ from the Salmon River Confluence (≈RM 66) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp ~~2004a~~2005.

In agreement with KRWQM results, Klamath TMDL model (see Appendix D) results also indicate that under the Proposed Action (similar to the TMDL TCD2RN scenario), water temperature in the Klamath River downstream ~~of~~ from Iron Gate Dam (RM 190.1) would be 2–10 °C (3.6–18 °F) lower during August through November and 2–5 °C (3.6–9°F) higher during January through March than those under the No Action/No Project (similar to the TMDL T4BSRN scenario), due to removal of the large thermal mass created by the reservoirs (NCRWQCB 2010a). The Klamath TMDL model also predicts that ~~daily fluctuations~~diel variation in water temperature at this location during this same period would be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN) as water temperatures would be in equilibrium with (and would reflect) ~~daily fluctuations~~diel variation in ambient air temperatures. As with KRWQM, these impacts of removal of the Four Facilities would decrease in magnitude with distance downstream ~~of~~from Iron Gate Dam, and they would not be evident ~~by~~ in the reach downstream from the Salmon River confluence (≈RM 66) (NCRWQCB 2010a, Dunsmoor and Huntington 2006). Therefore, under the Proposed Action, water temperatures would not be directly affected in the lower river downstream ~~of~~from the confluence with the Salmon River, including the Klamath Estuary and the marine nearshore environment.

As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change were included in model projections for future water temperatures under the No Action/No Project Alternative and the Proposed Action. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures under the Proposed Action (where simulated flows are subject to KBRA flows) and climate change would be 1–2.~~3º~~3 °C (1.8–4.~~1º~~1 °F) warmer than historical temperatures (Perry et al. 2011). This temperature range is slightly lower than that suggested by projecting Bartholow (2005) historical (1962–2001) estimates of 0.~~05º~~05 °C (0.~~09ºF~~09 °F) per year, or 2–3 °C (3.6–5.4 °F) over 50 years. However, within the general uncertainty of climate change projections, results from the two models correspond reasonably well and indicate that water temperatures in the Upper Klamath Basin are expected to increase ~~with~~within the period of analysis on the order of 1–3 °C (1.8–5.4 °F).

RBM10 results also indicate that, despite warming of water temperatures under climate change, the primary effect of dam removal is still anticipated to be the return of approximately 160 miles of the Klamath River, from J.C. Boyle Reservoir (RM 224.7) to the Salmon River (RM 66), to a natural thermal regime (Perry et al. 2011). Model results indicate that the annual temperature cycle downstream ~~of~~from Iron Gate Dam would shift forward in time by approximately 18 days under the Proposed Action, with warmer temperatures in spring and early summer and cooler temperatures in late summer and fall immediately downstream ~~of~~from the dam. Just downstream ~~of~~from Iron Gate Dam, water temperatures under the Proposed Action including climate change would average ~~2º~~2 °C greater in May than those under the No Action/No Project Alternative, while during October water temperatures would average 4°C cooler. At the confluence with the Scott River, the differences would be diminished, but there would still be a slight warming (<1 ~~º~~°C) in the spring and cooling (1–2 ~~º~~°C) in the late summer and fall (Perry et al. 2011). Thus, despite the anticipated warming under climate change, water temperature improvements under the Proposed Action would still help to achieve the Oregon and California temperature TMDLs for the mainstem Klamath River.

Although all of the existing water temperature model projections (KRWQM, TMDL, RBM10) indicate that spring water temperatures would increase under the Proposed Action, as discussed in Section 3.3.4.3 (Alternative 2: Proposed Action) this effect could lead to earlier spawning of natural fall-run Chinook salmon, a longer incubation period, earlier emergence and growth, and would encourage earlier emigration, thus reducing stress and disease for this species (Hamilton et al. 2011). Overall, the increase in spring water temperatures under the Proposed Action would be a less than significant.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., prior to reservoir thermal stratification), water temperature effects of the Proposed Action in the Klamath River downstream ~~of~~from Iron Gate Dam would occur, either partially or fully, within the first 1 to 2 years following dam removal and would be a short-term effect as well as a long-term effect.

Under the *Proposed Action*, the short-term (<2 years following dam removal) ~~and~~ and long-term (2–50 years following dam removal) increases in spring water temperatures and increased diel temperature variation for the reach from Iron Gate Dam to the confluence with the Salmon River would be ~~potentially~~less than significant. Decreases in late summer/fall water temperatures would be beneficial. There would be no change from existing conditions on water temperatures for Klamath River downstream ~~of~~from the Salmon River, the Klamath Estuary, and the marine nearshore environment.

Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) and/or long-term (2-50 years following dam removal) increases in sediment deposition in the Klamath River or Estuary that could alter morphological characteristics and indirectly affect seasonal water temperatures. Increased sediment deposition in the estuary under the Proposed Action may decrease the size of the salt wedge, either by increasing the frequency of mouth closure, or by elevating the bottom of the estuary above portions of the tidal range when the mouth is open. Alternately, scouring of current estuarine sediment deposits may occur during the short-term high sediment transport predicted to occur following dam removal, which may sufficiently change morphology as to effect mouth closure, salt wedge formation, and associated seasonal water temperatures. However, because little short-term settling, sedimentation, or scouring is expected to occur in the Klamath River or the estuary as a result of the Proposed Action (see Section 3.11.4.3), and estimates of baseline sediment delivery for the Klamath Basin indicate that long-term sediment delivery rates will not change substantially under the Proposed Action (Stillwater Sciences 2010), **there would be no indirect effect on water temperatures in the Klamath Estuary under the *Proposed Action*.**

~~3.2.4.3.2.2~~ Suspended Sediments

Upper Klamath Basin

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in suspended material in the Hydroelectric Reach downstream ~~of~~from J.C. Boyle Dam due to the release of sediments currently trapped behind the dams at the Four Facilities. Results of sediment transport modeling of the impacts of dam removal on suspended sediment in the ~~lower~~Lower Klamath River indicate high short-term loads immediately downstream ~~of~~from Iron Gate Dam under the Proposed Action (~~Greimann et al. 2011~~Reclamation 2012, Stillwater Sciences 2008). Modeled SSCs[11] downstream ~~of~~from J.C. Boyle Reservoir are similarly high in the short-term, although due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (i.e., 15 percent of total volume for the Four Facilities, see also Figure 3.3-8), concentrations would be considerably less than those anticipated to occur downstream ~~of~~from Iron Gate Reservoir. Overall, and within the general uncertainty of the model predictions, SSCs at J.C. Boyle Reservoir across the three water year types would have

[11] For the purposes of this report, SSC is considered equivalent to TSS. As needed, data from multiple sources reported as either TSS or SSC are used interchangeably, despite potential differences in the numeric values reported by each method. (Gray et al. 2000).

peak values of 2,000–3,000 mg/L and occurring within 1–2 months of reservoir drawdown. Predicted SSCs quickly decrease to less than ~~100~~ 100 mg/L for 5–7 months following drawdown, and concentrations less than 10 mg/L for 6–10 months following drawdown (Figures 3.2-8 through 3.2-10). **Under the *Proposed Action*, the short-term (<2 years following dam removal) increases in SSCs in ~~the~~ the Hydroelectric Reach downstream ~~of~~from J.C. Boyle Dam would be a significant impact.**

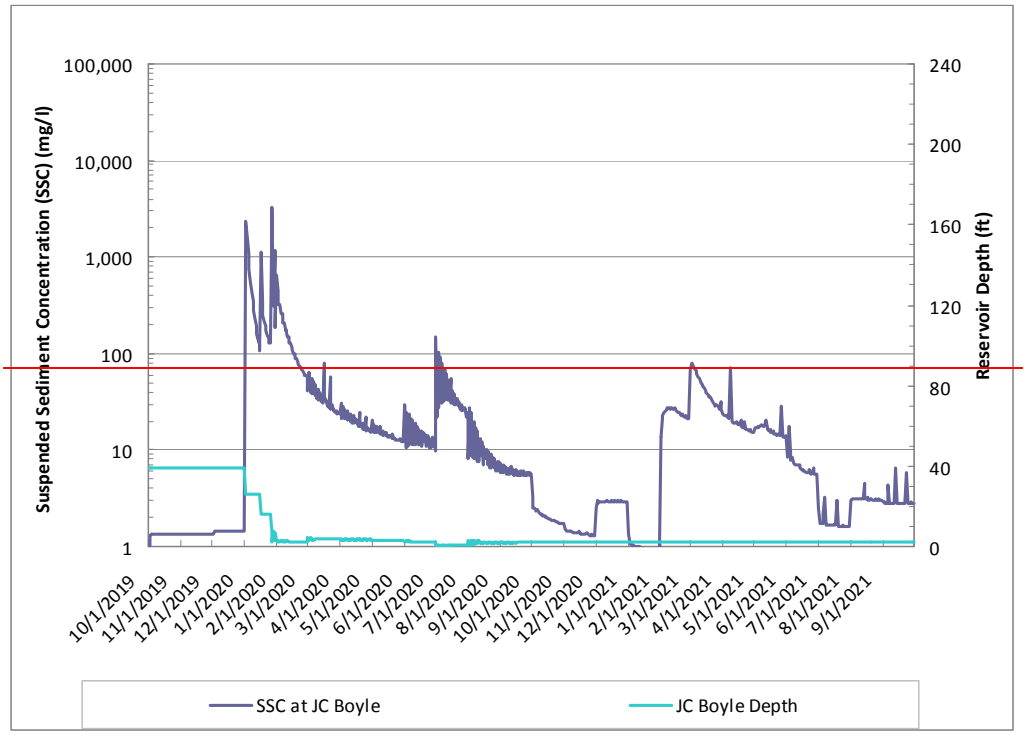
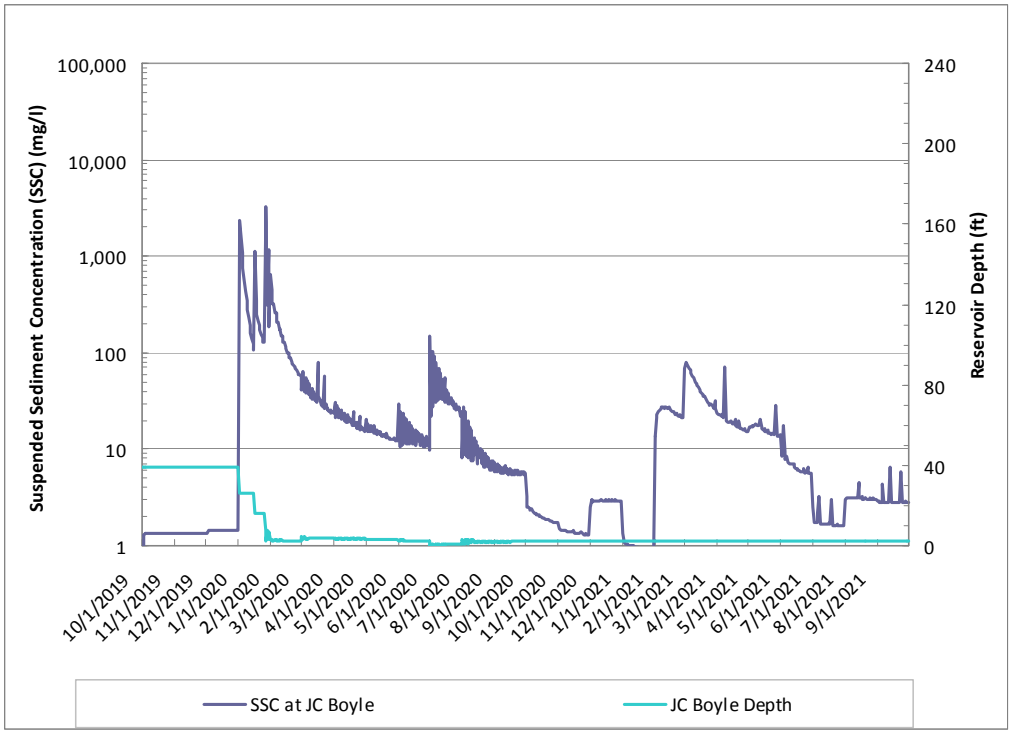
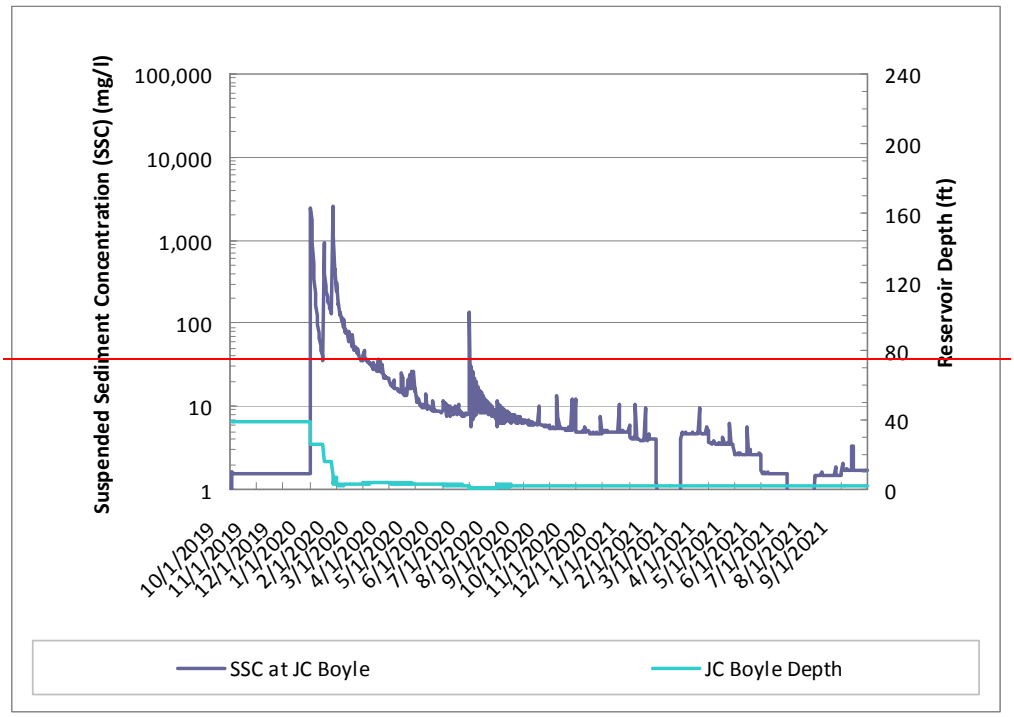


Figure 3.2-8. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Dry Hydrology (WY2001).




Suspended Sediment Concentration (SSC) (mg/l)
100,000
10,000
1,000
100
10
1
Reservoir Depth (ft)
240
200
160
120
80
40
0
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
8/1/2020
9/1/2020
10/1/2020
11/1/2020
12/1/2020
1/1/2021
2/1/2021
3/1/2021
4/1/2021
5/1/2021
6/1/2021
7/1/2021
8/1/2021
9/1/2021
SSC at JC Boyle
JC Boyle Depth

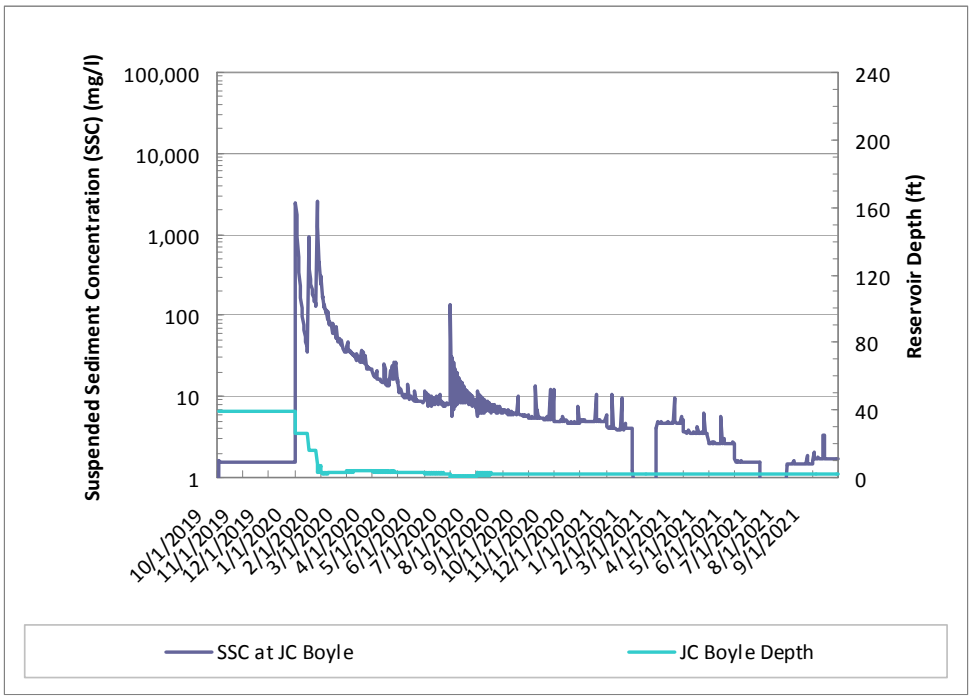
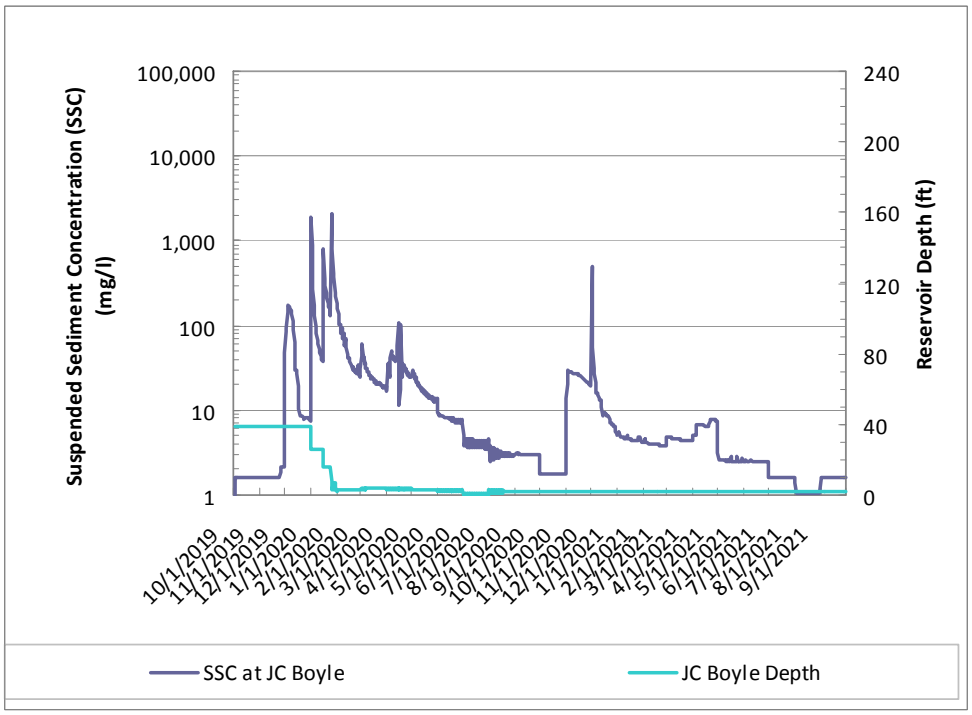


Figure 3.2-9. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Median Hydrology (WY1976).



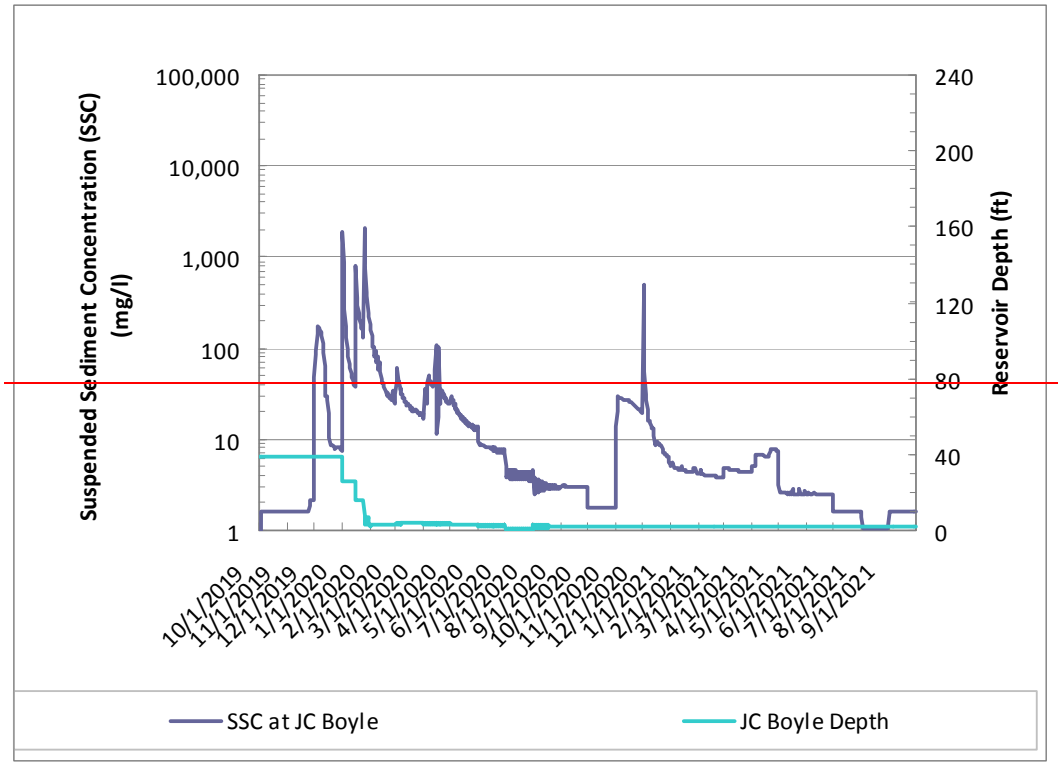


Figure 3.2-10. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Wet Hydrology (WY1984).

Stormwater runoff from deconstruction activities under the Proposed Action could cause short-term increases in suspended material in the Hydroelectric Reach during the deconstruction period. Deconstruction activities under the Proposed Action would include demolition of the dams and their associated structures, power generation facilities, transmission lines, installation of temporary cofferdams, road upgrading, hauling, reservoir restoration, and other activities (as described in Section 2.4.3.1). Deconstruction activities are scheduled to occur between January 10 and June 26, with cofferdam installation scheduled to occur between 2 January 2020 and 6 February 2020. Therefore, cofferdam installation would occur during the first month of reservoir drawdown and the period of peak SSCs associated with mobilization of reservoir sediment deposits during drawdown. While the magnitude of short-term effects on SSCs due to erosion of the large volume of reservoir sediment deposits trapped behind the dams would be substantially greater than those due to dam deconstruction activities, this does not alleviate the requirement to reduce impacts from deconstruction-related activities. The potential for sediments to enter the Hydroelectric Reach from deconstruction site runoff, cofferdam installation, or in-water deconstruction work can be minimized or eliminated through the implementation of BMPs for deconstruction activities that would occur in or adjacent to the Klamath River (Appendix B). **Under the *Proposed Action*, the effect of stormwater runoff from deconstruction activities on**

SSCs in the Hydroelectric Reach downstream ~~of~~ from J.C. Boyle Dam would be a less-than-significant impact.

Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach. The Proposed Action includes seven out of the eight years of gravel placement ~~(after an Affirmative Determination until 2019)~~under IM 7; the first year would be before the Secretary makes a determination, and would therefore be included in the No Action/No Project Alternative. The following seven years would be part of the Proposed Action. Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches. The spawning gravel would be placed using a passive approach before high flow periods, or to provide for other habitat enhancement in the Klamath River upstream of Copco 1 Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal~~.~~ (for effects on aquatic species, see Section 3.3.4.3.2). Passive gravel placement is specified by IM 7, which would avoid in-stream placement of gravel and would limit turbidity increases to periods of high river flow when turbidity is naturally elevated. The potential for sediments to enter the water during gravel placement along the river banks could be minimized or eliminated downstream ~~of~~from the enhancement sites through the implementation of BMPs for construction activities (Appendix B) (BLM 2011). Any disturbed sediments would be trapped by ~~Iron Gate~~Copco 1 Reservoir and not transferred downstream to the Klamath River prior to dam removal, particularly given implementation of BMPs. **Under the *Proposed Action*, the short-term effect of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, on SSCs in the Hydroelectric Reach would be a less-than-significant impact.**

Implementation of IM 16, Water Diversions, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach due to diversion screening deconstruction and construction activities. Under IM 16, PacifiCorp would seek to eliminate three screened diversions (the Lower Shovel Creek Diversion [7.5 cfs], Upper Shovel Creek Diversion [2.5 cfs], and Negro Creek Diversion [5 cfs]) from Shovel and Negro Creeks and would seek to modify its water rights to move the points of diversion from Shovel and Negro creeks to the mainstem Klamath River. If this were successful the screened diversions would be removed prior to dam removal in 2020. The intent of this measure is to provide additional water to Shovel and Negro creeks, thus increasing the quality and amount of suitable habitat for aquatic species within these tributaries, while not diminishing PacifiCorp's water rights. The potential for sediments to enter the water during screen removal activities is minimal if the diversions are individual pump intakes. If the diversions are larger concrete structures, the impacts would be of greater magnitude and longer duration, albeit still short-term and due to construction/deconstruction activities. In this case, impacts to SSCs can be minimized or eliminated through the implementation of BMPs for construction activities (Appendix B) stipulated during permitting of IM 16. Since IM 16 would be undertaken prior to dam removal, any disturbed sediments would be trapped by Copco 1 Reservoir and not

transferred downstream to the Klamath River prior to dam removal, particularly given implementation of BMPs. The diversions would not be likely to affect other aspects of short-term or long-term water quality in the mainstem Klamath River since the water rights are relatively small (7.5 cfs, 2.5 cfs, and 5 cfs) compared to seasonal low flows in the mainstem upstream of Copco 1 Reservoir (typically >800 cfs). **Under the *Proposed Action*, the effect of IM 16, Water Diversions, on SSCs in the Hydroelectric Reach in the J.C. Boyle Bypass Reach would be a less-than-significant impact.**

~~*Construction of the Yreka Pipeline under the Proposed Action could cause short-term increases in suspended material in the Hydroelectric Reach during the construction period.* For construction of the Yreka Pipeline, Dam Removal Entity (DRE) would construct a new, elevated pipeline and steel pipeline bridge to support the pipe above the river at the upstream end of Iron Gate Reservoir (see Section 2.4.3). The pipeline bridge would require in-water work in 2019 to build three concrete piers to support the bridge. Additional construction would occur along the Iron Gate Reservoir banks at each end of the new bridge where the new pipeline would be connected to the existing buried pipeline. The potential for sediments to enter the water during in-water pier construction and from construction site runoff can be minimized or eliminated in Iron Gate Reservoir through the implementation of BMPs for construction activities (Appendix B). Since the construction work will be undertaken in 2019, prior to dam removal, any disturbed sediments would be trapped by Iron Gate Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the *Proposed Action*, the effect of Yreka Pipeline construction activities on SSCs in the Hydroelectric Reach at the upstream end of Iron Gate Reservoir would be a less-than-significant impact.**~~

Under the Proposed Action, recreational facilities currently located on the banks of the existing reservoirs will be removed following drawdown, and could release suspended sediment into the Klamath River. The existing recreational facilities provide camping and boating access for recreational users of the reservoirs. Once the reservoirs are drawn down, these facilities will be removed. The potential for sediments to enter the water during the facilities removal will be minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **Under the *Proposed Action*, the short-term impacts on SSCs from the deconstruction of the recreational facilities would be less-than-significant.**

Under the Proposed Action, revegetation associated with management of the reservoir footprint area could decrease the erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach. Based on the reservoir area management planning currently underway, establishment of herbaceous vegetation in drained reservoir areas will be undertaken to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (O'Meara et al. 2010). Hydroseeding of herbaceous vegetation (i.e., grass) would be used, which typically entails applying a

mixture of wood fiber, seed, fertilizer, and stabilizing emulsion to exposed slopes. Hydroseeding would be undertaken using a barge in spring 2020 while reservoir levels are high enough to operate and access the barge. Later in spring and summer 2020, aerial application would be necessary for precision applications of material near the newly established river channel, as well as in the remaining areas (see Section 2.3.4.5). Some aerial fall seeding in 2020 might be necessary to supplement areas where spring hydroseeding was unsuccessful.

Hydroseeding would be undertaken using standard BMPs for reducing water quality impacts during deconstruction and/or construction activities and restoration projects (Appendix B). Additional BMPs specific to hydroseeding, such as avoiding over-spray onto roads, trails, existing vegetation, and the stream channel, would also be implemented so that the hydroseed mixture itself would not easily runoff or be directly sprayed into the Klamath River. **Under the *Proposed Action*, hydroseeding would decrease the short-term (<2 years following dam removal) erosion of fine sediments from exposed reservoir terraces into the river channel in the Hydroelectric Reach and would be beneficial.**

Under the Proposed Action, the lack of continued interception and retention of mineral (inorganic) suspended material by the dams at the Four Facilities could result in long-term (2–50 years following dam removal) increases in suspended material in the Hydroelectric Reach. Peak concentrations of mineral (inorganic) suspended material (silts and clays with diameter < 0.063 mm) in the Hydroelectric Reach during the winter/early spring (November through April) would likely remain associated with high-flow events and any increases due to the lack of interception by the dams would not be large; estimates of baseline sediment delivery for the Klamath Basin indicate that a relatively small fraction of total sediment (199,300 tons per year or 3.4 percent of the cumulative average annual delivery from the basin) is supplied to the Klamath River on an annual basis from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) due to the generally lower rates of precipitation and runoff, more resistant and permeable geologic terrain, and relatively low topographic relief and drainage density of the Upper Klamath Basin as compared with the lower basin. (Stillwater Sciences 2010).**Under the *Proposed Action*, the long-term (2–50 years following dam removal) increase in mineral (inorganic) suspended material in the Hydroelectric Reach would be a less-than-significant impact.**

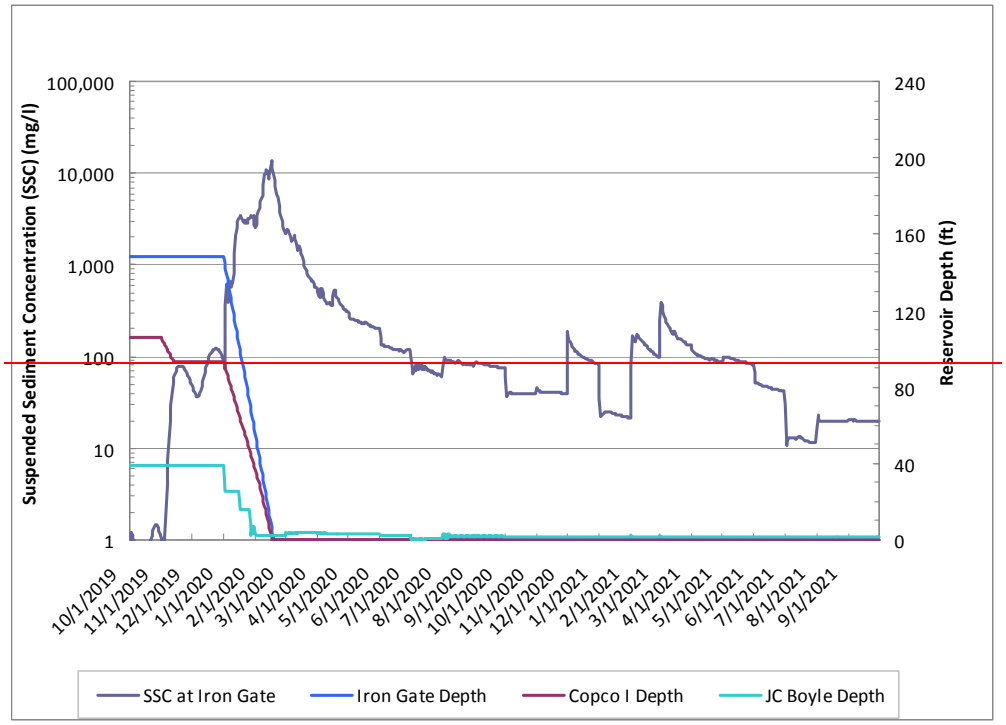
Under the Proposed Action, the lack of continued interception and retention of algal-derived (organic) suspended material by the dams at the Four Facilities could result in slight long-term (2–50 years following dam removal) increases in suspended material in the Hydroelectric Reach. Episodic increases (10–20 mg/L) in algal-derived (organic) suspended material resulting from in-reservoir algal productivity are not expected to

occur in the Hydroelectric Reach following dam removal. SSCs in the Hydroelectric Reach may attain levels similar to those observed upstream of J.C. Boyle Dam under existing conditions during May through October (>15 mg/L; see Appendix C), as algal-dominated suspended material is transported downstream from Upper Klamath Lake. However, similar to the No Action/No Project Alternative, interception and retention of suspended material from upstream sources would still occur to a large degree in the Keno Impoundment~~ (including~~ /Lake Ewauna~~)~~, as would additional decreases in concentration due to mechanical breakdown of algal remains in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, and dilution from the springs downstream ~~of~~from J.C. Boyle Dam. If slight long-term increases in suspended materials did occur, they would likely be offset by the loss of algal-derived suspended material previously produced in Copco 1 and Iron Gate Reservoirs and would not exceed levels that would substantially adversely affect the cold freshwater habitat (COLD) beneficial use (see discussion under Alternative 2 – Suspended Sediments – Lower Klamath Basin). **Under the *Proposed Action*, the long-term (2–50 years following dam removal) changes in algal-derived (organic) suspended material in the Hydroelectric Reach would be a less-than-significant impact.**

Lower Klamath Basin

Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in suspended material in the ~~lower~~Lower Klamath River and the Klamath Estuary. Sediment transport modeling of the impacts of dam removal on suspended sediment in the ~~lower~~Lower Klamath River indicates high short-term loads immediately downstream ~~of~~from Iron Gate Dam under the Proposed Action (~~Greimann et al. 2011~~Reclamation 2012, Stillwater Sciences 2008). The Proposed Action involves a three-phase drawdown for Copco 1 Reservoir beginning on ~~November~~ November 1, 2019, and a single-phase drawdown for J.C. Boyle and Iron Gate Reservoirs beginning on January 1, 2020 (~~Greimann et al. 2011~~Reclamation 2012), which allows maximum SSCs[12] to occur during winter months when flows and SSCs are naturally high in the mainstem river (e.g., see Appendix C, Figure C-9). Suspended sediment model predictions downstream from Iron Gate Dam for the Proposed Action are presented in Figure 3.2-11 through 3.2-13 for ~~the~~ the three water year types (dry, median, wet) considered as part of the Secretarial Determination process. Model predictions are discussed below and summarized in ~~Table~~ Table 3.2-11.

[12] For the purposes of this report, SSC is considered equivalent to TSS. As needed, data from multiple sources reported as either TSS or SSC are used interchangeably, despite potential differences in the numeric values reported by each method. (Gray et al. 2000).



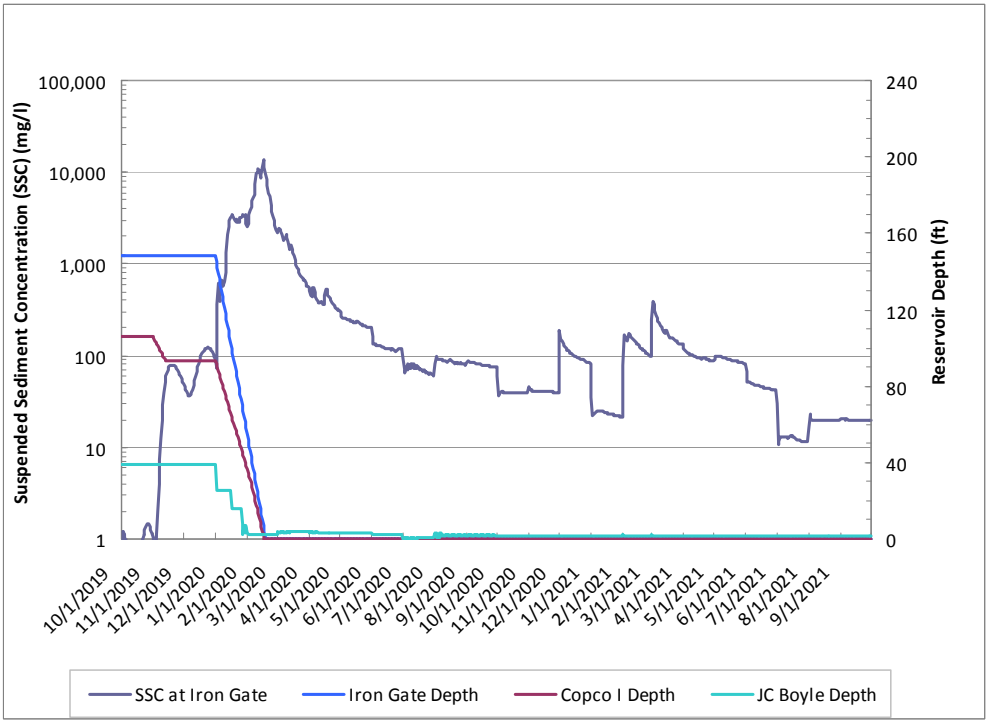
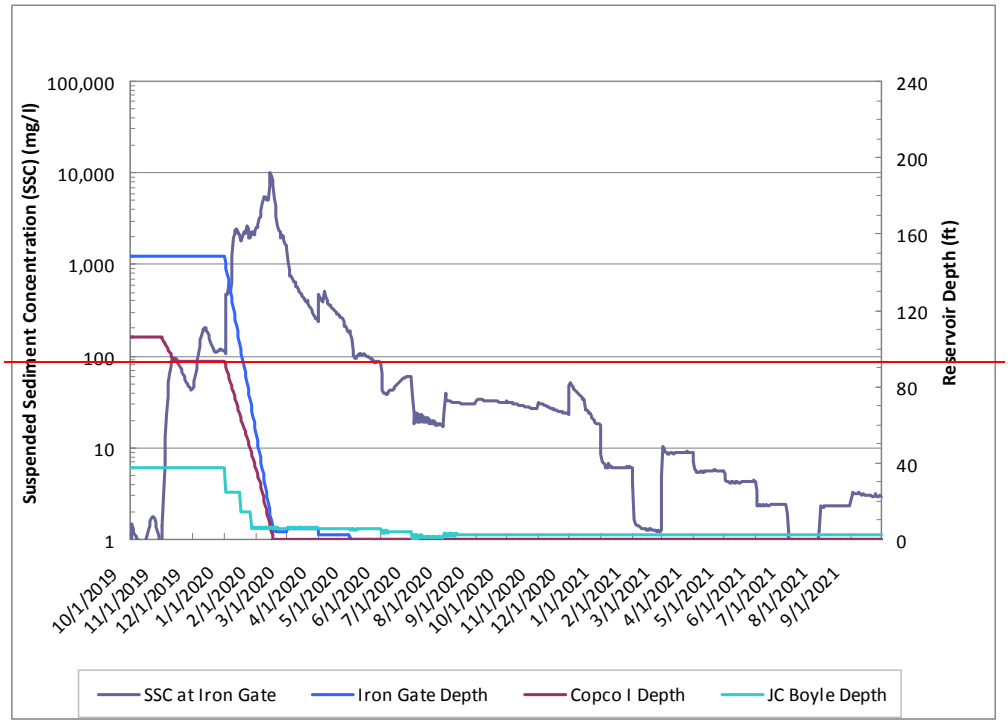


Figure 3.2-11. SSCs Modeled Downstream ~~of~~from Iron Gate Dam Under the Proposed Action Assuming Typical Dry Hydrology (WY2001).



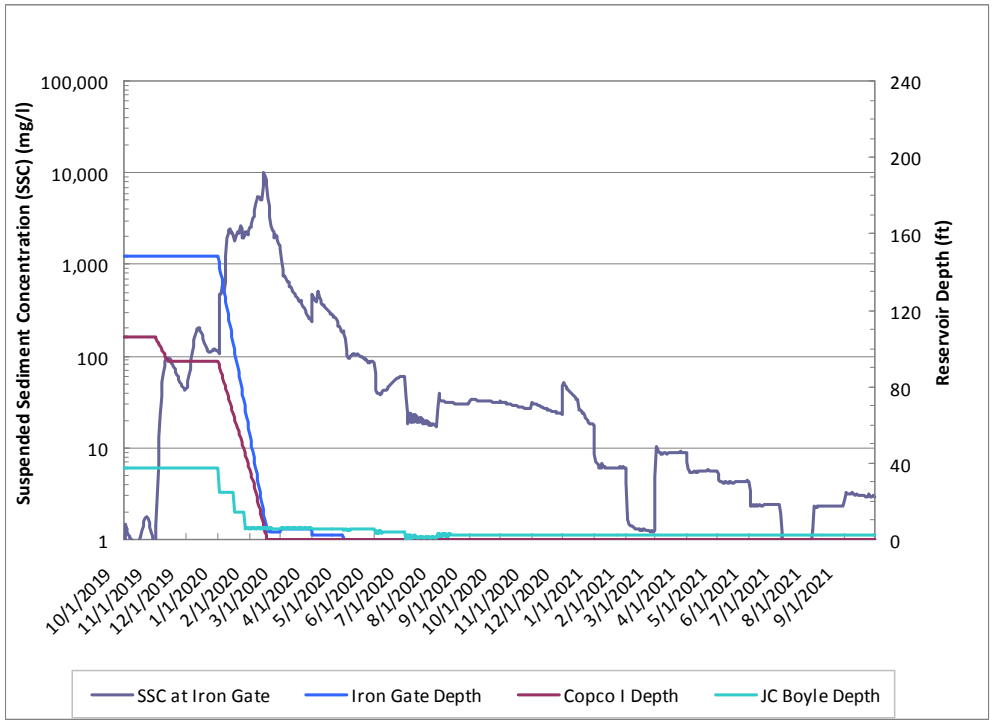
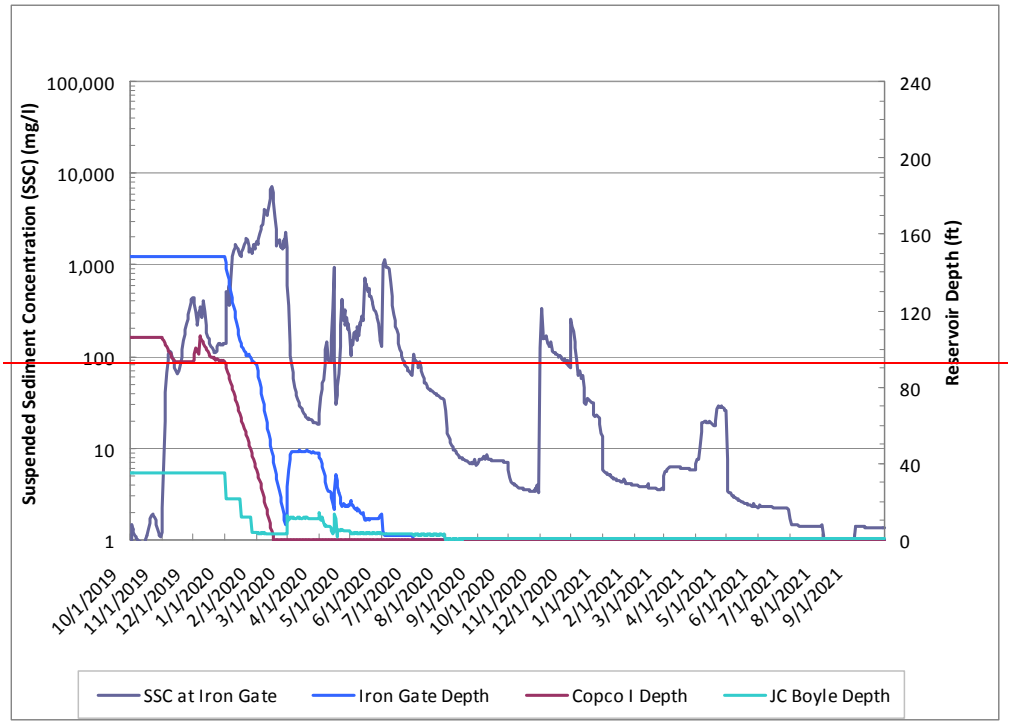


Figure 3.2-12. SSCs Modeled Downstream ~~of~~from Iron Gate Dam Under the Proposed Action Assuming Median Hydrology (WY1976).



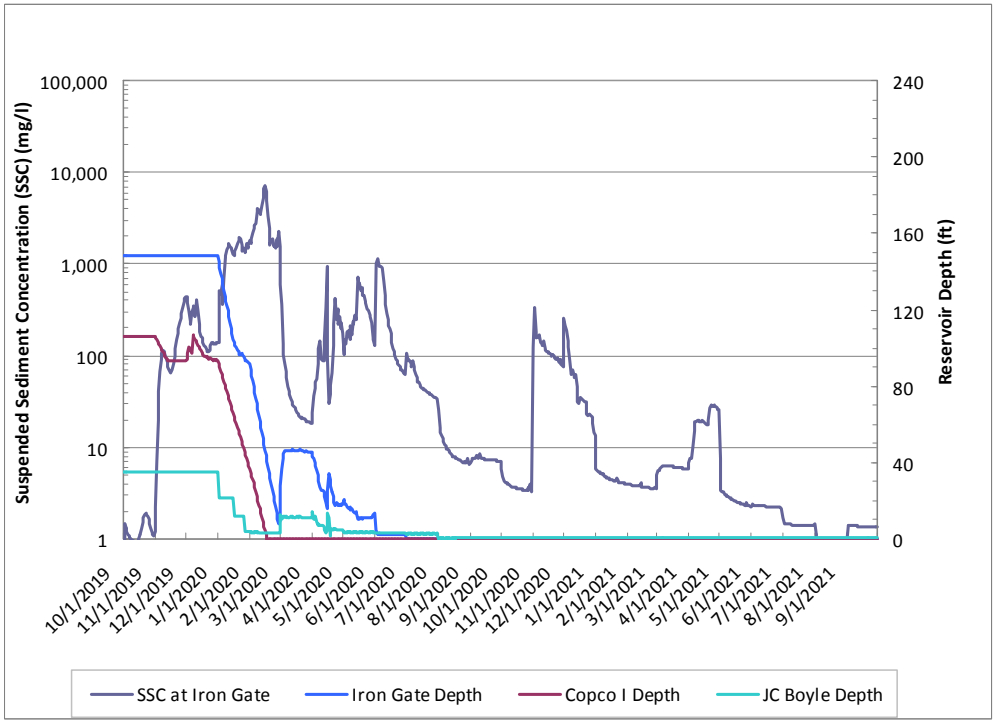


Figure 3.2-13. SSCs Modeled Downstream ~~of~~from Iron Gate Dam Under the Proposed Action Assuming Typical Wet Hydrology (WY1984).

Table 3.2-11. Summary of Model Predictions for SSCs in the Klamath River Downstream ~~of~~from Iron Gate Dam for the Proposed Action~~.~~

Water Year Type	Peak SSC (mg/L)	SSC≥1,000 mg/L		SSC≥100 mg/L		SSC≥30 mg/L	
		Duration (Months)	Time Period	Duration (Months)	Time Period	Duration (Months)	Time Period
Dry (WY2001)	13,600	3	January–March 2020	6	January–June 2020	10	January–October 2020
Median (WY1976)	9,900	2	January–February 2020	5	January–May 2020	6	January–June 2020
Wet (WY1984)	7,100	2	January–February 2020 and April–July 2020	7	November 2019–February 2020 and April– June 2020	9	November 2019–July 2020

For typical dry year (WY2001) hydrologic conditions, predicted SSCs in the Klamath River immediately downstream ~~of~~ from Iron Gate Dam (RM 190.1) experience a relatively small increase to near 100 mg/L in mid-November 2019 as Copco 1 undergoes the first phase of drawdown~~, and a~~. A second, relatively large increase (>1,000 mg/L) would occur in early January 2020 when Iron Gate and J.C. Boyle begin drawdown and Copco 1 ~~enters~~ enters phase 2 of drawdown. Concentrations remain very high (>1,000 mg/L) for approximately 3 months from January through April 2020 (see Figure 3.2-11), with peak values exceeding 10,000 mg/L to reach approximately 13,600 mg/L for a short period
(4–5 days) in mid-February 2020. SSCs generally return to less than 100 mg/L by July 2020, and to concentrations near 30 mg/L by October 2020. Predicted SSCs increase again to levels between 200–400 mg/L during winter and spring of 2021 due to flushing of sediments that were not removed during the first year following drawdown.

Model predictions for median year (WY1976) hydrologic conditions follow a pattern similar to that of a typical dry year (WY2001), with a relatively small increase in SSCs (i.e., to near 200 mg/L) in mid-December 2019, and a large (>1,000 mg/L) increase again in early January 2020. Peak SSCs downstream ~~of~~ from Iron Gate Dam are predicted to be lower for the median year condition, reaching levels just under 10,000 mg/L. Relative ~~to~~ to the typical dry year, the lower median year peak SSCs are a result of greater flows flushing the same volume of sediment out of the reservoir and downstream. Peak concentrations also occur in mid-February 2020 for the median year hydrologic condition (see Figure 3.2-12). Predicted SSCs downstream ~~of~~ from Iron Gate Dam (RM 190.1) remain very high (>1,000 mg/L) for approximately 2 months following the inception of drawdown in Iron Gate and Copco 1 Reservoirs, from January through February 2020. There is a slightly earlier return to SSCs less than 100 mg/L for the median year (WY1976), with concentrations decreasing by May 2020. SSCs decrease to less than ~~30~~ 30 mg/L by June 2020, and fluctuate between 10 mg/L and 100 mg/L through the remainder of 2020. The increases above 100 mg/L are not predicted for the typical median water year condition in the year following dam removal (2021), but fluctuating SSCs may occur in the second year following dam removal due to erosion of sediment deposits remaining in the reservoir footprint area.

Model predictions for typical wet year (WY1984) hydrologic conditions indicate a higher initial pulse of fine sediments following the first phase of Copco 1 drawdown in early to mid-December 2019, with concentrations at or near 400 mg/L. Model predictions indicate that for typical wet year conditions, the outlet capacity at Copco 1 Dam is exceeded during the same timeframe and the reservoir fills slightly (see Figure 3.2-13). Very high (>1,000 mg/L) SSCs are experienced for approximately 2 months following the inception of drawdown in the reservoirs, from January through February 2020 (see Figure 3.2-13). SSCs reach approximately 7,100 mg/L, with peak values occurring in mid-February 2020. Secondary peaks (≈1,000 mg/L) in SSCs occur in mid-April and June 2020 for wet year (WY1984) hydrologic conditions. SSCs generally return to less than 100 mg/L during the month of March 2020 and then again by July 2020. Concentrations return to less than 30 mg/L by July 2020.

For all three water year types, predicted SSCs in the ~~lower~~Lower Klamath River decrease to 60–70 percent of their value at Iron Gate Dam by Seiad Valley (RM 129.4) and to ~~40~~ 40 percent of their ~~initial~~ value at Iron Gate Dam by about RM 59, downstream ~~of~~from Orleans (~~≈RM 59) (Greimann et al. 2011~~Reclamation 2012).

Overall, and within the general uncertainty of the model predictions, SSCs across the three water year types would have peak values of 7,000–14,000 mg/L and ~~occurring~~would occur within 2–3 months of reservoir drawdown. SSCs in excess of 1,000 mg/L would occur on a timescale of weeks to months (see Table 3.2-11), as compared to SSCs greater than 1,000 mg/L that can occur during winter storm events on a timescale of days to weeks under existing conditions in the Klamath River downstream from Iron Gate Dam (see Appendix C, Section C.2.2.2). Predicted SSCs would remain greater than or equal to ~~100~~ 100 mg/L for 5–7 months following drawdown, and concentrations would remain greater than or equal to 30 mg/L for 6–10 months following drawdown (Table 3.2-11). Model results also indicate that while dilution in the lower river would decrease SSCs to 60–~~70~~ 70 percent of their initial value downstream from Seiad Valley (RM 129.4) and to 40 percent of their initial value downstream ~~of Seiad Valley (RM 129.4) and to 40 percent of their initial value downstream of~~from Orleans (≈RM 59), within a factor of ~~2~~ 2 uncertainty for the model results it can be conservatively assumed that SSCs in the ~~lower~~Lower Klamath River would be sufficient (≥30 mg/L) to substantially adversely affect beneficial uses throughout the lower River and the Klamath Estuary for 6–10 months following drawdown (~~Greimann et al. 2011~~Reclamation 2012). A more detailed analysis of the anticipated suspended sediment effects on key fish species in the lower river is presented in ~~Section~~ Section 3.3.4.3.

Overall, sediment release associated with the Proposed Action would cause short-term increases in suspended material (≥30 mg/L for 6–10 months following drawdown) that would result in non-attainment of applicable North Coast Basin Plan water quality objectives for suspended material in the ~~lower~~Lower Klamath River and the Klamath Estuary and would substantially adversely affect the cold freshwater habitat (COLD) beneficial use. **Under the *Proposed Action*, the short-term (<2 years following dam removal) increases in SSCs in the ~~lower~~Lower Klamath River and the Klamath Estuary would be a significant impact.**

Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in sediment loads from the Klamath River to the Pacific Ocean and corresponding increases in concentrations of suspended material and rates of deposition in the marine nearshore environment. ~~The results of model predictions for sediment~~ Sediment transport ~~following dam removal under the Proposed Action indicate that dam removal would cause a release of less than~~ modeling predicted that 1.2 to 2.3 million tons of ~~fine~~ sediment (5.4 to ~~the Klamath River downstream of Iron Gate Dam (see Figure 3.2-14). While estimates of long-term average annual sediment discharge to the Klamath Estuary vary considerably, they are generally well above the projected 3 million tons. For example, annual sediment~~

~~supply from Trinity River alone is calculated to be~~ 8.~~5 million tons based on data provided in USEPA (2001). Additionally~~6 million yd^3, or 36 to 57 % of the total sediments deposited behind the dams by 2020) would be eroded from the reservoir areas upon dam removal (Reclamation 2012) (see also Section 2.2, text box on sediment weight and volume). The range of potential erosion volumes is due to the range in potential water year types that could occur during the year of dam removal.

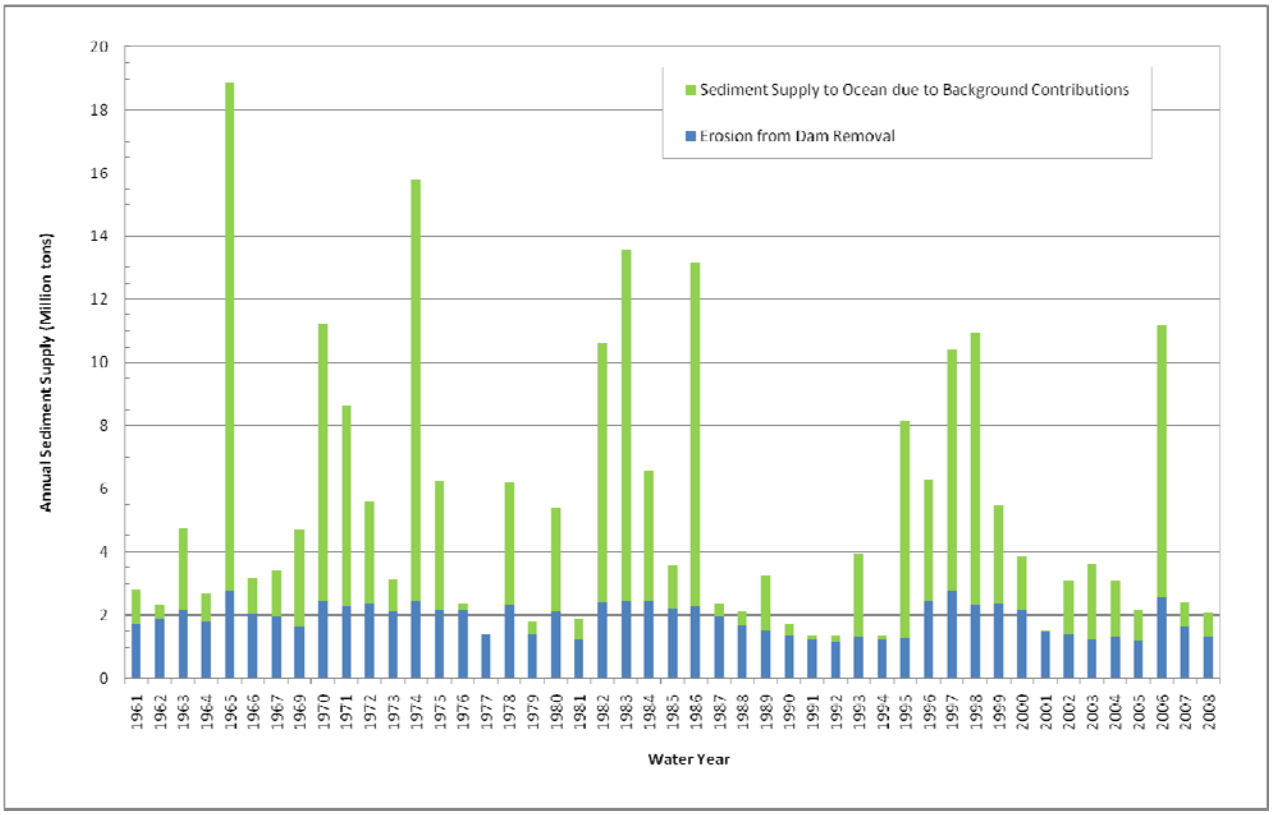
To put the anticipated erosion volume due to dam removal in the context of annual basin-wide sediment discharge, Stillwater Sciences (2010) estimated that Klamath River annual total sediment discharge to the estuary is approximately 5.8 million tons[13]. The predicted (4 million tons/yr of fine sediment and 1.8 million tons/yr of sand and larger sediment release due to dam removal under the Proposed Action ranges from 1.5 to 2.6 million tons depending on water year type (see Figure 3.2-14) and is only about one eighth of the cumulative sediment transport in the Klamath River at Hoopa in a four-day period during the December 1964 flood event. Lastly,). Farnsworth and Warrick (2007) estimate that the predicted sediment release due to dam removal annual average silt and clay discharge is 1.2 million tons/yr. There is approximatelyconsiderable uncertainty in the same as the cumulativeannual average sediment load estimates because there is large variation in the measurement of suspended sediment concentrations (SSCs) and there is not a unique relationship between flow and SSCs. In addition, the annual variation in sediment transport over a loads in the Klamath River is large. A single day at the Salmon River confluence during a very large flood event (i.e., the January 1974 flood) (storm in 1964-1965 is estimated to have contributed more than 15 million tons of sediment to the Pacific Ocean (Reclamation 2012; Stillwater Sciences 2010). However, in dry years the supply of sediment to the ocean could be much less than 1 million tons/yr (see

[13] The estimated Klamath River sediment supply to the estuary by Farnsworth and Warrick (2007) is 1.2 million tons per year, but this estimate is likely low because their estimated upper bound of 1.7 million tons is much lower than observations. The calculated sediment transport based on field data for the period of 22 through 26 December 1964, for example, is more than 25 million tons (Stillwater Sciences 2010). As a result, the Farnsworth and Warrick (2007) estimate of Klamath River sediment delivery is not used for direct comparisons here.

Figure 3.2-14). Given these estimates, it is expected that the amount of sediment released as a result of dam removal would be similar to that transported by the Klamath River to the Pacific Ocean in year with average flow, much less than that transported by the Klamath River in a wet year, and significantly greater than that transported by the Klamath River in a dry year.

Figure 3.2-14. Annual predicted sediment delivery to the Pacific Ocean under the Proposed Action and the No Action (background conditions) by Water Year. Note: model results are only valid for the year of dam removal. No significant increase in sediment loads is predicted in years following dam removal (Source: Reclamation 2012).

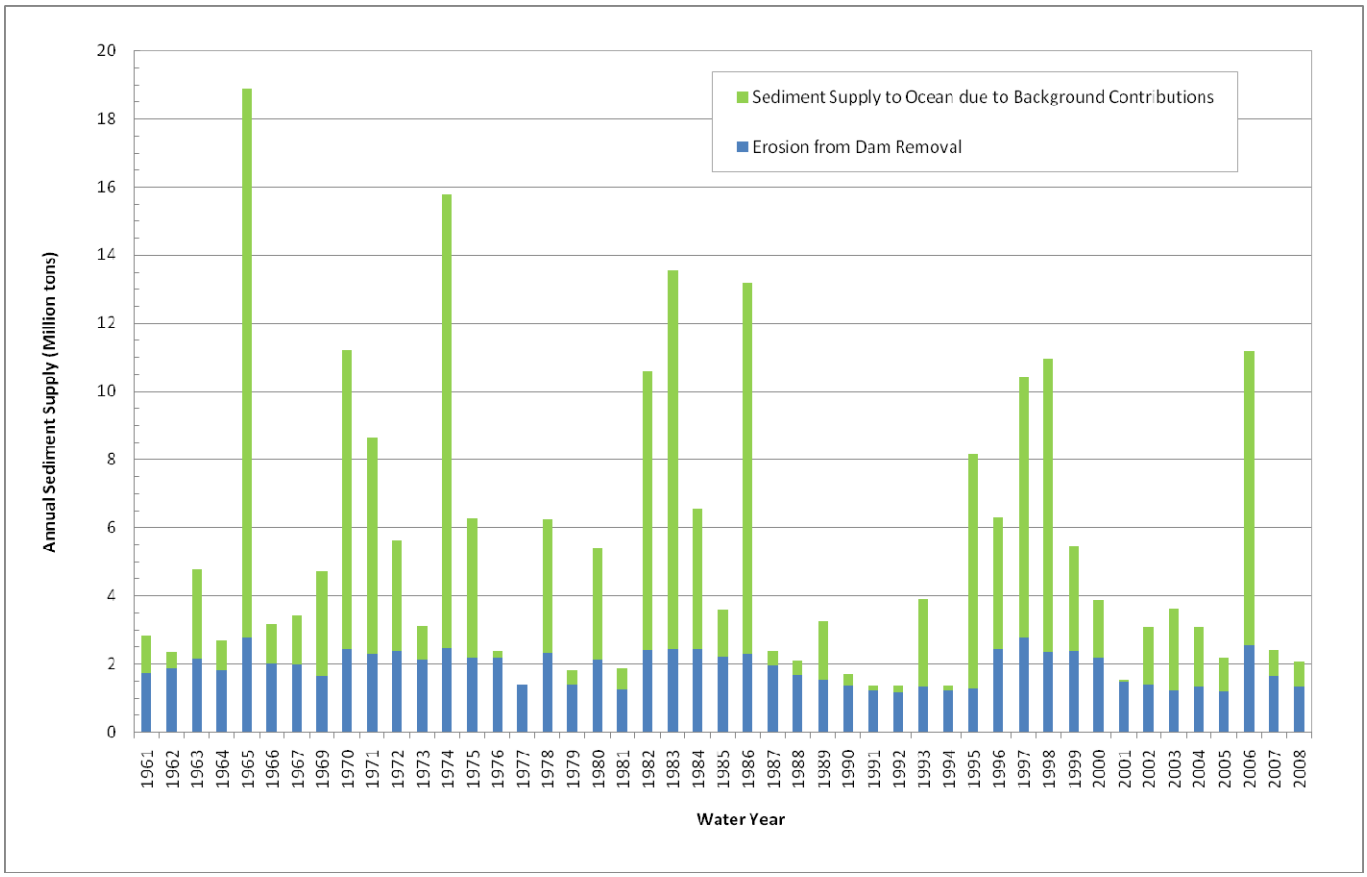
After exiting the river mouth, the high SSCs (>1,000 mg/L) transported by the



~~lower~~Lower Klamath River would form a surface plume of less dense, turbid, surface water floating on more dense, salty ocean water (Mulder and Syvitski 1995). No detailed investigations of the likely size and dynamics of the Klamath River plume have been conducted. Thus, it is not possible to predict accurately the sediment deposition pattern and location in the nearshore environment. However, the general dynamics and transport

mechanisms of fine sediment can be surmised based upon regional oceanographic and sediment plume studies.

The California Marine Life Protection Act (MLPA) 2008 Draft Master Plan identifies freshwater plumes as one of three prominent habitats with demonstrated importance to coastal species (California Marine Life Protection Act 2008). The California MLPA Master Plan Science Advisory Team (2011) Methods Report designates river plumes as a key habitat to be included in marine protected areas because they harbor a particular set of species or life stages, have special physical characteristics, or are used in ways that differ from other habitats.



~~**Figure 3.2-14. Annual predicted sediment delivery to the Pacific Ocean under the Proposed Action and the No Action (background conditions) by Water Year. Note: model results are only valid for the year of dam removal. No significant increase in sediment loads is predicted in years following dam removal (Source: Greimann et al. 2011).**~~

A recent USGS overview report on the sources, dispersal, and fate of fine sediment delivered to California's coastal waters (Farnsworth and Warrick 2007) found the following:

- Rivers dominate the supply of fine sediment to the California coastal waters, with an average annual flux of 34 million metric tons.
- All California coastal rivers discharge episodically, with large proportions of their annual sediment loads delivered over the course of only a few winter days.
- After heavy loading of fine sediment onto the continental shelf during river floods, there is increasing evidence that fluid-mud gravity flows occur within a layer 10 to 50 cm above the seabed and efficiently transport fine sediment offshore.
- Although fine sediment dominates the mid-shelf mud belts offshore of California river mouths, these mud belts are not the dominant sink of fine sediment, much of which is deposited across the inner shelf and deeper water off the continental shelf.
- Accumulation rates of fine sediment, which can exceed several millimeters per year, are generally highest near river sources of sediment and along the inner shelf and midshelf.

Farnsworth and Warrick (2007) conclude that fine sediment is a natural and dynamic element of the California coastal system because of large, natural sediment sources and dynamic transport processes.

In northern California, plume zones are primarily north of river mouths because alongshore currents and prevailing winds are northward during periods of strong runoff (Geyer et al. 2000, Pullen and Allen 2000, Farnsworth and Warrick 2007, California MLPA Master Plan Science Advisory Team 2011). Surface plumes occurring during periods of northerly (upwelling favorable) winds will thin and stretch offshore, while in the presence of southern downwelling-favorable winds, the plume may hug the coastline and mix extensively (Geyer et al. 2000, Pullen and Allen 2000, Borgeld et al. 2008). River plume area, location, and dynamics are also affected by the magnitude of river discharge, SSCs, tides, the magnitude of winter storms, and regional climatic and oceanographic conditions such as El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) climate cycles (Curran et al. 2002).

During several large flood events on the geographically proximal Eel River in the winter of 1997 and 1998, Geyer et al. (2000) found the following: flood conditions were usually accompanied by strong winds from the southern quadrant. The structure of the river plume was strongly influenced by the wind-forcing conditions. During periods of strong southerly (i.e., downwelling favorable) winds, the plume was confined inside the 50-m isobath (i.e., sea floor contour at 50-m below the water surface), within about 7 km of shore. Occasional northerly (upwelling favorable) winds arrested the northward motion of the plume and caused it to spread across the shelf. Transport of the sediment plume was confined to the inner shelf (water depths less than 50 m), during both southerly and

northerly wind conditions. During southerly wind periods, fine, un-aggregated sediment was rapidly transported northward to at least 30 km from the river mouth, but flocculated sediment was deposited within 1–10 km of the river mouth. During northerly (upwelling-favorable) winds, most of the sediment fell out within 5 km of the mouth, and negligible sediment was carried offshore. The Eel River mouth is 120 km (75 miles) to the south of the Klamath River mouth and thus serves as a reasonable system for comparison.

Based upon Eel River plume studies and current knowledge of northern California oceanographic patterns, the fine sediment discharged to the marine nearshore environment under the Proposed Action would likely be delivered to the ocean in a buoyant river plume that hugs the shoreline as it is transported northward. However, since the flushing of sediments from behind the dams will occur over a number of weeks to months (and perhaps to some degree over 1-2 years), the plume carrying reservoir sediments would likely be influenced by a range of meteorological and ocean conditions (e.g., storm and non-storm periods, differing storm directions). Therefore, some of the time the plume would likely be constrained to shallower nearshore waters, while at other times it would likely extend further offshore and spread more widely. While elevated SSCs (i.e., 10–100 mg/L) created in the nearshore plume would affect physical water quality characteristics specified in the Ocean Plan (i.e., visible floating particulates, natural light attenuation, the deposition rate of inert solids [Table 3.2-7]), the effects are likely to be within the range caused by historical storm events.

A 1995 Eel River flood with a 30-yr return period delivered an estimated 25 ± 3 million metric tons of fine-grained (<62 µm) sediment to the ocean (Wheatcroft et al. 1997). Transported sediments formed a distinct layer on the sea bed that was centered on the 70-m isobath, extended for 30 km along shelf and 8 km across shelf, and was as thick as 8.5 cm. Wheatcroft et al. (1997), estimated that 75% of the flood-derived sediment did not form a recognizable sea-floor deposit, but was instead rapidly and widely dispersed over the continental margin.

A considerable amount of fine sediment in the plume is anticipated to initially deposit on the seafloor shoreward of the 60-m isobath along the coast, with greater quantities depositing in close proximity to the mouth of the Klamath River. After this initial deposition, as described by Farnsworth and Warrick (2007), resuspension during the typical winter storms would likely occur before final deposition and burial. Much of this sediment will eventually be transported further offshore to the mid-shelf and into deeper water depths off-shelf through progressive resuspension and fluid-mud gravity flows.

Because of the complexities of the transport processes, the area and depth of the deposition of fine sediment from the Proposed Action cannot be precisely predicted. However, the short-term (< 2 years following dam removal) plume effects and long-term (2–50 years following dam removal) sediment deposit effects would be less-than-significant given the relatively small amount of total sediment input, in comparison to the total annual sediment inputs to the nearshore environment, and the fact that river plume sediment inputs are a naturally occurring process. As a result, net deposition of reservoir

sediments to the marine nearshore bottom substrates should be relatively less concentrated (i.e., thinner deposits in any one spot) and more widespread.

In summary, due to the relatively small magnitude of SSCs released to the nearshore environment, the anticipated rapid dilution of the sediment plume as it expands in the ocean, and the relatively low rate of deposition of sediments to the marine nearshore bottom substrates, **the short-term (< 2 years following dam removal) increases in SSCs and fine sediment deposition in the marine nearshore environment under the *Proposed Action* would be a less-than-significant impact.**

Stormwater runoff from deconstruction activities under the Proposed Action could cause short-term increases in suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment during the deconstruction period. Deconstruction activities under the Proposed Action would include demolition of the dams and their associated structures, power generation facilities, transmission lines, installation of temporary cofferdams, road upgrading, hauling, reservoir restoration, and other activities (as described in Section 2.4.3.1). Deconstruction activities are scheduled to occur between January 10 and June 26, with cofferdam installation scheduled to occur between 2 January 2020 and 6 February 2020. Therefore, cofferdam installation would occur during the first month of reservoir drawdown and the period of peak SSCs associated with mobilization of reservoir sediment deposits during drawdown. While the magnitude of short-term effects on SSCs due to erosion of the large volume of reservoir sediment deposits trapped behind the dams would be substantially greater than those due to dam deconstruction activities, this does not alleviate the requirement to reduce impacts from deconstruction-related activities. Although suspended materials from deconstruction would not likely reach the Klamath Estuary or marine nearshore environment, the potential for sediments to enter the water from deconstruction site runoff or in-water deconstruction work can be minimized or eliminated through the implementation of BMPs for deconstruction activities that would occur in or adjacent to the Klamath River. **Under the *Proposed Action*, the effect of stormwater runoff from deconstruction activities on SSCs in the ~~lower~~Lower Klamath River and the Klamath Estuary would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.**

Under the Proposed Action, revegetation associated with management of the reservoir footprint area could decrease the transport of fine sediments eroded from exposed reservoir terraces into the ~~lower~~Lower Klamath River and Klamath Estuary. As described for the Upper Klamath Basin, establishment of herbaceous vegetation in drained reservoir areas will be undertaken to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (O'Meara et al. 2010). Hydroseeding would be undertaken using standard BMPs for reducing water quality impacts during deconstruction and/or construction activities and restoration projects (Appendix B). Additional BMPs specific to hydroseeding, such as avoiding over-spray onto roads, trails, existing vegetation, and the stream channel, would also be implemented so that the hydroseed mixture itself would not easily runoff or be directly

sprayed into the Klamath River. **Under the *Proposed Action*, hydroseeding would decrease the short-term (<2 years following dam removal) transport of fine sediments eroded from exposed reservoir terraces into the ~~lower~~Lower Klamath River and Klamath Estuary and would be beneficial. There would be no change from existing conditions on the marine nearshore environment.**

Under the Proposed Action, the lack of continued interception and retention of mineral (inorganic) suspended material behind the dams at the Four Facilities could result in long-term (2–50 years following dam removal) increases in suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. As would be the case for the Upper Klamath Basin, peak concentrations of mineral (inorganic) suspended materials in the Lower Klamath Basin during the winter/early spring (November through April) would likely remain associated with high-flow events and any increases due to the lack of interception by the KHP dams would not be large; estimates of baseline sediment delivery for the Klamath Basin indicate that a relatively small fraction of total sediment (199,300 tons/yr or 3.4 percent of the cumulative average annual delivery from the basin) is supplied to the Klamath River on an annual basis from the upper and middle Klamath River (i.e., from Keno Dam to the Shasta River) (Stillwater Sciences 2010).

Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases in mineral (inorganic) suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

Under the Proposed Action, the lack of continued interception and retention of algal-derived (organic) suspended material by the dams at the Four Facilities could result in slight long-term (2–50 years following dam removal) increases in suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. While removal of the Four Facilities would eliminate the potential for downstream increases in suspended material due to seasonal algal blooms occurring within the reservoirs at the Four Facilities, overall sediment (both suspended and fluvial or bedload) trapping in the Hydroelectric Reach would no longer occur, such that, in the long~~-~~ term, summertime algal-derived suspended material originating from Upper Klamath Lake may move farther downstream into the lower basin and cause a relative increase in suspended material. However, similar to the No Action/No Project Alternative, interception and retention of suspended material from upstream sources would still occur to a large degree in the Keno Impoundment~~ (including~~ /Lake Ewauna~~)~~, as would additional decreases in concentration due to mechanical breakdown of algal remains in the turbulent river reaches between Keno Dam and Copco 1 Reservoir, and dilution from the springs downstream ~~of~~ from J.C~~.~~. Boyle Dam.

Because existing conditions indicate that average June–October suspended sediment values decrease from over 16 mg/L at the mouth of Link River to 6 mg/L in the Klamath River downstream ~~of~~from J.C. Boyle Reservoir (2001–2003), with median turbidity

values following a similar pattern over the long-term historical record (1950–2001) (see Section 3.2.3.1 and Appendix C, Section C.2), it is likely that the suspended sediment signal would not increase beyond typical existing conditions concentrations of 10–15 mg/L. Therefore, summertime suspended sediment in the ~~lower~~Lower Klamath River is unlikely to increase beyond a sustained 30 mg/L for four weeks, the water quality criterion adopted for significant adverse impacts on the cold freshwater habitat (COLD) beneficial use for the Klamath Facilities Removal EIS/EIR analysis (see Section 3.2.4.2.2.1). If slight long-term increases in suspended materials did occur, they would likely be offset by the loss of algal-derived suspended material previously produced in Copco 1 and Iron Gate Reservoirs and would not exceed levels that would substantially adversely affect the cold freshwater habitat (COLD) beneficial use.

Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases algal-derived (organic) suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

~~3.2.4.3.2.3~~

Nutrients

Upper Klamath Basin

Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in sediment-associated nutrients. Short-term increases in TN and TP concentrations in the Hydroelectric Reach would occur because particulate (primarily organic) nutrients contained in reservoir sediment deposits would be transported along with the sediments themselves. However, minimal deposition of fine suspended sediments, including associated nutrients, would occur in the river channel (~~Greimann et al. 2011~~Reclamation 2012, Stillwater Sciences 2008). Further, reservoir drawdown under the Proposed Action would occur during winter months when rates of primary productivity and microbially mediated nutrient cycling (e.g., nitrification, denitrification) are also expected to be low. Light limitation for primary producers that do persist during winter months is also likely to occur, further decreasing the potential for uptake of TN and TP released along with reservoir sediment deposits. Therefore, particulate nutrients released along with sediment deposits are not expected to be bioavailable and should be well-conserved during transport through the Hydroelectric Reach. **Under the *Proposed Action*, the short-term (<2 years following dam removal) increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact.**

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could cause long-term (2–50 years following dam removal) increases in nutrient levels in the Hydroelectric Reach. The Four Facilities, and primarily the two largest reservoirs (Copco 1 and Iron Gate Reservoirs), intercept and retain suspended material behind the dams, including phosphorus and nitrogen originating from Upper Klamath Lake (see Section 3.2.3.1). Under the Proposed Action, these nutrients would be transported downstream and potentially be available for uptake (e.g., by nuisance algae species). Analyses of the effects of dam removal on nutrients have been conducted by PacifiCorp for its relicensing efforts (FERC 2007), NCRWQCB for development of the California Klamath River TMDLs (NCRWQCB 2010a), and the Yurok Tribe as part of an evaluation to improve previous mass-balance estimates of nutrients in the Klamath River and increase understanding of retention rates in free-flowing river reaches (Asarian et al. 2010). While the results of all of the evaluations recognize the trapping efficiency of ~~the reservoirs~~ Copco 1 and Iron Gate Reservoirs with respect to TP and TN, such that under the Proposed Action total nutrient concentrations in the Klamath River downstream ~~of~~from Iron Gate Dam would increase on an annual basis, the majority of the results are focused on the Klamath Basin downstream ~~of~~from Iron Gate Dam.

However, modeling conducted for development of the California Klamath River ~~TMDLs~~ TMDLs (NCRWQCB 2010a) provides some information applicable to the assessment of long-term (2–50 years following dam removal) effects of the Proposed Action on nutrients at locations in the Upper Klamath Basin (i.e., upstream of Iron Gate Dam) (Kirk et al. 2010). Klamath TMDL model results indicate that under the Proposed Action

(similar to the TMDL TOD2RN scenario, which includes Oregon TMDL allocations), TP and TN in the Hydroelectric Reach immediately downstream ~~of~~ from J.C. Boyle Dam would increase slightly (<0.015 mg/L and <0.05 mg/L, respectively) during summer months compared to those of the No Action/No Project Alternative (similar to the TMDL T4BSRN scenario) due to the absence of nutrient interception and retention in both Keno Impoundment/Lake Ewauna and J.C. Boyle Reservoir (the former because the TMDL model TOD2RN scenario includes the historic Keno Reef instead of Keno Dam [Appendix D]). At the Oregon-California ~~state~~State line, the situation would be much the same, although the lack of hydropower peaking operations under the Proposed Action may result in decreased daily variation in TP and ortho-phosphorus, as well as nitrate and ammonium (NCRWQCB 2010a). Overall however, the predicted increases would be very small and these increases may be at least partially due to the assumption that the historic Keno Reef exists rather than Keno Dam. ~~Regardless, the~~Further, the TMDL model predictions generally agree with empirical data regarding J.C. Boyle Reservoir; with its shallow depth and short residence time, this reservoir does not retain high amounts of nutrients (PacifiCorp 2006a) (see Appendix C for more detail) and its removal would not be expected to increase nutrient transport further downstream in the Hydroelectric Reach.

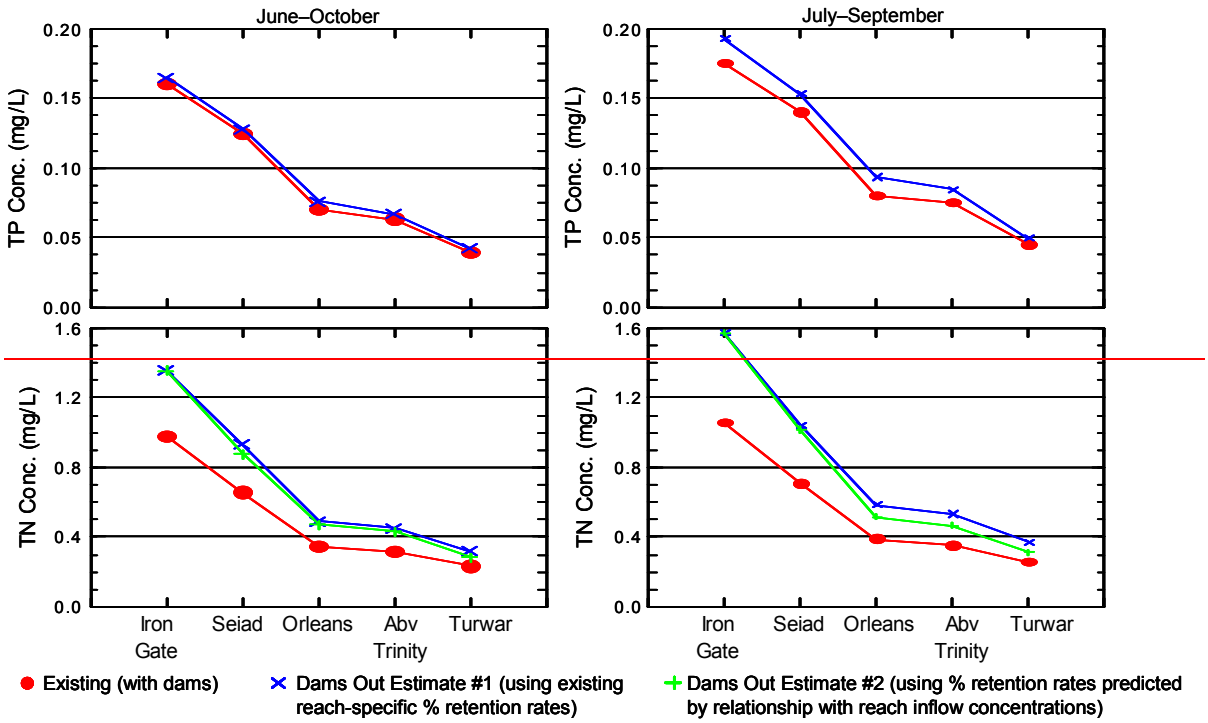
Based on available information, the slight nutrient increases in the Hydroelectric Reach would not be expected to result in exceedances of either Oregon water quality objectives for nuisance algae growth, or California North Coast Basin Plan water quality objectives for biostimulatory substances, beyond levels experienced under the No Action/No Project Alternative. While periphyton colonization would likely increase in this reach under the Proposed Action, the increases would be due to habitat increases rather than nutrient increases (see Section 3.4.4.3.2 Algae). Further, the lacustrine environment that supports the growth of nuisance algae blooms of such as *M. aeruginosa* or other cyanobacteria would be eliminated under the Proposed Action (see Section 3.4, Algae), reducing the likelihood of uptake of the slightly increased nutrient concentrations by nuisance ~~algae~~ species of phytoplankton algae. This is mainly relevant for Copco 1 and Iron Gate Reservoirs, where the longer residence times support seasonal nuisance algae blooms (see Section 3.4, Algae). **Under the *Proposed Action*, the long-term (2–50 years following dam removal) increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact.**

Lower Klamath Basin

Sediment release associated with the removal of the Four Facilities under the Proposed Action could cause short-term (<2 years following dam removal) increases in sediment-associated nutrients in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. **Under the *Proposed Action*, the short-term (<2 years following dam removal) increase in nutrients in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be the same as in the Hydroelectric Reach and would be a less-than-significant impact.**

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could cause long-term (2–50 years following dam removal) increases in nutrient levels in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. The reservoirs at the Four Facilities currently intercept and retain suspended material behind the dams, including phosphorus and nitrogen originating from Upper Klamath Lake (see Section 3.2.3.1). Under the Proposed Action, these nutrients would be transported downstream and potentially be available for uptake by algae, including nuisance algae species. Analyses of the effects of dam removal on nutrients have been conducted by PacifiCorp for its relicensing efforts (FERC 2007), NCRWQCB for development of the California Klamath River TMDLs (NCRWQCB 2010a), and the Yurok Tribe as part of an evaluation to improve previous mass-balance estimates of nutrients in the Klamath River and increase understanding of retention rates in free-flowing river reaches (Asarian et al. 2010). Results of all of the evaluations recognize the trapping efficiency of the reservoirs with respect to TP and TN, such that under the Proposed Action total nutrient concentrations in the Klamath River downstream ~~of~~from Iron Gate Dam would increase~~.~~ on an annual basis.

Based on the Yurok Tribe analysis, TP concentrations would increase approximately 2-12 percent for the June–October period under the Proposed Action, while increases ~~in~~ in TN concentrations would be relatively larger, at an estimated 37-42 percent for June-October and 48-55 percent for July–September (see Figure 3.2-15). Asarian et al. (2010) conducted their analysis using two different approaches; 1) calculated reach-specific nutrient retention rates based on measured nutrient concentration data, and 2) predicted retention rates using an empirical relationship between observed retention rates and measured concentrations developed for the river from Iron Gate Dam to Turwar (this approach was only applicable to TN because TP data demonstrated a weak relationship between retention rate and measured TP concentrations). This calculation implicitly includes nutrient recycling processes such as assimilative uptake for algal growth and subsequent downstream release, as these processes were ongoing and inherently included in the retention estimates determined for existing conditions. Both approaches yield similar results, indicating small increases in TP and relatively larger increases in TN concentrations downstream ~~of~~from the Hydroelectric Reach under the Proposed Action, which diminish with distance downstream due to both tributary dilution and nutrient retention (i.e., uptake of nutrients).



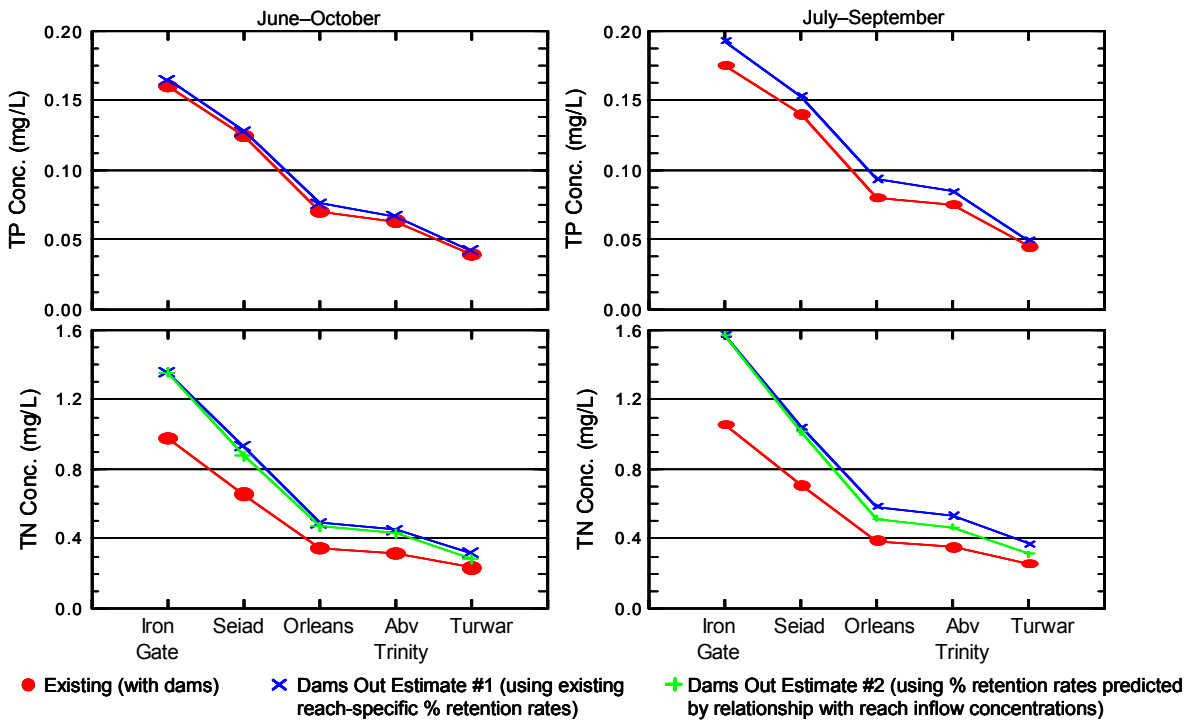


Figure 3.2-15. Comparison of TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.8) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate using Percent Retention Rates Predicted by the Empirical Relationship between Reach Inflow Concentration and Retention (Green Cross). Source: Asarian et al. 2010.

Due to a lack of available data, the Yurok Tribe analysis does not consider other possible factors that may decrease nutrients upstream of Copco 1 Reservoir under the Proposed Action, such as TMDL implementation or elimination of peaking flows from hydropower operations (Asarian et al. 2010). If reductions in nutrient concentrations do occur upstream of Copco 1, then less nutrients would be available for removal in the reservoirs and dam removal would likely result in smaller long-term increases in nutrient concentration than predicted by the Yurok Tribe analysis (Asarian et al. 2010) analysis.

Klamath TMDL modeling efforts include an assumption of compliance with upstream TP and TN load allocations for both Oregon and California (NCRWQCB 2010a). Results are in general agreement with PacifiCorp (FERC 2007) and Yurok Tribe (Asarian et al. 2010) analyses regarding dam removal effects on nutrients, with very small annual increases in TP (0.01–0.015 mg/L) and relatively larger annual increases in TN (0.1-0.125 mg/L) immediately downstream ~~of~~from Iron Gate Dam (RM 190.1). Increases in nutrients would diminish with distance downstream. Note that while

following the same relative trend as the Yurok Tribe analysis, the absolute increases predicted by TMDL model are much lower (e.g., 0.1–0.125 mg/L TN increase for the TMDL model vs. 0.1-0.5 mg/L TN increase for the Yurok Tribe analysis).

Continuing increased variability in TP and TN are predicted by the Klamath TMDL model (see Appendix D) during summer months, presumably due to nutrient uptake dynamics by periphyton and macrophytes. The TMDL model does not include denitrification as a possible nitrogen removal term in riverine segments (Tetra Tech 2009), meaning that TN concentrations under the Proposed Action (but also the No Action/No Project Alternative) may be ~~slightly~~ overpredicted. The magnitude of this potential over-prediction would be expected to increase with distance downstream (i.e., relatively lower over-prediction at Iron Gate Dam and the Upper Klamath Basin, but relatively higher over-prediction at sites in the lowest portion of the river such as Orleans), due to a longer distance of river within which denitrification and other nitrogen removal processes would operate. Corresponding small differences in ortho-phosphorus, nitrate, and ammonium concentrations under the Proposed Action (as compared with the No Action/No Project Alternative, including TMDL compliance) are predicted by the model; however, within the uncertainty of future nutrient dynamics these differences are not clearly discernable as increases or decreases. TMDL model results indicate that while resulting TP levels would meet the existing Hoopa Valley Tribe numeric water quality objective (0.035 mg/L TP) at the Hoopa reach (≈RM 45–46) of the Klamath River, TN levels would continue to be in excess of the existing objective (0.2 mg/L TN) in some months (NCRWQCB 2010a). However, as noted previously, TN concentrations in the model may be over-predicted and therefore the Hoopa Valley Tribe objective may in fact be met.

Despite the overall increases in absolute nutrient concentrations anticipated under the Proposed Action, the relatively greater increases in TN may not result in significant biostimulatory effects on ~~primary productivity (i.e.,~~ periphyton growth~~)~~ because it will be accompanied by only a relatively minor increase in TP. Existing data ~~indicate that the~~ regarding TN:TP ratios suggest the potential for the Klamath River ~~is~~ to be generally N-limited (TN:TP ~~<10), with some periods of co-limitation by N and P (see Section 3.2.3.4 and Appendix C, Section C.3.2.1~~). However, concentrations of both nutrients are high enough in the river from Iron Gate Dam (~~RM~~ RM 190.1) to approximately Seiad Valley (RM 129.4) (and potentially further downstream) that nutrients are not likely to be limiting primary productivity (i.e., periphyton growth) in this portion of the Klamath River (FERC 2007, HVTEPA 2008, Asarian et al. 2010). In addition, N-fixing species dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010). Since these species can fix their own nitrogen from the atmosphere, increases in TN due to dam removal may not significantly increase ~~their growth~~ algal biomass (see also Section 3.4, Algae), particularly if overall TN increases are less than those predicted by existing models due to implementation of TMDLs and general ~~nutrient~~ nutrient reductions in the Klamath Basin. **Under the *Proposed Action*, the long-term (2–50 years following dam removal) increase in nutrients in the ~~lower~~Lower Klamath River and the Klamath Estuary would be a less-than-significant impact.**

~~3.2.4.3.2.4~~ Dissolved Oxygen

Upper Klamath Basin

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in oxygen demand and reductions in dissolved oxygen in the Hydroelectric Reach downstream ~~of~~ from J.C. Boyle Reservoir. While modeled oxygen demand is not available downstream ~~of~~from J.C. Boyle Reservoir, model results are available downstream ~~of~~from Iron Gate Dam as a function of SSC (see Section 3.2.4.3.2.4, Lower Klamath Basin) and can be applied to the Hydroelectric Reach downstream ~~of~~from J.C. Boyle Reservoir. This assumes as a worst case scenario that the effects of sediment release on short-term oxygen demand (and reductions in dissolved oxygen) in the Hydroelectric Reach downstream ~~of~~from J.C. Boyle Dam would be the same as those for the ~~lower~~Lower Klamath River. This is a conservative assumption because peak SSCs downstream ~~of~~from J.C. Boyle Reservoir would be much lower and of shorter duration (i.e., 2,000–3,000 mg/L occurring within 1–2 months of reservoir drawdown) than those predicted downstream ~~of~~from Iron Gate Dam (i.e., 7,000–14,000 mg/L occurring within 2–3 months of reservoir drawdown) (see Section 3.2.4.3.2.2 and Figures 3.2-8 through 3.2-10). Like the effect determination for the Klamath River downstream ~~of~~from Iron Gate Dam, this would be a significant impact (see detailed analysis for Lower Klamath Basin, below).

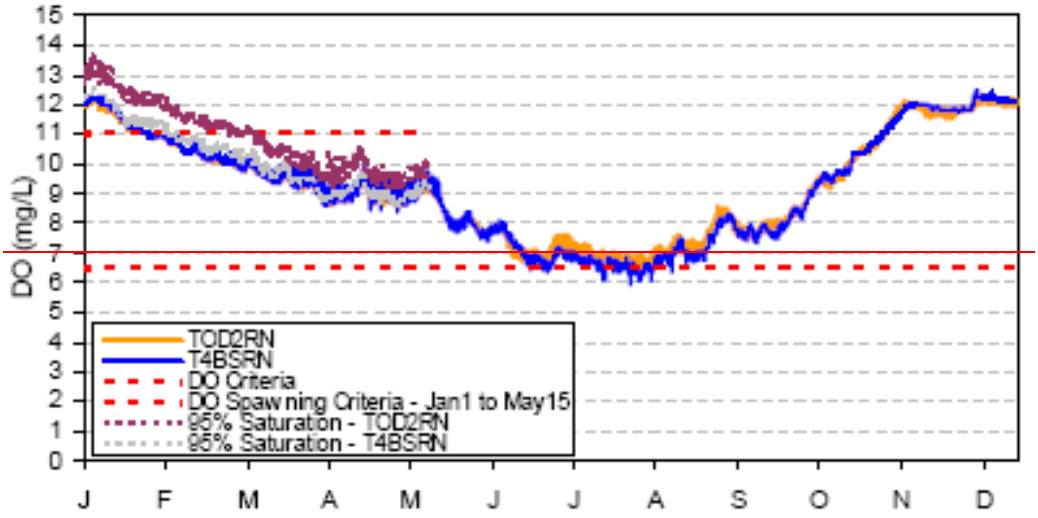
Under the *Proposed Action*, the short-term (<2 years following dam removal) decrease in dissolved oxygen concentrations would be a significant impact on the riverine reaches of the Klamath River downstream ~~of~~from J.C. Boyle Dam to the Oregon-California ~~state~~ State line.

Removal of the Four Facilities under the Proposed Action could cause long-term (2–50 years following dam removal) increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the Hydroelectric Reach. Modeling conducted for development of the Oregon and California Klamath River TMDLs indicates that under the Proposed Action (similar to the TMDL TOD2RN scenario), dissolved oxygen concentrations in the Hydroelectric Reach downstream ~~of~~ from J.C. Boyle Dam and at the Oregon-California ~~state~~ State line would be slightly greater during July through October than those under the No Action/No Project (similar to the TMDL T4BSRN scenario), due to the removal of J.C. Boyle Reservoir (see Figure 3.2-16 and Figure 3.2-17; NCRWQCB 2010a). The same pattern is predicted for 30-day mean minimum and 7-day mean minimum dissolved oxygen criteria. The Klamath TMDL model (see Appendix D) also predicts that daily fluctuations in dissolved oxygen ~~at these locations~~ immediately downstream from J.C. Boyle Dam during this same period ~~may~~ would be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN~~), a condition potentially~~) (Figure 3.2-16) While the model-predicted increases in daily dissolved oxygen fluctuations may be linked to greater periphyton biomass and associated daily swings in photosynthetic ~~swings in~~ oxygen production and respiratory consumption in the free-flowing river~~. Modeling~~, the results are not entirely certain. The role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is unknown because nutrient cycling and resulting rates of primary productivity under the No

Action/No Project Alternative are uncertain (see Section 3.2.1.1). Further, scouring in the free-flowing river from increased bed mobility and variable streamflows (see Section 3.4.4.3.2) may also limit primary productivity under the Proposed Action, which would decrease daily dissolved oxygen variability.

Further downstream at State line (i.e., in the Peaking Reach), the TMDL model predicts somewhat reduced daily fluctuations in dissolved oxygen under the Proposed Action (TCD2RN) as compared to the No Action/No Project Alternative (T4BSRN) (Figure 3.2-17). The predicted decreases in daily variability at State line may be due to elimination of hydropower peaking operations; however, since daily variability in dissolved oxygen is not currently an issue in the Peaking Reach, nor would the predicted reduced fluctuations result in an inability to meet water quality objectives (see below paragraph), this potential effect would be less than significant.

For the river downstream from J.C. Boyle Dam and at State line, modeling predictions are generally in compliance with the Oregon water quality objectives for supporting warm water (5.5 mg/L) and cool water (6.5 mg/L) fish beneficial uses, where lower dissolved oxygen concentrations in June–August would meet the Oregon narrative natural conditions criterion that supersedes the numeric objectives for the cold water beneficial use (8.0 mg/L). The same would occur for predicted concentrations in mid-February–May as related to the spawning (11 mg/L) beneficial use (Figure 3.2-16 and Figure 3.2-17; NCRWQCB 2010a).



~~Figure 3.2-16. Predicted Dissolved Oxygen Downstream of J.C. Boyle Dam (RM 224.7 to 228.3) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.~~

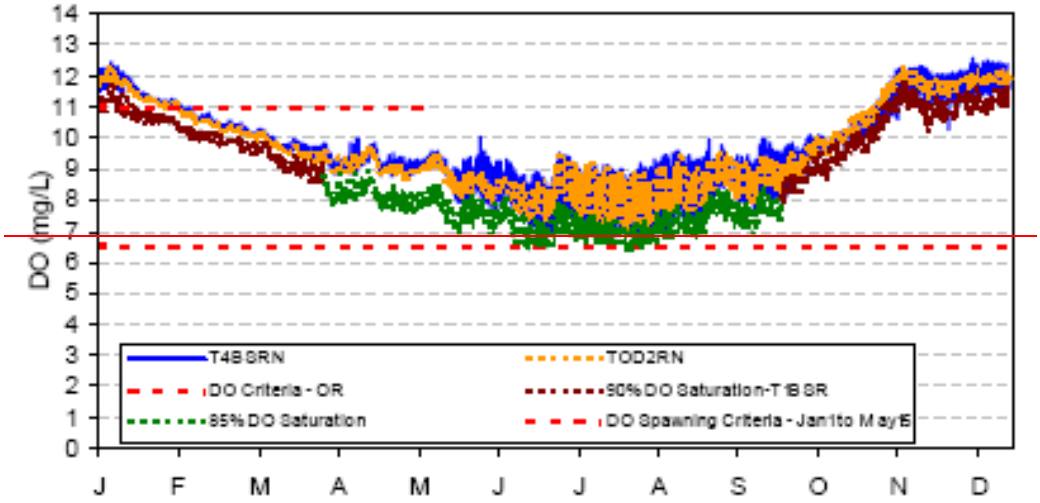


Figure 3.2-17. Predicted Dissolved Oxygen at the Oregon-California State Line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

For the free-flowing reaches of the river replacing the reservoirs, long-term dissolved oxygen levels would differ substantially from the super-saturation (i.e., >100% saturation) that currently occurs in surface waters and the hypolimnetic oxygen depletion in that occurs in bottom waters of Copco 1 and Iron Gate Reservoirs during the April/May through October/November period (see Section 3.2.3.5). Dissolved oxygen in the free-flowing reaches of the river replacing the reservoirs would not exhibit such extremes, instead possessing the riverine signal characteristic of primary production in lotic (flowing) ecosystems described above. Relative changes in dissolved oxygen under the Proposed Action would be less pronounced in the reach currently occupied by J.C. Boyle Reservoir, due to the lack of persistent thermal stratification in that reservoir.

The increased daily fluctuations in dissolved oxygen indicated by the Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.2.1.1).

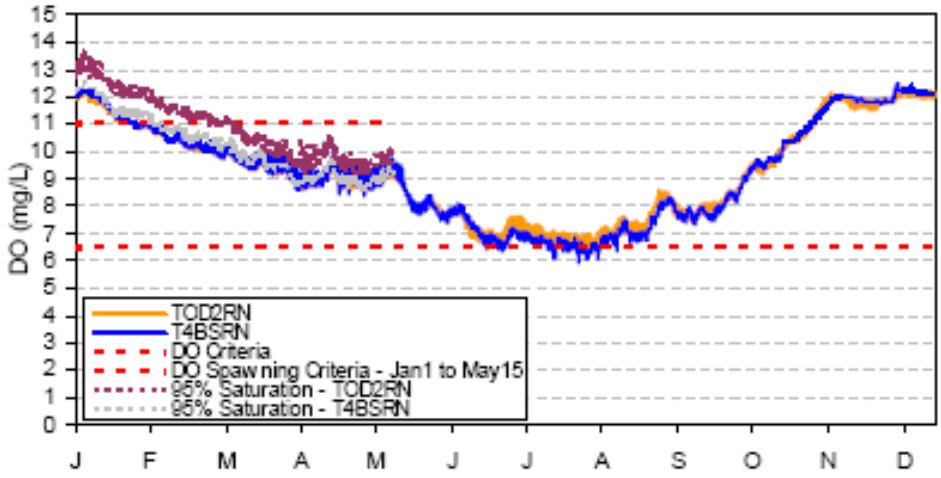


Figure 3.2-16. Predicted Dissolved Oxygen Downstream from J.C. Boyle Dam (RM 224.7 to 228.3) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

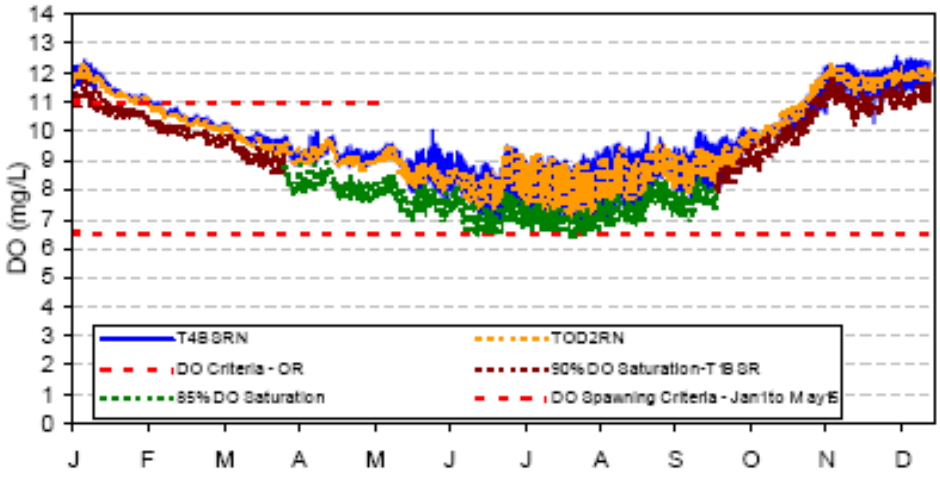


Figure 3.2-17. Predicted Dissolved Oxygen at the Oregon-California State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

Under the *Proposed Action*, ~~the~~ long-term (2–50 years following dam removal) ~~increase~~slight increases in summer and fall dissolved oxygen concentrations and daily fluctuations downstream from J.C. Boyle Dam would be beneficial. Slight decreases in daily fluctuations at the California-Oregon State line would be less than significant. Elimination of seasonal extremes in dissolved oxygen (i.e., supersaturation in surface waters and oxygen depletion in bottom waters) in the riverine reaches replacing Copco 1 and Iron Gate Reservoirs in the Hydroelectric Reach would be beneficial.

Lower Klamath Basin

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in oxygen demand (~~Immediate Oxygen Demand [~~IOD~~]~~ and ~~Biological Oxygen Demand [~~BOD~~]~~) and reductions in dissolved oxygen in the ~~lower~~Lower Klamath River, the Klamath Estuary and the marine nearshore environment. Under the Proposed Action, high SSCs are expected in ~~the~~ the middle and ~~lower~~Lower Klamath River immediately following dam removal (see Alternative 2 – Full Facilities Removal of Four Dams – Suspended Sediments). The high fraction of organic carbon present in the reservoir sediments (see Section 3.2.3.1) allows for the possibility of oxygen demand generated by microbial oxidation of organic matter exposed to the water column from deep within the sediment profile and mobilized during dam removal.

Based on results from a dissolved oxygen spreadsheet model (see Section 3.2.4.1), IOD downstream ~~of~~from Iron Gate Dam would be 0–8.6 mg/L and BOD would be 0.3–43.~~8~~ 8 mg/L for all water year types considered (i.e., wet, median, dry) and for all six months following drawdown (see Table 3.2-12). The highest predicted oxygen demand levels (i.e., IOD and BOD) would occur during the first four to eight weeks following drawdown of Copco 1 and Iron Gate Reservoirs (i.e., in February 2020) corresponding to the peak SSCs in the river (see above section on suspended sediments). Despite the relatively high predicted IOD and BOD values, dissolved oxygen concentrations downstream ~~of~~ from Iron Gate Dam would generally remain greater than 5 mg/L (see ~~Table~~ Table 3.2-13)~~, the minimum acceptable dissolved oxygen concentration for salmonids~~. Exceptions include predicted concentrations in February 2020 for median (WY1976) and typical dry year (WY2001) hydrologic conditions, which exhibit minimum values of 3.5 mg/L and 1.3 mg/L, respectively.

For all water year types (wet, median, dry), the predicted dissolved oxygen minimum values would occur by approximately RM 188–190 (≈ 1–3 km downstream from Iron Gate Dam) and would return to at least 5 mg/L by approximately RM 175–177 (within 20-25 km of the dam), or near the confluence with the Shasta River (RM 176.7) (see Table 3.2-13). The North Coast Basin Plan water quality objective for dissolved oxygen is expressed as percent saturation; at 90 percent saturation, the water quality objective for November through April, assuming average February (2009) water temperatures, would be 9.6–10.6 mg/l (see Table 3.2-5). Based on the spreadsheet model results, recovery to the North Coast Basin Plan water quality objective of 90 percent saturation would occur generally within the reach from Seiad Valley (RM 129.4) to the mainstem confluence

with Clear Creek (see Figure 3.2-1 for location of Clear Creek), or within a distance of 100–150 km (62–93 mi) downstream from the Hydroelectric Reach, for all water year

Table 3.2-12. Estimated Short-term Immediate Oxygen Demand (IOD) and Biochemical Oxygen Demand (BOD) by Month for Modeled Flow and SSCs Immediately Downstream ~~of~~from Iron Gate Dam Under the Proposed Action~~.~~

Year	Avg. Monthly Temperature (deg C)[1]	80% Dissolved Oxygen[2]	Flow (cfs)[3]	Flow (cms)	SSC (mg/L)[4]	IOD (mg/L)	BOD (mg/L)
Typical Wet Hydrology (WY 1984 Conditions Assumed)							
11/30/2019	9.9	7.29	3,343	95	444	0.3	1.6
12/1/2019	5.0	9.40	7,139	202	430	0.3	1.5
1/21/2020	3.7	9.73	8,675	246	1,962	1.2	6.9
2/15/2020	4.4	9.55	3,949	112	7,116	4.5	25.1
3/1/2020	6.7	9.00	4,753	135	593	0.4	2.1
4/15/2020	8.4	8.63	4,374	124	939	0.6	3.3
Median Hydrology (WY 1976 Conditions Assumed)							
11/12/2019	9.9	7.29	2,074	59	96.2	0.1	0.3
12/12/2019	5.0	9.40	2,156	61	202.5	0.1	0.7
1/22/2020	3.7	9.73	6,533	185	2,593.5	1.6	9.1
2/14/2020	4.4	9.55	2,933	83	9,893.2	6.2	34.8
3/1/2020	6.7	9.00	3,016	85	1,461.2	0.9	5.1
4/7/2020	8.4	8.63	2,657	75	509.3	0.3	1.8
Typical Dry Hydrology (WY 2001 Conditions Assumed)							
11/19/2019	9.9	7.29	1,141	32	79.1	0.0	0.3
12/23/2019	5.0	9.40	1,284	36	122.2	0.1	0.4
1/17/2020	3.7	9.73	4,245	120	3,513.7	2.2	12.4
2/16/2020	4.4	9.55	1,040	29	13,573.5	8.6	47.8
3/2/2020	6.7	9.00	1,344	38	2,420.7	1.5	8.5
4/5/2020	8.4	8.63	1,150	33	551.1	0.3	1.9

Source: Stillwater Sciences 2011

Table 3.2-12. Estimated Short-term Immediate Oxygen Demand (IOD) and Biochemical Oxygen Demand (BOD) by Month for Modeled Flow and SSCs Immediately Downstream ~~of~~from Iron Gate Dam Under the Proposed Action~~.~~

Year	Avg. Monthly Temperature (deg C)[1]	80% Dissolved Oxygen[2]	Flow (cfs)[3]	Flow (cms)	SSC (mg/L)[4]	IOD (mg/L)	BOD (mg/L)

[1] Raw daily water temperature data for 2009 from ~~http://www.pacificorp.com/es/hydro/hl/kr.html#~~http://www.pacificorp.com/es/hydro/hl/kr.html# (PacifiCorp 2009). Monthly summary data also presented in Table 3.2-12.

[2] Initial dissolved oxygen downstream from Iron Gate Dam calculated for 80% saturation using average monthly water temperature, salinity = 0 ppt, and elevation = 707 m (2,320 ft). An initial dissolved oxygen at 70% saturation was used for the November model runs based on 2009 conditions (Appendix C, Table C-7).

[3] Predicted daily flow values from Reclamation hydrologic model output (Reclamation 2012). Daily flow values correspond to the peak suspended sediment concentration (SSC) for each month.

[4] Predicted peak suspended sediment concentration (SSC) by month from Reclamation model output under the Proposed Action (Reclamation 2012).

~~[2] Initial dissolved oxygen downstream of Iron Gate Dam calculated for 80% saturation using average monthly water temperature, salinity = 0 ppt, and elevation = 707 m (2,320 ft). An initial dissolved oxygen at 70% saturation was used for the November model runs based on 2009 conditions (Appendix C, Table C-7).~~**Table 3.2-13. Estimated Location of Minimum Dissolved Oxygen and Location at which Dissolved Oxygen Would Return to 5 mg/L Downstream from Iron Gate Dam Due to High Short-term SSCs Under the Proposed Action**

~~[3] Predicted daily flow values from Reclamation hydrologic model output (Greimann et al. 2011). Daily flow values correspond to the peak suspended sediment concentration (SSC) for each month.~~

~~[4] Predicted peak suspended sediment concentration (SSC) by month from Reclamation model output under the Proposed Action (Greimann et al. 2011).~~

~~Table 3.2-13. Estimated Location of Minimum Dissolved Oxygen and Location at which Dissolved Oxygen Would Return to 5 mg/L Downstream of Iron Gate Dam Due to High Short-term SSCs Under the Proposed Action.~~

Date	Boundary Conditions at Iron Gate Dam			Spreadsheet Model Output		
	Initial Dissolved Oxygen (at 80% Saturation)[1]	IOD	BOD	Minimum Dissolved Oxygen	Location of Minimum Dissolved Oxygen	Location at which Dissolved Oxygen Returns to 5 mg/L[2]
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	RM	RM
Typical Wet Hydrology (WY 1984 Conditions Assumed)						
11/30/2019	7.29	0.3	1.6	7.10	189.5	~~190.1~~NA [3]
12/1/2019	9.40	0.3	1.5	9.18	188.9	~~190.1~~NA
1/21/2020	9.73	1.2	6.9	8.56	188.2	~~190.1~~NA
2/15/2020	9.55	4.5	25.1	5.21	188.9	~~190.1~~NA
3/1/2020	9.00	0.4	2.1	8.70	188.9	~~190.1~~NA
4/15/2020	8.63	0.6	3.3	8.11	188.9	~~190.1~~NA
Median Hydrology (WY 1976 Conditions Assumed)						
11/12/2019	7.29	0.1	0.3	7.29	190.1	~~190.1~~NA
12/12/2019	9.40	0.1	0.7	9.34	189.5	~~190.1~~NA
1/22/2020	9.73	1.6	9.1	8.18	188.2	~~190.1~~NA
2/14/2020	9.55	6.2	34.8	3.49	188.9	175.2
3/1/2020	9.00	0.9	5.1	8.19	188.9	~~190.1~~NA
4/7/2020	8.63	0.3	1.8	8.38	189.5	~~190.1~~NA
Typical Dry Hydrology (WY 2001 Conditions Assumed)						
11/19/2019	7.29	0.0	0.3	7.29	190.1	~~190.1~~NA
12/23/2019	9.40	0.1	0.4	9.40	190.1	~~190.1~~NA
1/17/2020	9.73	2.2	12.4	7.62	188.9	~~190.1~~NA
2/16/2020	9.55	8.6	47.8	1.33	189.5	177.1
3/2/2020	9.00	1.5	8.5	7.62	189.5	~~190.1~~NA
4/5/2020	8.63	0.3	1.9	8.39	189.5	~~190.1~~NA

Source: Stillwater Sciences 2011.

[1] Initial dissolved oxygen downstream ~~of~~ from Iron Gate Dam calculated for 80% saturation using average monthly water temperature, salinity = 0 ppt, and elevation = 707 m (2,320 ft). An initial dissolved oxygen at 70% saturation was used for the November model runs. See average monthly dissolved oxygen (% saturation) for 2009 in Appendix C, Table C-7. Raw daily water temperature data from ~~http://www.pacificorp.com/es/hydro/hl/kr.html#~~http://www.pacificorp.com/es/hydro/hl/kr.html# (PacifiCorp 2009).

[2] Minimum acceptable dissolved oxygen concentration for salmonids. Although the minimum acceptable water quality objective for dissolved oxygen in the Klamath River for warm freshwater, saline, and marine habitats was previously 5 mg/L (NCRWQCB 2006), recent Basin Plan amendments require 85-90% saturation (generally ranging from 6–11 mg/L) depending on location and month (NCRWQCB 2010). Section 3.3 (Aquatics) of this EIS/EIR references a threshold of 6 mg/L for migrating adult anadromous salmonids (USEPA 1986), which is also a useful benchmark for dissolved oxygen concentrations. Based on BOD/IOD model results, a return to 6 mg/L dissolved oxygen would occur further downstream than the results presented in Table 3.2-13, on the order of 5–15 miles (10–25 km) depending on hydrologic conditions.

[3] NA = not applicable because dissolved oxygen consistently remains greater than 5 mg/L.

~~For all water year types (wet, median, dry), the predicted dissolved oxygen minimum values would occur by approximately RM 188–190 (≈ 1–3 km downstream of Iron Gate Dam) and would return to at least 5 mg/L by approximately RM 175–177 (within 20-25 km of the dam), or near the confluence with the Shasta River (RM 176.7) (see Table 3.2-13). The North Coast Basin Plan water quality objective for dissolved oxygen is expressed as percent saturation; at 90 percent saturation, the water quality objective for November through April, assuming average February (2009) water temperatures, would be 9.6–10.6 mg/l (see Table 3.2-5). Based on the spreadsheet model results, recovery to the North Coast Basin Plan water quality objective of 90 percent saturation would occur generally within the reach from Seiad Valley (RM 129.4) to the mainstem confluence with Clear Creek (see Figure 3.2-1 for location of Clear Creek), or within a distance of 100–150 km (62–93 mi) downstream of the Hydroelectric Reach, for all water year types considered (i.e., wet, median, dry). Thus, model results indicate that~~ **Under the *Proposed Action*, long-term (2–50 years following dam removal) slight increases in summer and fall dissolved oxygen concentrations and daily fluctuations downstream from J.C. Boyle Dam would be beneficial. Slight decreases in daily fluctuations at the California-Oregon State line would be less than significant. Elimination of seasonal extremes in dissolved oxygen (i.e., supersaturation in surface waters and oxygen depletion in bottom waters) in the riverine reaches replacing Copco 1 and Iron Gate Reservoirs in the Hydroelectric Reach would be beneficial.**

Lower Klamath Basin

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) ~~effects on dissolved oxygen would resolve well upstream of the Klamath Estuary and the Proposed Action would not affect dissolved oxygen in the estuary or the marine nearshore environment.~~

~~While predicted short-term~~ *increases in oxygen demand* ~~under the Proposed Action generally result in dissolved oxygen concentrations above the minimum acceptable level (5 mg/L) for salmonids, exceptions to this would occur four to eight weeks following drawdown of J.C. Boyle~~*(IOD and* ~~Iron Gate reservoirs (i.e., in February 2020), when dissolved oxygen would remain below 5 mg/L from Iron Gate Dam to near the confluence with the Shasta River (RM 176.7), or for a distance approximately 20–25 km downstream of the dam. Recovery to the North Coast Basin Plan water quality objective~~

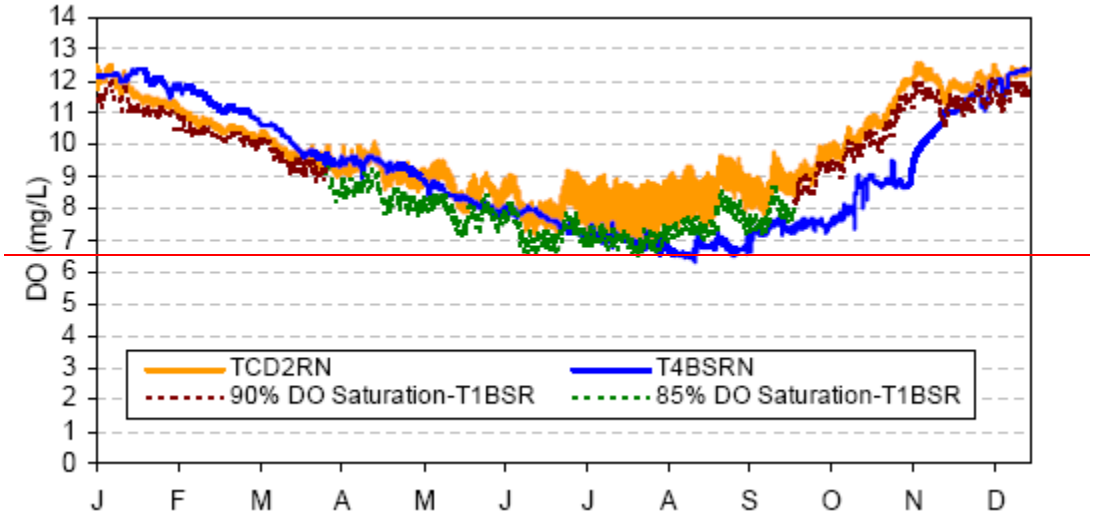
~~of 90 percent saturation (i.e., 10–11 mg/L) would occur within a distance of 100–150 km (62–93 mi) downstream of Iron Gate Dam, or generally in the reach from Seiad Valley to the mainstem confluence with Clear Creek,~~*BOD)* *and* ~~would therefore not effect dissolved oxygen in the estuary or the nearshore environment. Since the estimated~~ *reductions in dissolved oxygen* ~~described above would occur as a result of high short-term SSCs following dam removal, they would not extend to the long-term (2-50 years following dam removal).~~*in the Lower Klamath River, the Klamath Estuary and the marine nearshore environment.* Under the Proposed Action, high SSCs are expected in the middle and Lower Klamath River immediately following dam removal (see Alternative 2 – Full Facilities Removal of Four Dams – Suspended Sediments). The high fraction of organic carbon present in the reservoir sediments (see Section 3.2.3.1) allows for the possibility of oxygen demand generated by microbial oxidation of organic matter exposed to the water column from deep within the sediment profile and mobilized during dam removal.

Under the *Proposed Action*, the short-term (<2 years following dam removal) decrease in dissolved oxygen concentrations would be a significant impact on the ~~lower~~Lower Klamath River from Iron Gate dam possibly to Clear Creek, but would not affect dissolved oxygen in the Klamath Estuary or the marine nearshore environment.

Removal of the Four Facilities under the Proposed Action could cause long-term (2-50 years following dam removal) overall increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the ~~lower~~Lower Klamath River, particularly for the reach immediately downstream ~~of~~from Iron Gate Dam. KRWQM (see Section 3.2.1.1 for model background) results using 2001–2004 data indicate that substantial improvements in long-term dissolved oxygen may occur immediately downstream ~~of Iron~~ from Iron Gate Dam if the Four Facilities are removed, with increases of 3 to 4 mg/L possible during summer and late fall (PacifiCorp ~~2004b~~2005). KRWQM output also predicts greater daily variations in dissolved oxygen concentrations downstream ~~of~~from Iron Gate Dam to the Trinity River confluence (RM 42.5) in the absence of the KHP dams, based upon the assumption that periphyton growth would occur in this reach if the dams were removed and would increase daily dissolved oxygen fluctuations~~.~~ due to photosynthetic oxygen production and respiratory consumption. However, the KRWQM does not include nutrient retention in the mainstem river downstream ~~of~~from Iron Gate Dam and assumes relatively high nutrient contributions from tributaries (Asarian and Kann ~~2006a~~2006b), which could amplify model predicted daily variations in dissolved oxygen due to periphyton growth.

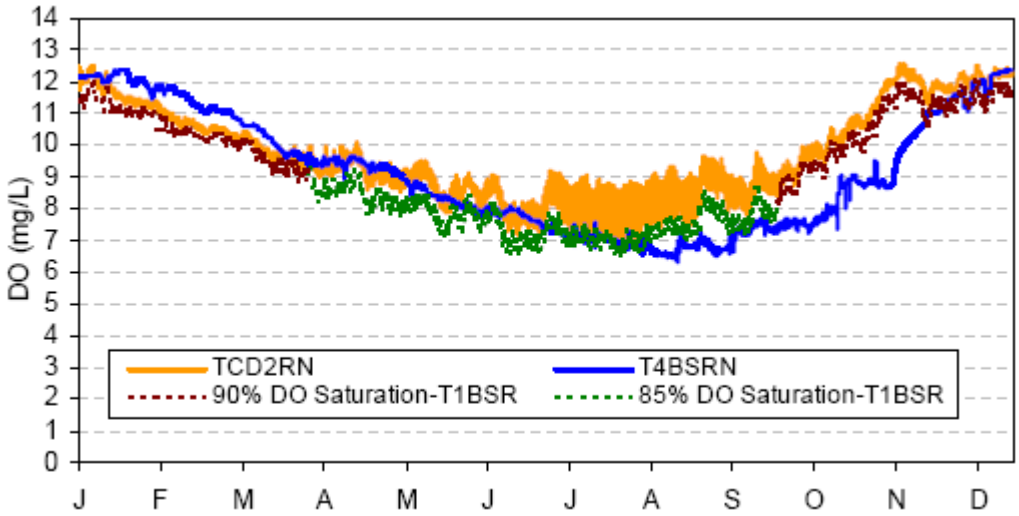
The Klamath TMDL model (see Appendix D) also indicates that under the Proposed Action (similar to the TMDL TCD2RN scenario), dissolved oxygen concentrations immediately downstream ~~of~~from Iron Gate Dam during July through November would be greater than those under the No Action/No Project (similar to the TMDL T4BSRN scenario), due to the lack of stratification and oxygen depletion in bottom waters in the upstream reservoirs as compared with a free-flowing river condition (see Figure 3.2-18 ~~to Figure 3.2-21; NCRWQCB 2010a~~). The model also predicts that daily fluctuations in

dissolved oxygen at this location during this same period would be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN) (Figure 3.2-18), a condition potentially linked to periphyton establishment in the free-flowing reaches of the river that are currently occupied by reservoirs and associated ~~photosynthetic~~ daily swings in ~~oxygen production. The Klamath TMDL model indicates consistent compliance with the California North Coast Basin Plan water quality objective of 85 percent saturation. Results also indicate that while minimum values may occasionally dip below the current Hoopa Valley Tribe minimum water quality objective (8 mg/L), they would not fall below the 90 percent saturation objective awaiting approval by USEPA (see Table 3.2-6). Winter time (January–March) dissolved oxygen concentrations would be slightly lower under the Proposed Action, but would not fall below Basin Plan minimum criteria for the winter season (90 percent saturation; see Table 3.2-4).~~photosynthetic oxygen production and respiratory consumption. Differences in long-term dissolved oxygen concentrations between the Proposed Action and the No Action/No Project Alternative diminish with distance downstream ~~of~~from Iron Gate Dam, with similar or the same predicted dissolved oxygen concentrations and similar magnitude and duration of daily fluctuations by Seiad Valley (RM 129.4) and no differences by the confluence with the Trinity River (~~RM~~ RM 42.5) (see Figure 3.2-18 to Figure 3.2-21).



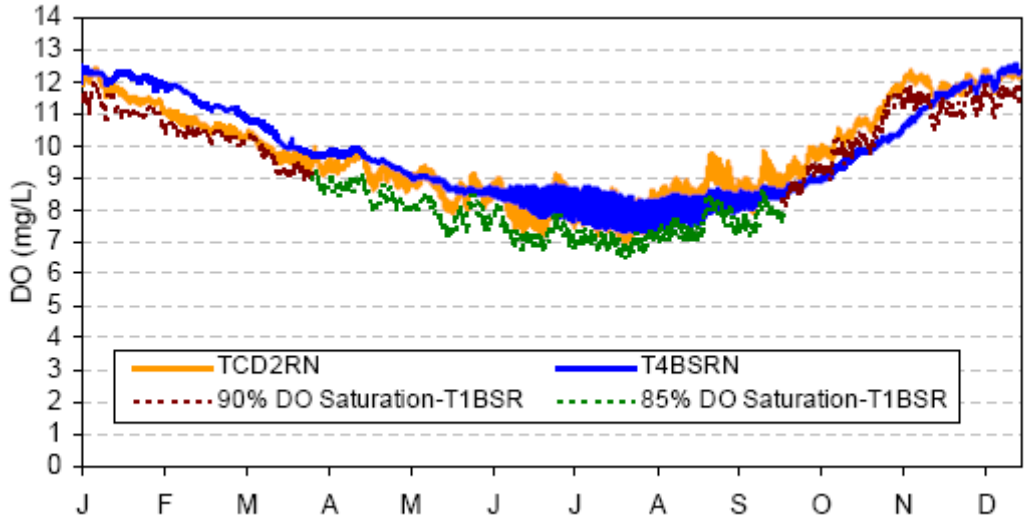
At all modeled locations, the Klamath TMDL model indicates consistent compliance with the California North Coast Basin Plan water quality objective of 85 percent saturation (see Figure 3.2-18 to Figure 3.2-21). Further downstream, near the confluence with the Trinity River (see Figure 3.2-21), results also indicate that while minimum values may occasionally dip below the current Hoopa Valley Tribe minimum water quality objective (8 mg/L) (applicable from ≈RM 45–46), they would not fall below the 80 percent saturation objective modeled for the TMDL and would likely also not fall below the 90 percent saturation Hoopa Valley Tribe objective awaiting approval by USEPA (see Table 3.2-6) (90 percent saturation objective not shown in Figure 3.2-21, but the general trend is apparent). Winter time (January–March) dissolved oxygen concentrations would be slightly lower under the Proposed Action, but would not fall below Basin Plan minimum criteria for the winter season (90 percent saturation; see Table 3.2-4).

The magnitude of the increased daily fluctuations in dissolved oxygen immediately downstream from Iron Gate Dam predicted by the PacifiCorp and Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.4, Algae). Therefore, overall, the removal of the Four Facilities under the Proposed Action would cause long-term increases in summer and fall dissolved oxygen in the Lower Klamath River immediately downstream from Iron Gate Dam, along with increases in daily variability, although the magnitude of the increased variability is somewhat uncertain. Effects would diminish with distance downstream from Iron Gate Dam, such that there would be no measurable effects on dissolved oxygen by the confluence with the Trinity River. **Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases in summer and fall dissolved oxygen**



concentrations immediately downstream from Iron Gate Dam would be beneficial.

Figure 3.2-18. Predicted Dissolved Oxygen Downstream ~~of~~from Iron Gate Dam (RM 190.1) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.



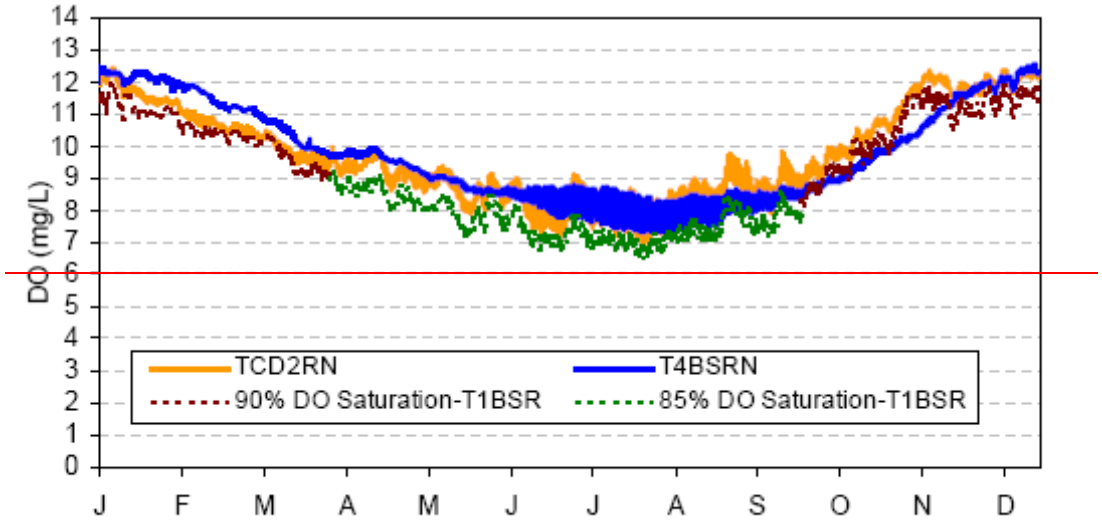
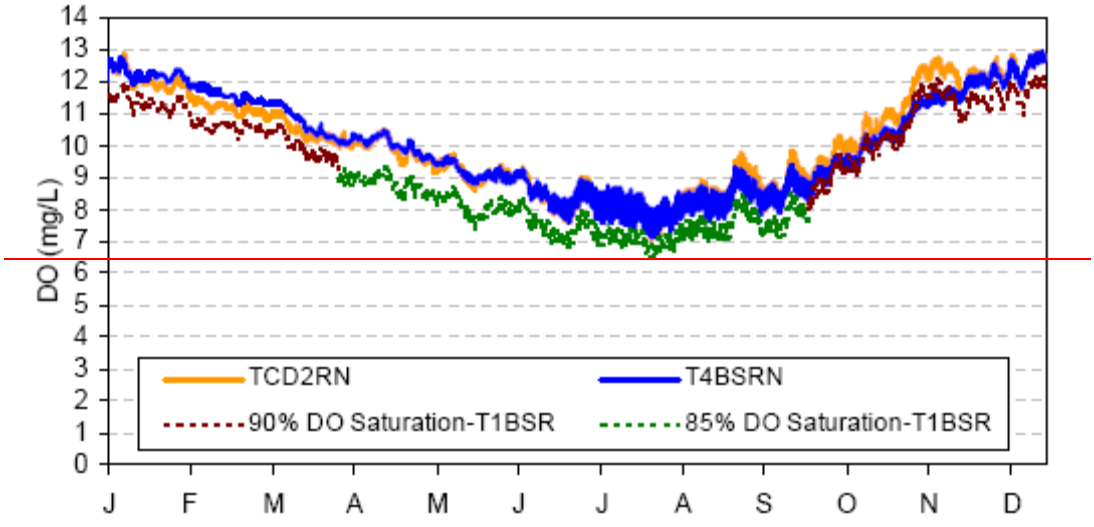


Figure 3.2-19. Predicted Dissolved Oxygen Downstream ~~of~~from the Mainstem Confluence with the Shasta River (RM 176.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.



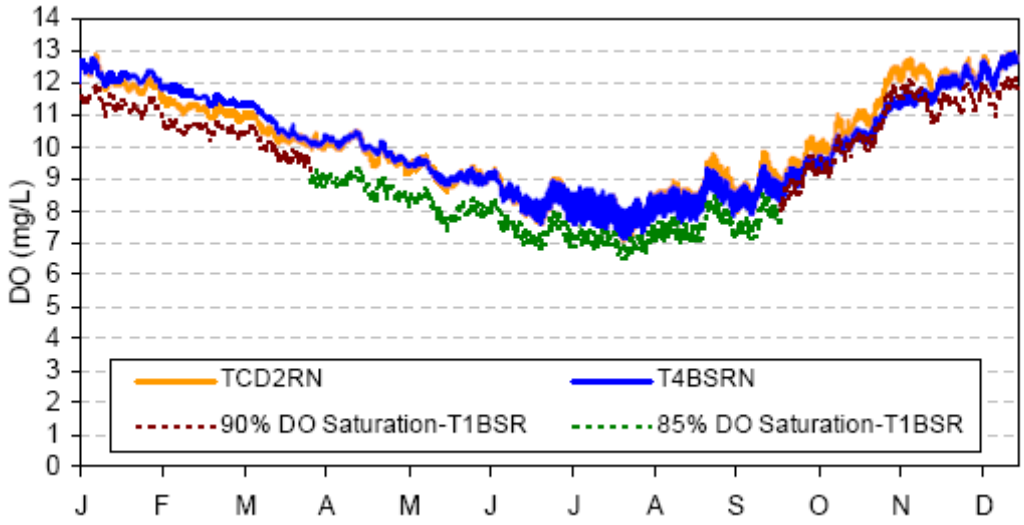
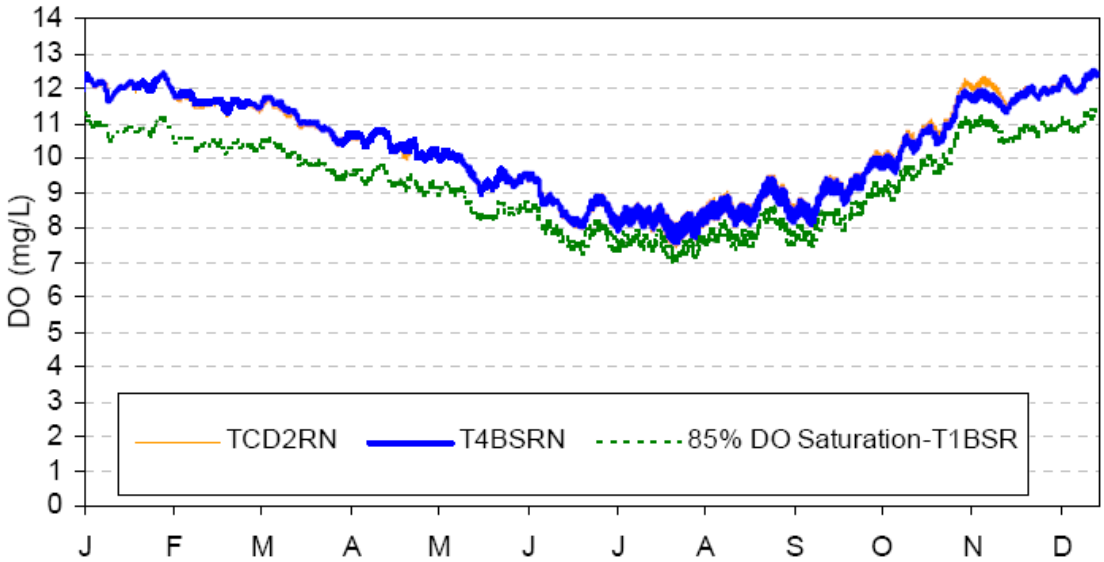


Figure 3.2-20. Predicted Dissolved Oxygen at Seiad Valley (RM 129.4) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.



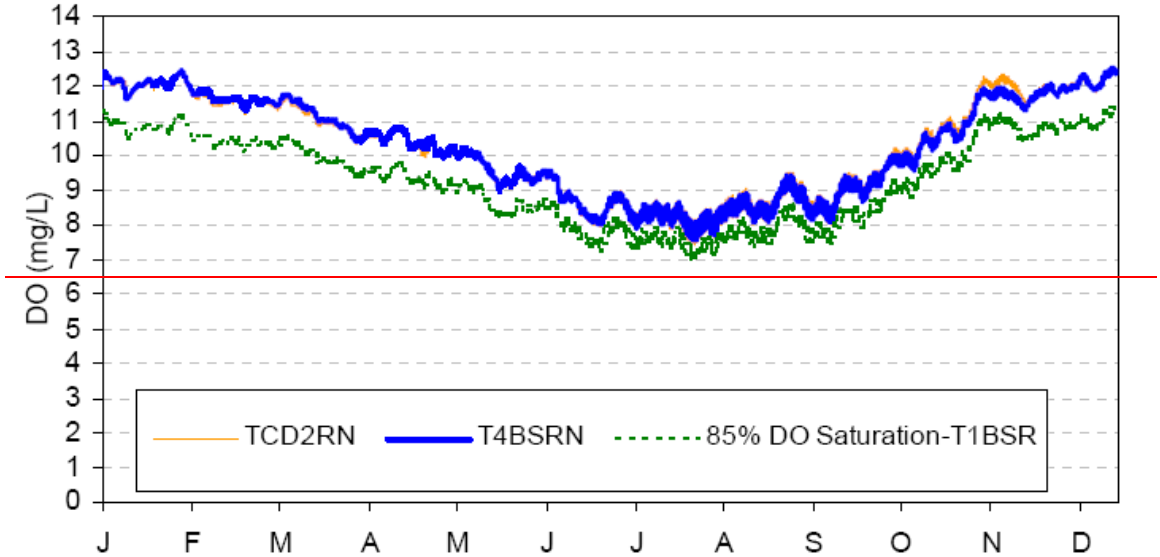


Figure 3.2-21. Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 42.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

~~The increased daily fluctuations in dissolved oxygen immediately downstream of Iron Gate Dam predicted by the PacifiCorp and Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is unknown because nutrient cycling and resulting rates of primary productivity~~

~~under the No Action/No Project Alternative are uncertain (see Section 3.4, Algae). Therefore, overall, the removal of the Four Facilities under the Proposed Action would cause long-term increases in summer and fall dissolved oxygen in the lower Klamath River immediately downstream of Iron Gate Dam, along with potentially increasing daily variability. Effects would diminish with distance downstream of Iron Gate Dam, such that there would be no measurable effects on dissolved oxygen by the confluence with the Trinity River.~~ ~~**Under the *Proposed Action*, the long-term (2–50 years following dam removal) increases in summer and fall dissolved oxygen concentrations immediately downstream of Iron Gate Dam would be beneficial.**~~

~~**3.2.4.3.2.5**~~

pH

~~Upper Klamath Basin~~

~~*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in summertime pH in the Hydroelectric Reach*. Modeling of pH conducted for development of the Oregon and California Klamath River TMDLs (Kirk et al. 2010, NCRWQCB 2010a) provides information applicable to the assessment of long-term effects of the Proposed Action on pH in the Upper Klamath Basin.~~

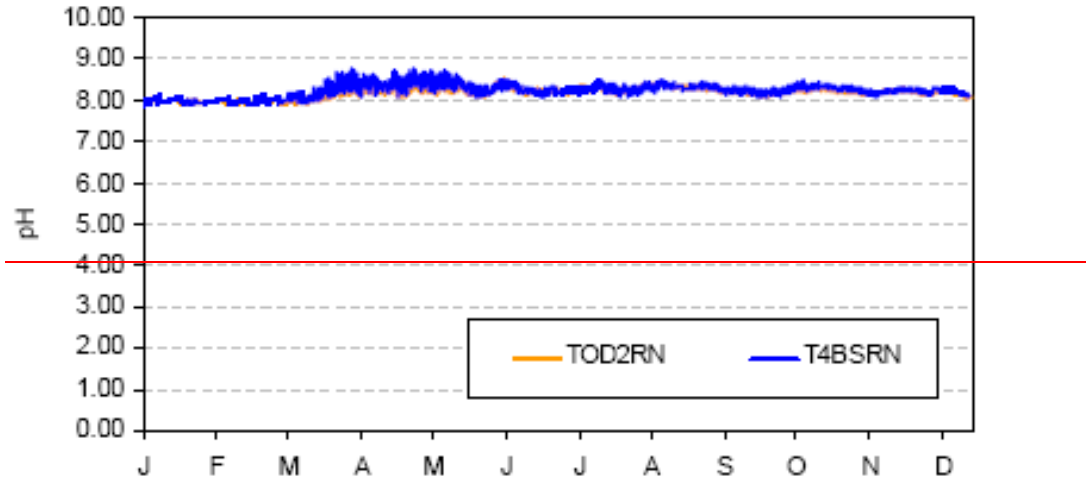
~~While reaches upstream of the Hydroelectric Reach (i.e., from RM 231 to RM 251, Upper Klamath Lake, Agency Lake, and the Sprague River) are included on Oregon's 303(d) list for pH, the hydropower reach itself is not currently identified as being impaired (see Table 3.2-8). Further, Klamath TMDL model results indicate that under the Proposed Action (similar to the TMDL TOD2RN scenario), pH in the Hydroelectric Reach immediately downstream of J.C. Boyle Dam would be the same as pH levels modeled under the No Action/No Project (similar to the TMDL T4BSRN scenario), with the potential for some decreases in minimum daily values (see Figure 3.2-22). At the Oregon-California state line, pH levels under the Proposed Action would be roughly the same as those predicted under the No Action/No Project , but with less daily variability during spring (March–May) and fall (October–November) (see Figure 3.2-23) due to the removal of reservoir habitat for suspended algal growth. Similar to dissolved oxygen (see above section), the changes in daily fluctuations for pH indicated by the Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities (including Keno Impoundment and Lake Ewauna as an assumption of the TOD2RN model [Appendix D]) is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.2.1.1). Periphyton growth may increase in the Hydroelectric Reach under the Proposed Action and increase daily variability in pH.~~

~~However, based on TMDL model results, pH under the Proposed Action in the Hydroelectric Reach upstream of the Oregon-California state line would consistently meet the Oregon water quality objective of 9.0 units for support of beneficial uses (based on Klamath TMDL model results).~~

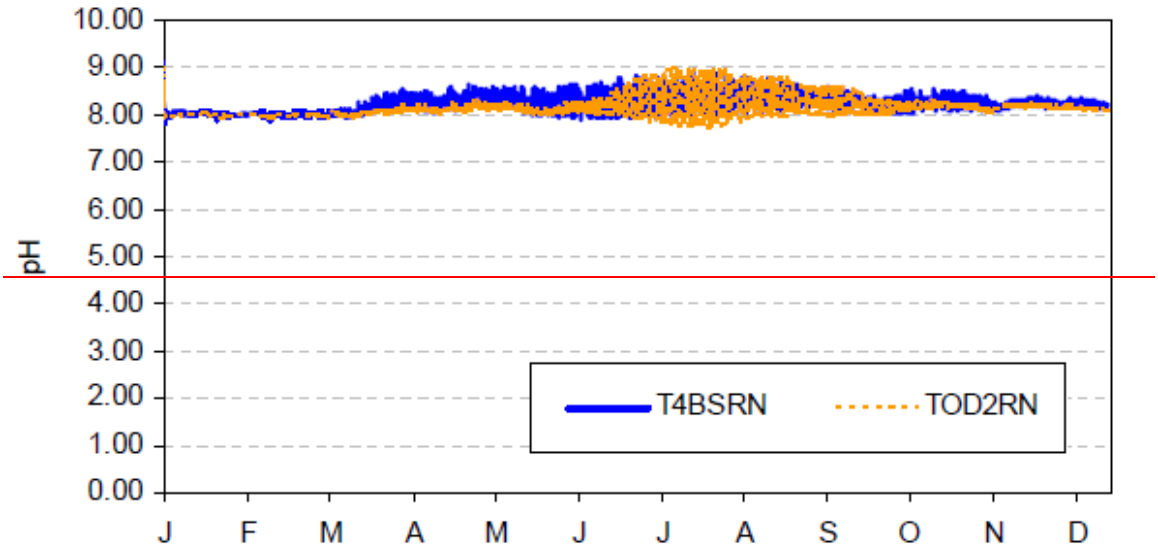
~~The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020, pH effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect. The exception to this is the potential for increased daily variability in pH due to increases in periphyton growth in the Hydroelectric Reach. Increased daily variability due to periphyton growth likely would not occur in the short-term because high SSCs and~~

~~scour in the river 1-2 years following dam removal would limit the establishment of periphyton in the free-flowing river reaches.~~

~~**Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decrease in high summertime daily pH fluctuations in the Hydroelectric Reach would be beneficial.**~~



~~**Figure 3.2-22. Predicted pH Downstream of J.C. Boyle Reservoir (RM 224.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.**~~



~~**Figure 3.2-23. Predicted pH at the Oregon-California State Line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN**~~

~~**Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).**~~
~~**Source: NCRWQCB 2010a.**~~

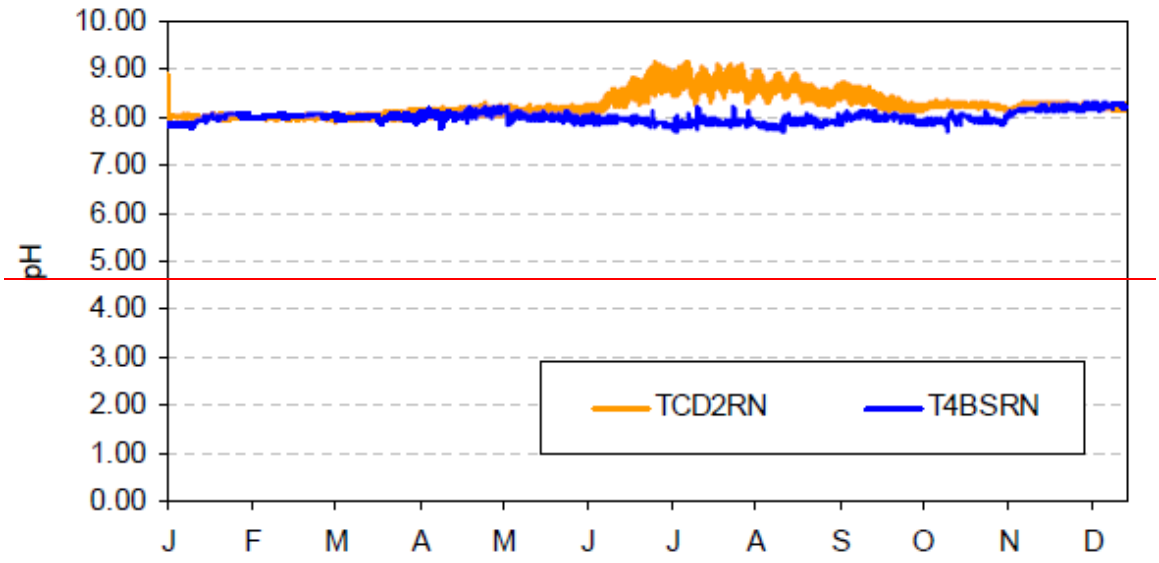
~~Lower Klamath Basin~~

~~*Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in long-term (2–50 years following dam removal) summertime increases in pH in the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.* Modeling of pH conducted for the development of the California Klamath River TMDLs provides information applicable to the assessment of long-term effects of the Proposed Action on pH in the Lower Klamath Basin. In general, results from the Klamath TMDL model (see Appendix D for a summary of model attributes) indicate that spikes in photosynthetic activity in the relatively low alkalinity (typically <100 mg/L; PacifiCorp [2004b], Karuk Tribe of California [2010]) water of the Klamath River, coupled with high air temperatures and high levels of biostimulatory nutrients during the late-summer and early-fall months, would result in large daily variation in pH and generally high pH levels in the Klamath River downstream of Iron Gate Dam (see Figure 3.2-24). This may result in instantaneously exceeding the North Coast Basin Plan water quality objective maximum pH value of 8.5 (see Table 3.2-4), which may be stressful to fish and other aquatic life and adversely affect beneficial uses.~~

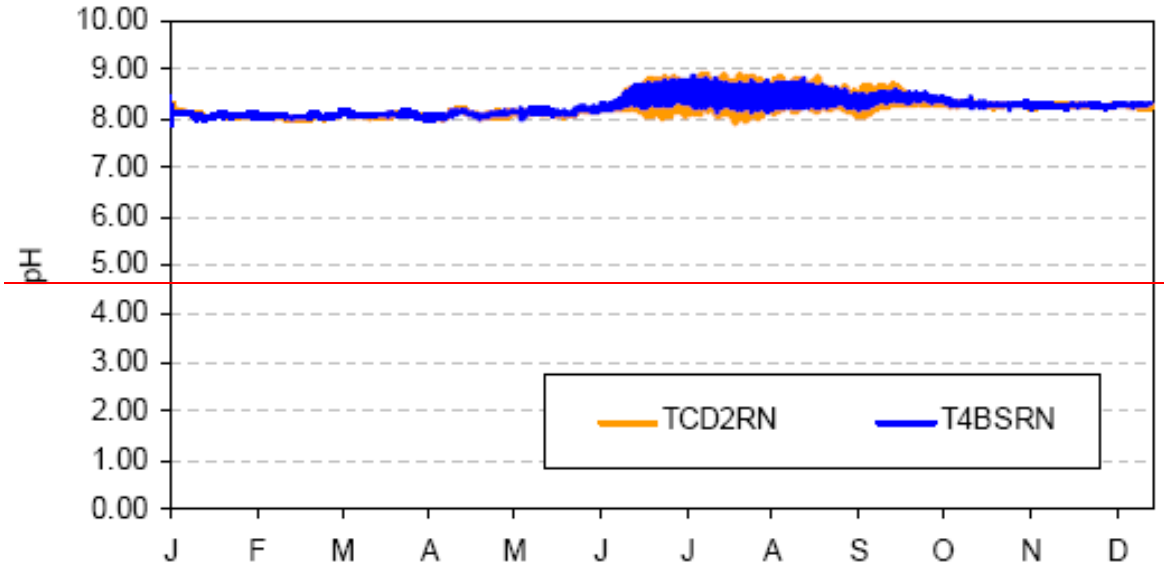
~~Predicted differences in pH between the Proposed Action and No Action/No Project Alternative decrease in magnitude with distance downstream of Iron Gate Dam, and would no longer be evident by the Scott River confluence (RM 143.0) (see Figure 3.2-25). The Hoopa Valley Tribe water quality objective for pH (7.0-8.5) (see Table 3.2-6) is met at all times under the Proposed Action (similar to the TMDL TCD2RN scenario) for the Klamath River at the reach of Hoopa jurisdiction (≈45–46). Therefore, under the Proposed Action, pH would not be affected in the lower river downstream of the Scott River, including the Klamath Estuary and the marine nearshore environment.~~

~~Although the California Klamath River TMDL model predicts long-term increases in pH due to enhanced periphyton growth and increased rates of photosynthesis immediately downstream of Iron Gate Dam, this condition may be counteracted by increased scour at this location under the Proposed Action (see Section 3.4, Algae). Given the uncertainty in the model output from Iron Gate Dam to the Shasta River, and given the localized and instantaneous nature of the predicted high pH levels during summer months, these long-term pH increases would be less than significant.~~

~~The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020, pH effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect. The exception to this is the potential for increases in pH due to increases in periphyton growth in the Hydroelectric Reach. The latter likely would not occur in the short-term because high SSCs and scour in the river 1-2 years following dam removal would limit the establishment of periphyton in the free-flowing river reaches.~~



~~Figure 3.2-24. Predicted Klamath River pH Immediately Downstream of Iron Gate Dam for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.~~



~~Figure 3.2.25. Predicted Klamath River pH upstream of the Scott River (RM 143.0) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.~~

~~**Long-term summertime increases in pH under the *Proposed Action* would be less than significant for the reach from Iron Gate Dam to the Scott River (RM 143). There would be no change from existing conditions on pH in the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) for the Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the marine nearshore environment.**~~

~~**3.2.4.3.2.6 Chlorophyll-a and Algal Toxins**~~

Upper Klamath Basin

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could ~~cause~~ result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in summertime pH in the Hydroelectric Reach. While both reservoir and riverine reaches upstream of the Hydroelectric Reach (i.e., from RM 231 to RM 251, Upper Klamath Lake, Agency Lake, and the Sprague River) are included on Oregon's 303(d) list for pH, the Hydroelectric Reach itself is not currently identified as being impaired (see Table 3.2-8). While the California Klamath River TMDLs do not include specific allocations or targets for pH, it is included under load allocations and targets for nutrients as biostimulatory substances (NCRWQCB, 2010a), which are assigned to the KHP and are designed to limit algal photosynthesis. Consistent with this, pH values in Copco 1 and Iron Gate Reservoirs can exceed 9, with large (0.5–1.5 pH units) daily fluctuations occurring in reservoir surface waters during periods of intense algal blooms (see Section 3.2.6).

Modeling of pH conducted for development of the Oregon and California Klamath River TMDLs (Kirk et al. 2010, NCRWQCB 2010a) provides information applicable to the assessment of long-term effects of the Proposed Action on pH in riverine reaches in the Upper Klamath Basin. Klamath TMDL model results indicate that under the Proposed Action (similar to the TMDL TOD2RN scenario), pH in the Hydroelectric Reach immediately downstream from J.C. Boyle Dam would be the same as pH levels modeled under the No Action/No Project (similar to the TMDL T4BSRN scenario), with the potential for some small decreases in minimum daily values (see Figure 3.2-22). At the Oregon-California State line, pH levels under the Proposed Action would exhibit less daily variability during spring (March–May) and fall (October–November) (see Figure 3.2-23), while daily variability in the river during the period June–September would be similar or somewhat greater under the Proposed Action, likely due to enhanced periphyton growth in the free-flowing river reaches previously occupied by the upstream J.C. Boyle Reservoir. The modeled increases at the Oregon-California State line would consistently meet the Oregon water quality objective of 9.0 units for support of beneficial uses and would therefore be less than significant. While there are no TMDL model results for riverine locations upstream of Copco 1 or Iron Gate Reservoirs, these locations would be expected to exhibit similar patterns as those predicted for the Klamath River at the Oregon-California State line.

The Proposed Action would also eliminate the occurrence of high pH (> 9 pH units) and large (0.5–1.5 pH units) daily fluctuations occurring in the surface waters of Copco 1 and Iron Gate Reservoirs during periods of intense algal blooms. pH in the free-flowing reaches of the river replacing these reservoirs would not exhibit such extremes, instead possessing the riverine signal described above.

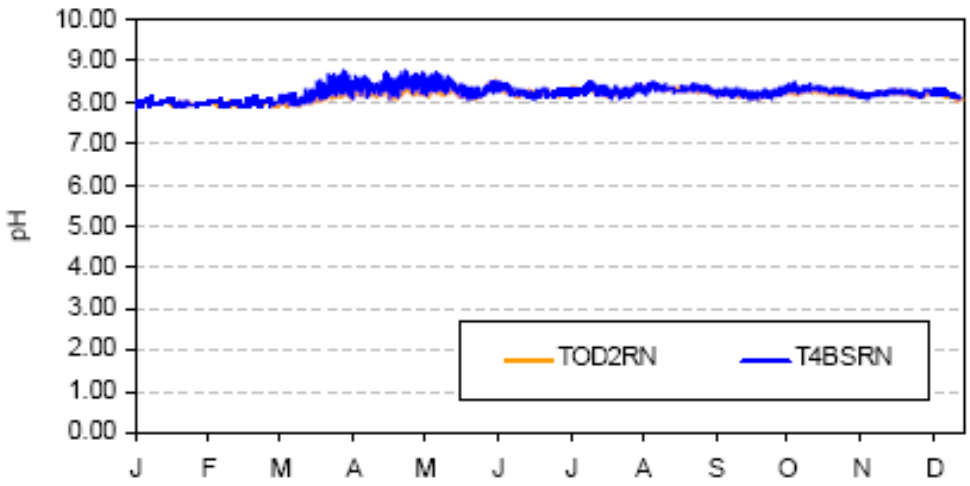


Figure 3.2-22. Predicted pH Downstream from J.C. Boyle Reservoir (RM 224.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

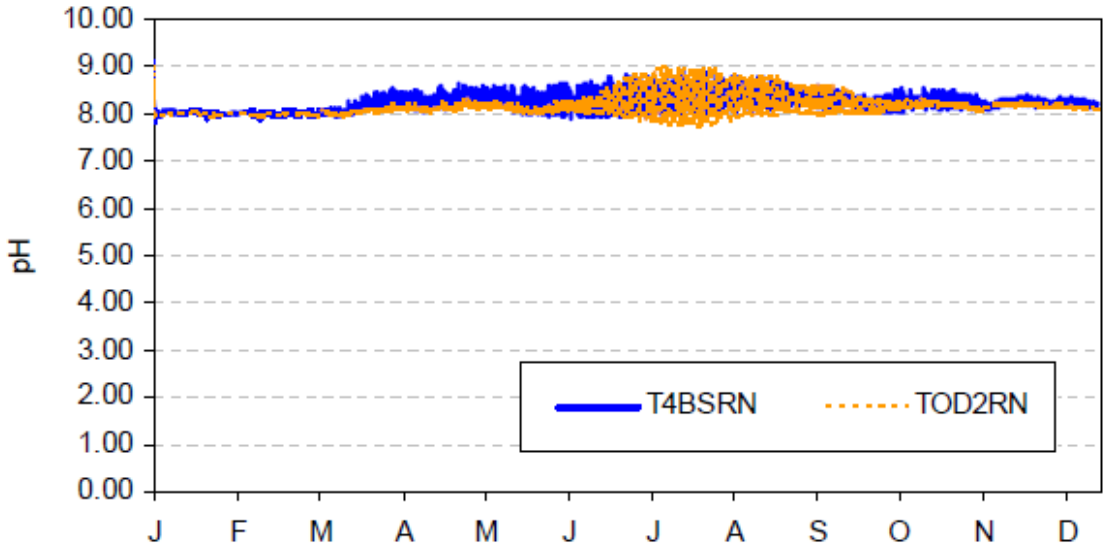


Figure 3.2-23. Predicted pH at the Oregon-California State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the

Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

Similar to dissolved oxygen (see above section), the changes in daily fluctuations for pH indicated by the Klamath TMDL modeling efforts are not entirely certain; the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities (including Keno Impoundment/Lake Ewauna as an assumption of the TOD2RN model [Appendix D]) is not well known because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are not well known (see Section 3.2.1.1).

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020, pH effects of the Proposed Action in the Hydroelectric Reach would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect. The exception to this is the potential for increased daily variability in pH due to increases in periphyton growth in the Hydroelectric Reach. However, increased daily variability due to periphyton growth likely would not occur in the short term because high SSCs and scour in the river 1-2 years following dam removal would limit the establishment of periphyton in the free-flowing river reaches.

Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) slight summertime increases in pH and daily pH fluctuations at the Oregon-California State line and upstream and downstream reaches that are currently riverine would be less than significant. The decrease in high summertime daily pH fluctuations in the free-flowing reaches of the river that replace Copco 1 and Iron Gate Reservoirs in the Hydroelectric Reach would be beneficial.

Lower Klamath Basin

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could result in long-term (2–50 years following dam removal) summertime increases in pH in the Lower Klamath River immediately downstream from Iron Gate Dam. Modeling of pH conducted for the development of the California Klamath River TMDLs provides information applicable to the assessment of long-term effects of the Proposed Action on pH in the Lower Klamath Basin. In general, results from the Klamath TMDL model (see Appendix D for a summary of model attributes) indicate that spikes in photosynthetic activity in the relatively low alkalinity (typically <100 mg/L; PacifiCorp 2005, Karuk Tribe of California 2010) water of the Klamath River, coupled with high air temperatures and high levels of biostimulatory nutrients during the late-summer and early-fall months, would result in large daily variation in pH and generally high pH levels in the Klamath River downstream from Iron Gate Dam (see Figure 3.2-24). This condition is not unlike current conditions, where pH during late-summer and early-fall months (August–September) in the Klamath River downstream from Iron Gate Dam (particularly upstream of the Shasta River confluence [RM 176.7]) ranges from just above neutral to greater than 9, with large (0.5–1.5 pH

units) daily fluctuations occurring in the lower river during periods of high photosynthesis (see Section 3.2.3.6).

Predicted differences in pH between the Proposed Action and No Action/No Project Alternative decrease in magnitude with distance downstream from Iron Gate Dam, and are considerably dampened by the Scott River confluence (RM 143.0) (see Figure 3.2-25). The Hoopa Valley Tribe water quality objective for pH (7.0-8.5) (see Table 3.2-6) is met at all times under the Proposed Action (similar to the TMDL TCD2RN scenario) for the Klamath River at the reach of Hoopa jurisdiction (≈45–46).

Similar to the pH analysis for the Upper Klamath Basin (see prior section), the changes in daily fluctuations for pH indicated by the Klamath TMDL modeling efforts immediately downstream from Iron Gate Dam are not entirely certain because the magnitude of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river replacing the reservoirs at the Four Facilities is not well known. The final Klamath TMDL targets and allocations are based on several lines of evidence and results from a number of different analytical tools; this is a particularly important consideration for the reach immediately downstream from Iron Gate Dam because the modeled pH changes are relatively larger than those predicted further upstream in the Hydroelectric Reach (see above discussion). The Klamath River mainstem periphyton target (150 ug/m^2 chlorophyll-*a*) was developed using the California NNE framework and calculation tools (Creager et al. 2006, Tetra Tech 2008). Building on the NNE analysis, Butcher (2008) determined that the periphyton target is met for the TMDL dams-out model scenario nutrient concentration targets (TP and TN targets are presented in Section 3.2.4.2.2.2, page 3.2-44). Because it uses a slightly different periphyton biomass estimate than the NNE framework tool, the TMDL model may overestimate summertime pH levels and variability immediately downstream from Iron Gate Dam. Additionally, based on the NNE analysis, pH is not expected to exceed the NCRWQCB Basin Plan objective of pH 8.5 on a regular basis for the dams out condition. Mitigating factors that could potentially limit periphyton densities to levels below the TMDL model estimate include increased scour and alterations in nutrient dynamics in the free flowing river due to retention from periphyton growth further upstream – see Section 3.4, Algae). As discussed under the No Action/No Project Alternative (see page 3.2-61), adaptive management strategies will be employed to refine efforts toward achieving water quality objectives and targets as part of the TMDL process. Given that there are multiple lines of evidence suggesting potentially different responses to pH from dam removal, adaptive management monitoring under the Proposed Action should include provisions for monitoring periphyton density in the reaches downstream from where Iron Gate Dam is currently located. Overall, the weight of evidence suggests that the potential for long-term pH increases during the summer months immediately downstream from Iron Gate Dam is less than significant.

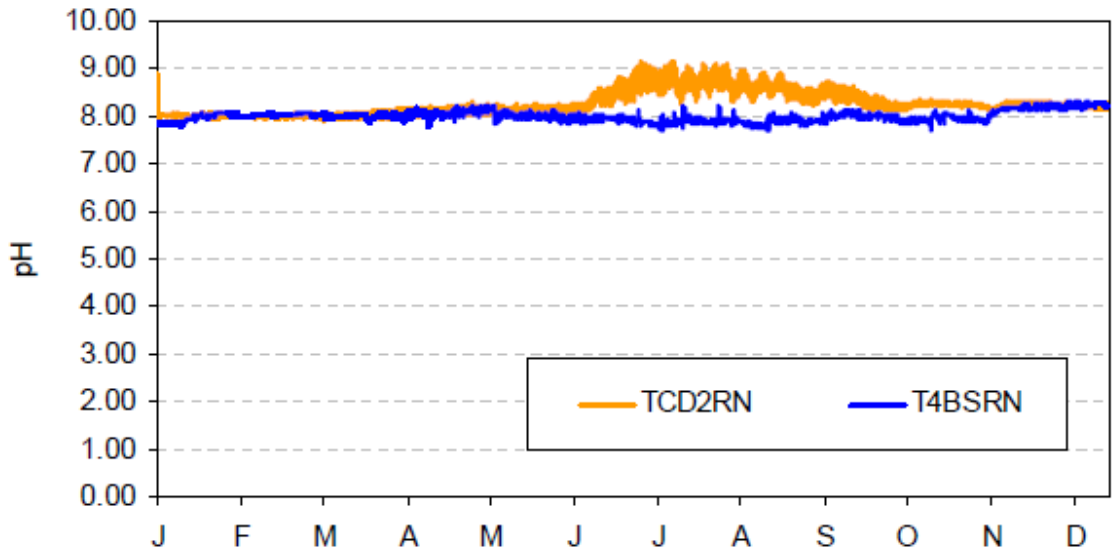


Figure 3.2-24. Predicted Klamath River pH Immediately Downstream from Iron Gate Dam for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).
Source: NCRWQCB 2010a.

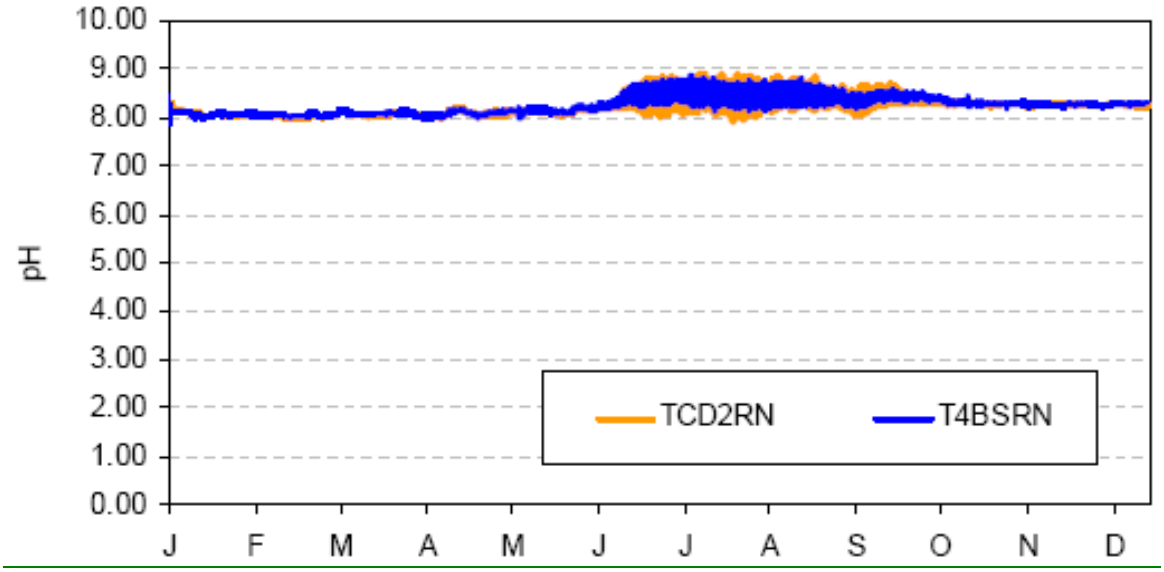


Figure 3.2.25. Predicted Klamath River pH upstream of the Scott River (RM 143.0) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).
Source: NCRWQCB 2010a.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020, pH effects of the Proposed Action in the Lower Klamath River would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect. The exception to this is the potential for increases in pH due to increases in periphyton growth in the Lower Klamath River. The latter likely would not occur in the short term because high SSCs and scour in the river 1-2 years following dam removal would limit the establishment of periphyton in the free-flowing river reaches.

Long-term summertime increases in pH under the *Proposed Action* would be less than significant for the reach from Iron Gate Dam to the Scott River (RM 143). There would be no change from existing conditions on pH in the short term (<2 years following dam removal) and long-term (2–50 years following dam removal) for the Klamath River downstream from the Scott River, the Klamath Estuary, and the marine nearshore environment.

Chlorophyll-a and Algal Toxins

Upper Klamath Basin

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could substantially reduce or eliminate short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) levels of chlorophyll-a and algal toxins in the Hydroelectric Reach. Despite the slightly increased total nutrient concentrations anticipated under the Proposed Action in the Hydroelectric Reach (see Alternative 2 – Full Facilities Removal of Four Dams – Nutrients), elimination of the lacustrine (reservoir) environment that currently supports growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* would result in decreases in high seasonal concentrations of chlorophyll-*a* (>10 µg/L) and periodically high levels of algal toxins (> 8 µg/L microcystin) generated by suspended blue-green algae. ~~While algal toxins and chlorophyll-*a* produced in Upper Klamath Lake may still be transported into the Hydroelectric Reach at levels exceeding water quality objectives for Oregon and California, additional *in situ* production of the toxins and chlorophyll-*a* associated with suspended algae would be significantly less likely to occur in the free-flowing river under the Proposed Action.~~

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., the beginning of the growth season), elimination of the lacustrine (reservoir) environment under the Proposed Action would occur, either partially or fully, within the first 1 to 2 years following dam removal. Therefore, this would be a short-term effect on chlorophyll-*a* and algal toxins in the Hydroelectric Reach as well as a long-term effect.

Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decrease in ~~production~~chlorophyll-*a* and substantial decrease or elimination of algal toxins and ~~chlorophyll-*a*~~ in the Hydroelectric Reach would be beneficial.

Lower Klamath Basin

Removal of the Four Facilities under the Proposed Action and conversion of the reservoir areas to a free-flowing river could ~~cause~~substantially reduce or eliminate short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) ~~decreases in~~ levels of chlorophyll-a and algal toxins transported into the ~~lower~~Lower Klamath River and potentially the Klamath Estuary. In addition to the decreases in high seasonal concentrations of chlorophyll-*a* (>10 µg/L) and periodically high levels of algal toxins (>8 µg/L microcystin) generated by nuisance algal species that are described for the Hydroelectric Reach (see Section 3.2.4.3.2.6, Upper Klamath Basin), growth of *M. aeruginosa* in reaches of the Klamath River downstream ~~of~~ from Iron Gate Dam would ~~be~~ be reduced in the absence of significant reservoir blooms. While algal toxins and chlorophyll-*a* produced in Upper Klamath Lake (see Section 3.2.3.1) may still be transported into the Lower Klamath Basin, existing data indicate that concentrations of microcystin leaving Upper Klamath Lake have rarely, if ever, been measured at levels that exceed water quality objectives for Oregon and California. In contrast, algal production in Iron Gate and Copco Reservoirs is responsible for the observed public health exceedances occurring in the Klamath River downstream ~~of~~ from Iron Gate Dam (see Section 3.2.3.7 and Appendix C, Section C.6). Under the Proposed Action, the *in situ* production of toxins and chlorophyll-*a* associated with suspended algae in the reservoirs would be eliminated.

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects. Because drawdown of the reservoirs would begin in winter and would be largely complete by March/April of 2020 (i.e., the beginning of the growth season), effects of the Proposed Action on chlorophyll-*a* and algal toxins in the ~~lower~~Lower Klamath River would occur, either partially or fully, within the first 1 to 2 years following dam removal and be a short-term effect as well as a long-term effect.

Under the *Proposed Action*, the short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) decreases in the production of algal toxins and chlorophyll-*a* in upstream reservoirs and subsequent transport into the ~~lower~~Lower Klamath River and the potentially the Klamath Estuary would be beneficial.

~~3.2.4.3.2.7~~ Inorganic and Organic Contaminants

Upper Klamath Basin

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the Hydroelectric Reach. Due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (i.e., 15 percent of total volume for the Four Facilities, see also Figure 3.3-8), concentrations of suspended sediments downstream ~~of~~ from J.C. Boyle Reservoir would be considerably less than those anticipated to occur downstream ~~of~~from Iron Gate Reservoir. Because the transport of

contaminants would be associated with the elevated SSCs, as a conservative estimate, effects of sediment release on inorganic and organic contaminants in the Hydroelectric Reach downstream ~~of~~ from J.C. Boyle Dam would be the same as those for the ~~lower~~Lower Klamath River. **Under the *Proposed Action*, the short-term (< 2 years following dam removal) and long-term (2–50 years following dam removal) effects of sediment release on freshwater aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants in the Hydroelectric Reach would be a less-than-significant impact.**

The Proposed Action could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) human exposure to contaminants from contact with deposited sediments on exposed reservoir terraces and river banks following reservoir drawdown. Potential human health risks associated with exposure to sediments deposited on exposed reservoir terraces and river banks within the Hydroelectric Reach were evaluated using comparisons of the 2009–2010 Secretarial Determination reservoir sediment core data to USEPA residential soil screening levels, and calculation of human/mammal TEQs and comparison to ODEQ Bioaccumulation screening level values (SLVs ~~(exposure "Scenario~~) ("Exposure Pathway 3" in CDM [2011]). No samples exceeded the total non-carcinogenic screening levels.

Forty-~~seven~~five samples exceeded the USEPA total carcinogenic screening level for residential soils for arsenic or nickel, including samples from J.C. Boyle, Copco 1 and Iron Gate Reservoirs ~~(and the Klamath Estuary, although this location is not relevant to reservoir deposits under the Proposed Action)~~. For arsenic, sampled concentrations in the reservoirs ranged from 4.3 to 15 mg/kg (see Appendix C, Table C-6), while the USEPA total carcinogenic screening level is 0.39 mg/kg. However, these screening levels were developed assuming residential exposure patterns (a 30-year exposure duration with soil ingestion rate of ~~200~~ 200 mg/day for children over 6 years and 100 mg/day for adults over 24 years) (USEPA 1991), which is quite conservative and the measured values are well within ~~typical background~~ the range of available soil concentrations for the Klamath Basin (arsenic may be naturally elevated in the Upper Klamath Basin [see Appendix C, Section ~~3.2.2.8, Inorganic~~ C.7.1]). Additionally, ODEQ suggests a default background soil/sediment concentration for arsenic of 7 mg/kg (ODEQ 2007), a similar magnitude to the concentrations measured in reservoir sediments and ~~Organic Contaminants]). For~~ a similar factor by which the reservoir sediments and background soils exceed the USEPA screening levels. Along these lines, ODEQ (2007) recommends the use of background concentrations as the screening levels when natural background is higher than a screening level. Lastly, under KHSA Section 7.6.4.A, the reservoir footprint areas would be designated as parcel B lands, which includes public interest purposes such as fish and wildlife habitat restoration and enhancement, public education, and public recreational access, and would not be used as residential lands. Therefore, potential exposure to arsenic measured in the reservoir sediments under the Proposed Action would be less than that assumed for the USEPA total carcinogenic screening levels, and it would be unlikely to have adverse effects under Exposure Pathway 2.

For nickel, sampled concentrations in the reservoirs ranged from 18 to 33 mg/kg (see Appendix C, Table C-6), while the USEPA total carcinogenic screening level is 0.38 mg/kg. As with arsenic, available Klamath Basin soil concentrations of nickel (median values 33 mg/kg and 65.7 mg/kg from two different studies) are in the same range as those measured in reservoir sediments (see Appendix C, Section C.7.1) and they exceed the USEPA total carcinogenic screening level for residential soils by a similar factor. The highest concentrations of nickel were found in sediments from the Klamath River Estuary, which further suggests that release of reservoir sediments downstream would not negatively affect nickel concentrations in downstream reaches. Accordingly, the observed concentrations of nickel are unlikely to have adverse effects to humans under Exposure Pathway 2.

For 19 analytes measured during 2009–2010, laboratory analytical reporting limits were greater than the applicable human health screening levels, including PCBs, VOCs, and SVOCs (CDM 2011). It is not possible to directly confirm that these compounds are above or below applicable human health screening levels.

TEQs calculated for dioxin, furan, and dioxin-like PCBs were at concentrations above ODEQ Bioaccumulation SLVs for mammals in sediments from each of the reservoirs (CDM 2011). ODEQ Bioaccumulation SLVs are not applicable to water bodies in California; however, they provide a reference for comparison purposes. Although site-specific background data are lacking, TEQs are also only slightly above regional background concentrations and thus have limited potential for adverse effects for humans exposed to sediment deposits on reservoir terraces or river banks. The sources of the slightly elevated dioxin, furan, and dioxin-like PCB compounds are not known; however, sources may include atmospheric deposition, regional forest fires, and possibly burning of plastic items (CDM 2011).

Results from the 2009–2010 Secretarial Determination sediment chemistry analyses indicate that sediment deposits associated with the Proposed Action would cause no adverse effects on humans (terrestrial biota were also evaluated qualitatively, but are not discussed here) (see Figure 3.2-2). **Under the *Proposed Action*, the effects of sediment deposition on reservoir terraces and river banks on short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) human exposure to sediment-associated inorganic and organic contaminants in the Hydroelectric Reach would be a less-than-significant impact.**

Dam deconstruction and revegetation (i.e., hydroseeding) activities could cause short-term (<2 years following dam removal) increases in inorganic and organic ~~contaminants~~ contaminants from hazardous materials associated with construction and revegetation (i.e., hydroseeding) equipment in the Hydroelectric Reach. These effects would be reduced through implementation of BMPs for deconstruction and revegetation activities that would occur in or adjacent to the Klamath River. BMPs would minimize or eliminate the potential for toxic substances to enter the water. **Under the *Proposed Action*, the short-term (<2 years following dam removal) effects on inorganic and**

organic contaminants in the Hydroelectric Reach from dam deconstruction and restoration (i.e., hydroseeding) activities would be a less-than-significant impact.

Under the Proposed Action, herbicide application associated with management of the reservoir footprint area could result in short-term (<2 years following dam removal) levels of organic contaminants in runoff that are toxic to aquatic biota in the Hydroelectric Reach. Based on the reservoir area management planning currently underway, establishment of herbaceous vegetation in drained reservoir areas will be undertaken to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (O'Meara et al. 2010). Herbicides would be necessary during this period to control the growth of invasive plant species, with application occurring during the first year following dam removal and potentially during the second, if further treatments are necessary. Herbicide application would be required for 25 percent, 50 percent, and 75 percent of the total reservoir area for the low, most probable, and high cost restoration estimates, respectively (O'Meara et al. 2010).

The reservoir area management plan recognizes the potential water quality effects of herbicide application and calls for the use of herbicides with low soil mobility, and thus low potential to leach into groundwater or surface waters. It also calls for low use rates of herbicides and application of chemicals that pose a low toxicity risk to fish and aquatic organisms. Glyphosate is suggested in the management plan as one potential herbicide with such characteristics (O'Meara et al. 2010). To minimize use rates, spot treatments of a post-emergent herbicide such as glyphosate would be used rather than aerial application.

If glyphosate is chosen as a suitable herbicide for reservoir invasive plan management, it is recommended that glyphosate formulations containing POEA or R-11 are avoided to reduce risks to amphibians and other aquatic organisms (BLM 2010). Aquatic formulations of glyphosate (i.e., Glyfos Aquatic) are developed for use in sensitive protected environments such as habitat restoration sites and wetlands. Additionally, best management practices such as the "no rain" rule should be followed, such that glyphosate would never be applied when weather reports predict precipitation within 24 hours of application, before or after (BLM 2010). If another herbicide is chosen, it should meet the characteristics of low soil mobility and low toxicity to fish and aquatic organisms, and should be applied using BMPs such as low use rates (i.e., spot treatments), avoidance of application in the rain, avoidance of treatments during periods when fish are in life stages most sensitive to the herbicide(s) used, and adherence to appropriate buffer zones around stream channels (BLM 2010). **Under the *Proposed Action*, given implementation of applicable BMPs, the effect of herbicide application on toxicity and/or bioaccumulation in the Hydroelectric Reach during the revegetation period would be a less-than-significant impact.**

Lower Klamath Basin

Freshwater Aquatic Life Toxicity and/or Bioaccumulation

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the ~~lower~~Lower Klamath River. Organic and inorganic contaminants have been identified in the sediment deposits currently trapped behind the dams (see Section 3.2.3.1). Under the Proposed Action, short-term (<2 years following dam removal) pathways of contaminant exposure for freshwater aquatic species include exposure during sediment transit through the Lower Klamath Basin river reaches (~~exposure "Scenario~~"Exposure Pathway 2" in CDM [2011]), while long-term (2-50 years following dam removal) pathways include exposure following deposition of sediments along river beds and the estuary bottom (exposure "Scenario 4" in CDM [2011]).

As described for the No Action/No Project Alternative, existing sediment chemistry data (2004–2005) collected from 26 cores in J.C. Boyle, Copco 1, and Iron Gate Reservoirs indicate generally low levels of metals, pesticides, chlorinated acid herbicides, PCBs, VOCs, SVOCs, cyanide, and dioxins (Shannon & Wilson, Inc. 2006; see Section 3.2.3.8). Collection of additional sediment cores in 2009–2010 for the Secretarial Determination process indicates no positive exceedances of applicable screening levels indicating a low risk of toxicity to freshwater sediment-dwelling organisms in the ~~lower~~Lower Klamath River under the Proposed Action. Results from acute (10-day) sediment bioassays for two national benchmark toxicity species (see above discussion under No Action/No Project Alternative) indicate generally equal or greater survival in reservoir sediments as compared with laboratory control samples. The exception is J.C. Boyle Reservoir, which exhibited considerably lower survival for *Chironomus dilutus* in the on-thalweg sample as compared with the laboratory control (64 percent ~~vs.~~versus 95 percent) and somewhat lower survival for the off-thalweg sample (83 percent ~~vs.~~versus 95 percent) (CDM 2011).

Although this result suggests potential for toxicity to freshwater benthic organisms downstream ~~of~~ from the dams, under the Proposed Action, sediments from all three reservoirs will mix as they move downstream, exposing downstream aquatic biota to an "average" sediment composition rather than a reservoir-specific composition. Further, under current conditions, the total volume of erodible sediments in Copco 1 and Iron Gate Reservoirs (~~2.~~7.4 million yd^3 and ~~2.83~~4.7 million yd^3, respectively; see Section 2.5.1) is considerably greater than that of J.C~~.~~. Boyle Reservoir (~~0.94~~1 million yd^3; see Section 2.5.1), diminishing the potential influence of J.C. Boyle Reservoir sediments downstream biota exposure (also see Section 2.2, text box on sediment weight and volume). Finally, fine sediments released during drawdown and dam removal will be transported by large water volumes, and are unlikely to settle along the riverbed (~~Greimann et al. 2011~~Reclamation 2012, Stillwater Sciences 2008); therefore, downstream freshwater benthic organisms are unlikely to experience the same intensity of exposure to sediment elutriate concentrations or reservoir sediments as during the bioassays themselves. Overall, the freshwater sediment bioassays indicate a low

likelihood of acute toxicity to downstream benthic organisms due to sediment release under the Proposed Action.

Elutriate chemistry results indicate that before consideration of dilution, aluminum, chromium, copper, lead, and mercury are present at concentrations above fresh water quality criteria for samples from J.C. Boyle, Copco 1, and Iron Gate Reservoirs (CDM 2011). However, as described above, dilution of mobilized sediments with reservoir and river water is anticipated during drawdown and dam removal activities, with further dilution occurring downstream ~~of~~ from Iron Gate Dam due to tributary inflows. Thus, water column toxicity due to the concentrations under the Proposed Action is unlikely (CDM 2011).

Elutriate bioassay results indicate no statistically significant reduction of mean 96-hour rainbow trout survival for exposure to samples from Copco 1 and Iron Gate Reservoirs tested at 1 percent and 10 percent elutriate treatments, but a significant reduction from Copco 1 at 100 percent elutriate treatment and from Iron Gate at 50 percent and 100 percent elutriate treatments. Of these, the 1 percent and 10 percent treatments are considered to be most representative of field conditions upon reservoir drawdown due to the expectation of substantial mixing and dilution with river water and tributary inputs (CDM 2011). For J.C. Boyle Reservoir, elutriate bioassay results indicate that no further dilution would be required to prevent water column toxicity to freshwater fish, even without considering the dilution that will take place during drawdown and dam removal (CDM 2011).

Combined, results from the 2004–2005 Shannon & Wilson, Inc. (2006) study and the 2009–2010 Secretarial Determination study (CDM 2011) indicate that in the short~~-~~ term (<2 years following dam removal), one or more chemicals are present at levels with potential to cause minor or limited adverse effects on freshwater aquatic species (see Figure 3.2-2). In the long-term, one or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence.

Under the *Proposed Action*, the short-term (< 2 years following dam removal) and long-term (2–50 years following dam removal) effects of sediment release, transit, and potential downstream river-bank deposition on freshwater aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants in the ~~lower~~Lower Klamath River would be a less-than-significant impact.

Marine Aquatic Life Toxicity and/or Bioaccumulation
Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) increases in concentrations of inorganic and organic contaminants and result in low-level exposure for aquatic species in the Klamath Estuary and marine nearshore environment. Organic and inorganic contaminants have been identified in the sediment deposits currently trapped behind the dams (see Section 3.2.3.8). Under the Proposed Action, short-term pathways of contaminant exposure for marine aquatic species include short-term

exposure during sediment transit through the Klamath Estuary and marine nearshore environment as well as exposure following deposition in the marine nearshore environment (~~exposure "Scenario~~"Exposure Pathway 5" in CDM [2011]).

For the 2009–2010 Secretarial Determination study, there were no positive exceedances of the applicable and available maximum marine screening levels (CDM 2011), with the exception of a small number of sediment samples from J.C. Boyle Reservoir, which exceeded the applicable marine screening level for dieldrin and 2,3,4,7,8,-PECDF (CDM 2011). As the marine screening levels are designed to be protective of direct toxicity to benthic and epibenthic organisms, corresponding to a "no adverse effects level," the vast majority of 2009–2010 samples indicate a low risk of toxicity to sediment-dwelling organisms. Additionally, the Proposed Action would result in mixing and dilution during sediment release and transit through the Klamath River estuarine and/or marine nearshore environment, exposing downstream aquatic biota to an "average" water column concentration rather than a reservoir- or site-specific concentration. For 33 analytes, laboratory analytical reporting limits were greater than the marine screening level itself (CDM 2011). For these analytes, it is not possible to determine whether these compounds are present in reservoir sediments either above or below levels of concern.

Sediment bioassays from a single upper Klamath Estuary sample indicate greater survival (89–99 percent survival) of national benchmark toxicity species in the estuary sediment sample as compared with the laboratory control samples (81–94 percent survival) (see CDM 2011). A simple comparison between the estuary area composite acute toxicity results and the reservoir super-composite results indicates similar survival for *Chironomus dilutus* (89 percent vs. 64–94 percent, respectively) and greater survival for *Hyalella azteca* (99 percent vs. 80–94 percent, respectively). The similarity in results is suggestive that under the Proposed Action, no further acute toxicity would be anticipated in the estuarine and/or marine environment as compared with that of the reservoir sediments; however, additional toxicity testing using estuarine and marine test organisms is needed to confirm this assumption. Elutriate chemistry results (prior to consideration for mixing and dilution) do not indicate likely toxicity in the marine nearshore environment under the Proposed Action (CDM 2011).

With respect to bioaccumulation potential, there are no exceedances of applicable marine bioaccumulation screening levels (CDM 2011). Further, with the exception of four samples in J.C. Boyle Reservoir (CDM 2011), levels of other known bioaccumulative compounds did not exceed ODEQ bioaccumulation SLVs for marine fish. Note that ODEQ bioaccumulatory screening levels are not strictly applicable in the California marine offshore environment; however, they are indicative of potentially bioaccumulative compounds.

Elutriate chemistry results indicate that several chemical concentrations in elutriate exceed one or more water quality criteria for evaluation of surface water exposures for marine biota. Chemicals that exceed marine surface water criteria include those

generally considered to be nontoxic (e.g., phosphorus) as well as those with substantial potential for contributing to adverse effects (e.g., copper). Exposures to suspended sediment with elevated concentrations of potentially toxic chemicals are of lower concern for marine receptors than exposures to elevated concentrations of dissolved chemicals. The chemicals with the greatest potential to cause adverse effects in elutriate (e.g., copper) are, under field conditions associated with this exposure ~~scenario~~pathway, expected to bind to particulate matter and therefore are unlikely to contribute substantially to elevated concentrations of dissolved forms in the water column. Further, substantial dilution of river water and associated suspended sediments in the marine environment would reduce the amount of sediment suspended in the water column compared to conditions directly below Iron Gate Dam (CDM 2011).

Although not conducted specifically for estuarine or marine organisms, additional lines of evidence from the 2009–2010 Secretarial Determination study including the evaluation of elutriate toxicity bioassay results for rainbow trout, sediment toxicity bioassay results for benthic invertebrate national benchmark species, comparisons of tissue-based TRVs to chemical concentrations in laboratory-reared freshwater clams and worms exposed to field collected sediments (see prior discussion of Proposed Action potential effects on freshwater aquatic species), and comparisons of tissue-based TRVs and TEQs to chemical concentrations in field collected fish tissue (see discussion under No Action/No Project, Section 3.2.4.3.1.7), exposure to inorganic and organic compounds in sediments released from the reservoirs under the Proposed Action is unlikely to cause adverse long-term impacts on estuary and marine near shore aquatic species (see Figure 3.2-2).

Under the *Proposed Action*, the short-term (< 2 years following dam removal) and long-term (2–50 years following dam removal) effects of sediment release, transit, and deposition on aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants in the Klamath Estuary and marine nearshore environment would be a less-than-significant impact.

Human Health
Sediment release associated with the Proposed Action could result in short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) human exposure to contaminants from contact with deposited sediments on downstream river banks following reservoir drawdown. Under the Proposed Action, potential human exposure to inorganic and organic chemicals during periods of drawdown and near-term flushing of elevated SSCs in the ~~lower~~Lower Klamath River (i.e., through ingestion of contaminants from drinking water withdrawals or dermal contact with water) is likely ~~to~~ to be of limited occurrence and shorter duration and is not further addressed.

Short-term human exposure through fish consumption (i.e., a food web pathway) can~~-~~not be assessed with the available data. Resident fish species in the reservoirs are considered unlikely to survive and populate the riverine environment following the Proposed Action (see Section 3.3, Aquatic Resources). Exposure and bioaccumulation by resident riverine species in the ~~lower~~Lower Klamath River and estuary from water and suspended

sediments transported under the Proposed Action is understood to be short~~-~~ term (<2 years following dam removal). Human exposure to contaminants from contact with residual sediments deposited on downstream river banks is possible and the mechanism for exposure is the same as that for potential contaminants deposited on exposed reservoir terraces and river banks in the Hydroelectric Reach (see Section 3.2.4.3.2.7, Upper Klamath Basin and Figure 3.2-2).

Under the *Proposed Action*, the effects of sediment release on human health due to short-term (<2 years following dam removal) and long-term (2–50 years following dam removal) exposure to sediment-associated inorganic and organic contaminants in the ~~lower~~Lower Klamath River would be a less-than-significant impact.

Dam deconstruction and restoration (i.e., hydroseeding) activities could cause short-term (<2 years following dam removal) increases in inorganic and organic contaminants from hazardous materials associated with construction and restoration (i.e., hydroseeding) equipment in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. These short-term effects would be a significant impact. However, the impacts may be reduced through implementation of BMPs for deconstruction and restoration activities that would occur in or adjacent to the Klamath River. BMPs would minimize or eliminate the potential for toxic substances to enter the water during the deconstruction and revegetation period. **Under the *Proposed Action*, the short-term (<2 years following dam removal) effects on inorganic and organic contaminants in the ~~lower~~Lower Klamath River and the Klamath Estuary from dam deconstruction and restoration (i.e., hydroseeding) activities would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.**

~~3.2.4.3.2.8~~ Keno Transfer

Implementation of the Keno Transfer could cause adverse water quality effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on water quality compared with existing facility operations. Following transfer of title, ~~DOI~~Reclamation would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (see KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

~~3.2.4.3.2.9~~ East and ~~West Side~~Westside Facilities – Programmatic Measure

Decommissioning the East and ~~West Side~~Westside Facilities could ~~cause adverse water quality effects.~~result in slight decreases in ammonia levels in the Keno Impoundment/Lake Ewauna). Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA will redirect water flows currently diverted at Link River Dam into the two canals, back in~~-~~to Link River. ~~Following decommissioning of the facilities there will be no change in outflow from~~ Redirection of water flows under the Proposed Action could

potentially result in additional nitrification of Upper Klamath Lake ~~or inflow into Lake Ewauna. **Therefore, implementation of the East and West Side**~~outflows that would otherwise not have occurred in the East and Westside canals and hydropower facilities. The additional water flowing through the 0.6-mile long reach between the Link River Dam and the upstream end of the Keno Impoundment/Lake Ewauna could experience slightly increased dissolved oxygen in the river due to turbulent mixing. While this process occurs under existing conditions, it would affect a greater volume of water under the Proposed Action than under existing conditions (i.e., existing conditions flows plus the redirected flows). While the reaeration potential of this reach has not been quantified, it is possible that increased dissolved oxygen in the river would increase nitrification, the microbially mediated process that, in the presence of oxygen, coverts ammonia into nitrate and nitrite. Deas (2008) reported that nitrification of Klamath River water occurs in the five-mile reach between Keno Dam and the upper end of J.C. Boyle Reservoir. The Link River reach is substantially shorter than the reach from Keno Dam to J.C. Boyle Reservoir, thus there would be relatively less increased nitrification potential due to the redirection of flows at Link River Dam. Nevertheless, there is potential for a slight long-term benefit in reduced ammonia toxicity in the Keno Impoundment/Lake Ewauna due to decommissioning of the East and Westside canals and hydropower facilities.

While increased dissolved oxygen could occur in the Link River due to the decommissioning, it may not translate into increased dissolved oxygen concentrations in the Keno Impoundment/Lake Ewauna itself since river turbulence would also break up algal cells and cause increased biological oxygen demand in the slow moving waters of the impoundment. Some of this algal cell destruction may also have occurred in the powerhouse turbines, therefore it is not clear whether there would be a net difference in the breakup of algal cells from Upper Klamath Lake outflows and how this would affect dissolved oxygen in the Keno Impoundment/Lake Ewauna. Further, there may be a slight decrease in daytime dissolved oxygen production in the Keno Impoundment/Lake Ewauna during large algal blooms due to the lost photosynthesis potential of algal cells that were destroyed in transit in the Link River. The increase in nitrification could also offset a portion of the oxygenation that occurs in the river, by chemically depleting the oxygen. Overall, given the competing dissolved oxygen effects and the relatively short extent of the Link River, it is likely that the East and Westside Facility Decommissioning action would result in no long-term change from existing conditions with respect to dissolved oxygen concentrations in the Keno Impoundment/Lake Ewauna. **Therefore, implementation of the East and Westside Facility Decommissioning action would be potentially beneficial due to slight decreases in ammonia levels.**

~~3.~~

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Construction of the Yreka Water Supply Pipeline under the Proposed Action could cause short-term increases in suspended material in the Hydroelectric Reach during the construction period. For construction of the Yreka Water Supply Pipeline, Dam Removal Entity (DRE) would construct a new, elevated pipeline and steel pipeline bridge to support the pipe above the river at the upstream end of Iron Gate Reservoir (see Section 2.4.3~~.2.10~~). The pipeline bridge would require in-water work in 2019 to build three concrete piers to support the bridge. Additional construction would occur along the Iron Gate Reservoir banks at each end of the new bridge where the new pipeline would be connected to the existing buried pipeline. The potential for sediments to enter the water during in-water pier construction and from construction site runoff can be minimized or eliminated in Iron Gate Reservoir through the implementation of BMPs for construction activities (Appendix B). Since the construction work will be undertaken in 2019, prior to dam removal, any disturbed sediments would be trapped by Iron Gate Reservoir and not transferred downstream to the Klamath River, particularly given implementation of BMPs. **Under the *Proposed Action*, the effect of Yreka Water Supply Pipeline construction activities on SSC in the Hydroelectric Reach at the upstream end of Iron Gate Reservoir would be a less-than-significant impact.**

KBRA – Programmatic Measures

The KBRA, which is a ~~component of the~~ connected action to the Proposed Action, encompasses several programs that could affect water quality, including:

- Phases I and II Fisheries Restoration Plans
- Fisheries Reintroduction and Management Plan
- Wood River Wetland Restoration

- Water Diversion Limitations
- Water Use Retirement Program
- Interim Flow and Lake Level Program
- Upper Klamath Lake and Keno Nutrient Reduction

Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin (with the exception of the Trinity Basin) including KHSA implementation (i.e., dam removal) and could affect short-term (i.e., during construction activities) and long-term water quality. Within the KBRA, the Fisheries Program and the Water Resources Program encompass the majority of the restoration actions envisioned under the agreement (see Section 2.4.3.8). Many of the KBRA implementation actions are for fisheries restoration, reintroduction, and actions that enhance the amount and timing of water available for fish. Restoration actions include, but are not limited to, prevention of fish entrainment, rehabilitation of uplands, flood plains, riparian habitats, and stream channels, provision of fish passage, and re-introduction of fish to the Upper Klamath Basin, and instream riparian, and upslope actions that protect water quality, improve water quality and/or increase habitat complexity. KBRA elements under both the Fisheries Program and Water Resources Program are also likely to affect water quality in the basin. Some actions will affect water quality through flow augmentation, while others, including the restoration and permanent protection of riparian vegetation, are anticipated to have non-flow-related water quality effects. The following sections present a programmatic analysis of potential KBRA effects on water quality.

Phase I Fisheries Restoration Plan

Implementation of the Phase I Fisheries Restoration Plan could result in long-term reductions in fine sediment inputs, reduced summer water temperatures, improved nutrient interception, and increased dissolved oxygen levels. Several ongoing resource management actions related to water quality may be amplified under the Phase I Plan (see Section 2.4.3.8). The following sections describe the ongoing actions and types of new programs that could be implemented, and their anticipated short-term and long-term effects at a programmatic level.

Floodplain Rehabilitation

Floodplain rehabilitation work would include activities to improve or restore connections between channels and floodplains to create and maintain off-channel habitat accessible to overwintering juvenile salmonids. Floodplain rehabilitation may also include activities such as riparian planting and understory thinning to facilitate the development of mature riparian stands that would provide streamside shade and large and small wood to stream channels and floodplains. Additionally, wetland restoration and levee setback or dike removal may be used to reconnect floodplain hydrology.

In the short~~-~~ term (i.e., during construction activities), these activities may involve the use of backhoe equipment to dig channels, remove/reposition levees and dikes, and conduct mechanical planting. These activities could increase suspended sediments and increase

the potential for inorganic and organic contaminants from hazardous materials associated with construction activities. In the long term, increased seasonal off-channel habitat, wetland restoration, and levee setbacks, may reduce fine sediment deposition in the main channel by allowing sediments and associated nutrients to deposit on floodplains and in wetlands during high flows. Increased stream shading would decrease summer temperatures and increase dissolved oxygen concentrations.

Wetland and Aquatic Habitat Restoration
Upstream of Upper Klamath Lake, activities would include the purchase of restoration easements and the creation of grass banks to facilitate habitat improvement and landowner economic stability. In the short term (i.e., during construction activities), these activities may involve the use of hydroseeding to conduct grass planting. In the long term, restoration easements may reduce fine sediment deposition in the main channel by allowing sediments and associated nutrients to deposit along streambanks and wetlands protected by easements and grass banks during high flows.

Woody Debris Placement
In-stream and streambank large woody debris placement may include both mobile wood (i.e., unanchored) and complex stationary (i.e., anchored) structures and may be used to create off-channel fish habitat or provide cover in deeper pools. In the short term, these activities may involve the use of construction equipment to place large wood in the stream channel or along banks.

Fish Passage Correction
Correction of fish passage issues throughout the Klamath Basin may include culvert upgrades or replacement to meet current fish passage standards and correction of other fish blockages to restore access to new or historical habitats. In the short term, these activities may include in-channel construction of culverts through existing roadways.

Cattle Exclusion Fencing
Cattle exclusion would include the construction of fencing as allowed by ~~federal~~Federal and ~~state~~State regulations and local land management plans to prevent cattle from trampling stream banks and would allow the regeneration of riparian vegetation and improving channel structure. Cattle exclusion may be conducted in conjunction with riparian planting as part of the aforementioned floodplain rehabilitation activities. In the long-term, these activities would decrease fine sediment inputs and associated nutrients (primarily phosphorus) to water bodies in the Klamath Basin and promote increased stream shading and reduced summer water temperatures.

Mechanical Thinning and Prescribed Burning
Mechanical thinning and prescribed burning of upland forest areas may be used to mimic some of the functions and characteristics historically provided by a natural fire regime. In the long term, thinning and prescribed burning may reduce the potential for catastrophic fires and the associated high rates of erosion and nutrient release (primarily phosphorus) to tributaries and the main-stem Klamath River.

Purchase of Conservation Easements and/or Land
Purchase of conservation easements and land from willing sellers may allow for more direct land management for habitat enhancement purposes, where the majority of the land involved would be agricultural land. In the long term, these activities would remove acreage from fertilizer and pesticide/herbicide applications, and would decrease nutrients (primarily nitrogen) and organic contaminants runoff to the Klamath River.

Road Decommissioning
Road decommissioning would reduce road densities in areas with a high potential for slope failure and would stabilize hillsides. These activities would decrease the incidence of road failure and would minimize a source of chronic fine sediment and nutrient (primarily phosphorus) input into water bodies in the Klamath Basin.

Treatment of Fine Sediment Sources
Treatment of fine sediment sources would include management of stormwater runoff from roads and improved agricultural and forestry management practices. In the long term, these activities would help decrease the input of fine sediment and associated nutrients (primarily phosphorus) into water bodies in the Klamath Basin.

Gravel Augmentation
Gravel augmentation involves the direct placement of spawning size gravel into the stream channel. Gravel augmentation can increase spawning habitat in systems by increasing the amount of area with suitable substrate. Gravel augmentation activities may involve transportation of gravel from an off-site source using dump trucks and placement in the stream using backhoes. In the short term, these activities would increase suspended sediments in waters proximal to the gravel deposition site and would increase the potential for inorganic and organic contaminants from hazardous materials associated with construction activities.

Individual resource management actions under the Phase I Fisheries Restoration Plan would require separate project-level evaluations under NEPA and ESA; at the programmatic level considered for this EIS/EIR, there is insufficient information to evaluate project-specific short-term (i.e., during construction activities) effects on water quality from these actions. The timing of and specific locations where these resource management actions could be undertaken is not certain, but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Although negative short-term effects of increased suspended sediments and increased potential for inorganic and organic contaminants from hazardous materials associated with construction equipment could occur, implementation of construction-related BMPs would occur as part of the Phase I Fisheries Plan resource management actions. **Given these BMPs (including the BMP requiring biodegradable oils in construction equipment used in streams or rivers, see Appendix B.1.1 Water Quality, the short-term effects on suspended sediment concentrations and inorganic and organic contaminants would be less-than-significant.**

In the long term, most of the above resource management actions would reduce fine sediment inputs into streams in the Klamath Basin. Treatment of fine sediment sources may also include other management actions, including managing stormwater runoff from roads and other developed areas, improved agricultural and forestry management practices, and other specific actions depending on the sources of fine sediments. The Phase I Fisheries Restoration Plan activities would also improve shading and thus cool summer water temperatures, increase riparian and wetland nutrient interception and transformation, and increase dissolved oxygen levels (through decreased water temperatures and decreased nutrient loading). As noted above the timing of and specific locations where these resource management actions could be undertaken is not certain, but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. **Resource management actions implemented under the KBRA Phase I Fisheries Restoration Plan would accelerate long-term improvements in fine sediment, water temperature, nutrients, and dissolved oxygen in the Klamath Basin and would be beneficial.**

Phase II Fisheries Restoration Plan

Implementation of the Phase II Fisheries Restoration Plan under the KBRA (see KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same short-term (i.e., during construction activities) and long-term impacts as Phase I. Individual resource management actions under the ~~Phase~~ Phase II Fisheries Restoration Plan would require separate project-level evaluations under NEPA and ESA; at the programmatic level considered for this EIS/EIR, there is insufficient information to evaluate project-specific short-term (i.e., during construction activities) effects on water quality from these actions. The timing of and specific locations where these resource management actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Although short-term adverse effects of increased suspended sediments and increased potential for inorganic and organic contaminants from hazardous materials associated with construction equipment could occur, implementation of construction-related BMPs would occur as part of the Phase II Fisheries Plan resource management actions. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects on suspended sediment concentrations and inorganic and organic contaminants would be less-than-significant. Resource management actions implemented under the KBRA Phase II Fisheries Restoration Plan would accelerate long-term improvements in fine sediment, water temperature, nutrients, and dissolved oxygen in the Klamath Basin and would be beneficial.**

Fisheries Reintroduction and Management Plan

Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan could affect water quality during construction. In the short~~-~~ term (i.e~~.,~~ ., during construction activities), constructing fish handling facilities downstream from Keno Dam and at Link River Dam would involve the use of construction equipment for

site work and building construction. These activities could increase suspended sediments and increase the potential for inorganic and organic contaminants from hazardous materials associated with construction activities. Although negative short-term effects could occur, implementation of construction-related BMPs would reduce these effects. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects on water quality would be less-than-significant.**

Wood River Wetland Restoration

Implementation of Wood River Wetland Restoration could result in warmer long-term spring water temperatures and reduced fine sediment and nutrient inputs to Upper Klamath Lake. Under the KBRA, the Wood River Wetland Restoration Project (see KBRA Section 18.2.3) would be a new project designed to provide additional water storage for a total of 16,000 acre-feet (AF) of storage in or adjacent to Agency Lake (see Section 2.4.3.8). Wood River Wetland is approximately 3,200 acres in size and is adjacent to Agency Lake and to the north of Agency Lake Ranch. Over 3,000 acres of wetland and two miles of Wood River channel have or are undergoing restoration actions. Options for water management may include using diked areas for pumped storage or breaching levees to reconnect former wetland areas to Agency Lake. Long-term water quality effects associated with the Wood River Restoration Project include the creation of warmer spring temperatures that would be beneficial for rearing juvenile fish in the wetlands (as compared to the cooler temperatures in the Wood River or Upper Klamath Lake) and improved interception and treatment of fine sediment from the Wood River, prior to entering Agency Lake. This may decrease overall nutrient inputs to Upper Klamath Lake by inundating wetland (peat) soils and creating anaerobic conditions that support nutrient retention, particularly in the case of phosphorus (Snyder and Morace 1997). Specific options still need to be developed and studied as part of a separate project-level NEPA evaluation and ESA consultation. There is insufficient information to evaluate project-specific construction-related effects on water quality from the Wood River Wetland Restoration project. The geographic location and timing of this project reduce the potential for any negative water quality effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. Although negative short-term effects could occur, implementation of construction-related BMPs would occur. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects would be less-than-significant. Under the KBRA, the Wood River Wetland Restoration Project would accelerate ongoing long-term improvements in water temperature, fine sediment, and nutrients in Agency Lake and would be beneficial.**

Water Diversion Limitations

Implementation of Water Diversion Limitations could result in long-term decreased summer water temperatures in the Klamath River upstream of the Hydroelectric Reach. Under the KBRA, the Water Diversions Limitations (see KBRA Section 15.1) would be a new project that provides specific allocations of water for refuges and limitations on specific diversions for Reclamation's Klamath Project (see Section 2.4.3.8). Actions reducing availability of irrigation water would increase stream flow and decrease summer

water temperatures in the Klamath River upstream of the Hydroelectric Reach, as needed for fisheries. The water quality improvements generated by these water diversion limitations would contribute to the long-term improvements anticipated from hydroelectric facility removal. Diversion limitations under KBRA would also provide a more reliable water supply to the National Wildlife Refuges (NWRs) and would be beneficial (see Section 3.14.4.3). **In the short term, there would be no change from existing conditions on water quality. In the long term, the KBRA Water Diversion Limitations would decrease summer water temperatures in the Klamath River upstream of the Hydroelectric Reach and would be beneficial.**

Water Use Retirement Program

Implementation of the Water Use Retirement Program could result in long-term decreases in summer water temperature and nutrient inputs to Upper Klamath Lake. Under the KBRA, the Water Use Retirement Program (WURP) (see KBRA Section 16.2.2) would be a new project that seeks to increase the inflow to Upper Klamath Lake by 30,000 acre-feet on an average annual basis (see Section 2.4.3.8). Actions reducing surface water use, such as the sale and retirement of irrigation surface water rights, split season irrigation, shift to dryland crops, and fallowing of crop land, would overall increase stream flows and lake levels in Upper Klamath Lake through deceased surface water withdrawals and increased groundwater recharge~~. Increased~~ (see also Reclamation 2012). Overall increased stream flows and lake levels in Upper Klamath Lake would improve water quality by decreasing summer water temperatures and decreased irrigation ~~and fallowing~~. Fallowing of crop land would decrease fertilizer (nutrient) and pesticide/herbicide (inorganic and organic contaminants) inputs. ~~The~~

Water elevations in Upper Klamath Lake affect water elevations in the emergent wetlands of Upper Klamath NWR, with the wetlands approximately 90% dry at lake elevations below 4,139.50 feet (Mauser and Mayer 2011). In an analysis of the potential effects of KBRA on Upper Klamath NWR, Mauser and Mayer (2011) found that the frequency in which Upper Klamath Lake levels fall below 4,139.50 feet would be greater under the KBRA (82% of years) compared to the No Action/No Project Alternative (68% of years). This means that the frequency of wetland drying at Upper Klamath NWR would increase under KBRA. However, according to the analysis presented by Mauser and Mayer (2011), the duration of the drying episodes would be less than currently occur. Therefore, drying of soils could be more extensive or complete under the No Action/No Project Alternative than the Proposed Action, which could affect phosphorus cycling and release to Upper Klamath Lake. Note that the potential impacts of the KBRA on waterfowl and migrating birds in Upper Klamath NWR are discussed in Section 3.14.4.3 of this Klamath Facilities EIS/EIR.

Mauser and Mayer's (2011) projections for future lake levels did not account for the 2008 Biological Opinion (USFWS 2008), which dictates lake levels under the current conditions including the No Action/No Project Alternative. According to the Biological Opinion, lake levels currently are allowed to go below 4,139.50 feet during July through January, or about 7 out of 12 months during a year. Therefore, the difference in number

of months that the Upper Klamath NWR could go dry as described by Mauser and Mayer (2011) would be partially dictated by Biological Opinion minimum values. Under the 2008 Biological Opinion, this represents only a one month difference in lake level management between KBRA (6 of 12 months) and the No Action/No Project Alternative (7 of 12 months). Thus the hydrologic effect on the Upper Klamath Lake NWR under KBRA could be less than described by Mauser and Mayer (2011).

According to research conducted on wetlands around Upper Klamath Lake, drying of wetland soils and associated aerobic decomposition of peat can contribute to release of phosphorus (Snyder and Morace 1997, Aldous et al. 2005). However, the degree to which this occurs is not universal, and in fact appears to be substantially less in "undisturbed" wetlands, including Upper Klamath NWR, than "restored" wetlands that had been previously diked and drained (Aldous et al. 2005).

If Upper Klamath NWR dries more frequently in the summer and fall, but for shorter periods that allow wetlands soil to remain wet in the root zone below the water level, the breakdown of peat soils may be minimized if not completely negated. Aldous et al. (2005) tested different hydrologic treatments for cores from undisturbed and restored wetlands around Upper Klamath Lake. If wetlands were allowed to remain moist, rather than dry completely, the release of phosphorus was minimized, and the undisturbed wetlands, which included Upper Klamath NWR, effectively had no phosphorus release. Because KBRA-flows and their effects on Upper Klamath Lake water elevation cannot be conclusively predicted at this time, it is not possible to determine whether the NWR wetlands or their soils would remain moist even if they are drained more frequently, which would minimize phosphorus release, or if they would dry out significantly more, which could foster some phosphorus release.

An additional consideration is the magnitude of potential phosphorus release from NWR wetlands compared to the magnitude of other external and internal nutrient loading sources to the lake. As a conservative calculation, the phosphorus loads from the Upper Klamath NWR and from Upper Klamath Lake internal loading can be estimated for the period of potential drying as shown in Mauser and Mayer (2011) (i.e., July–October). Phosphorus flux from the refuge was initially taken as the median phosphorus release rate from diked and drained wetlands (3.7 pounds per acre per day; Table 13 from Snyder and Morace [1997]), which should be significantly greater than the actual phosphorus release rate from the NWR because it represents "disturbed" wetlands. This rate is about a factor of 10 greater than what was found when the Williamson River Delta was breached and reflooded (Wong et al. 2011), reinforcing the conservative nature of this analysis. Assuming a wetland area of 13,000 acres in the refuge (Snyder and Morace 1997), and accounting for unit changes (i.e., from English units to SI units), Upper Klamath NWR could contribute as much as about 7200 kg of phosphorus to Upper Klamath Lake during this 120 day period. These estimates were compared with estimated loads in Upper Klamath Lake from data collected by the Klamath Tribes (Kann and Walker 1999), averaged over the same 120 day period from 1991 to 1998. Median total external loading to Upper Klamath Lake during the same 120 day periods from 1991

to 1998 was approximately 39,200 kg. Thus, Upper Klamath NWR could provide a significant additional load of phosphorus to Upper Klamath Lake compared to existing July-October external loading (i.e. about 18%) if the soils are allowed to dry significantly. However, the summertime nutrient and bloom dynamics of Upper Klamath Lake are dominated by internal loading; median July to October internal loading is about 163,000 kg, with total external and internal loading being about 201,000 kg. Therefore, loading from Upper Klamath NWR would be about 4.5% of the internal load, and 3.5% of the total load, as conservative estimates. Finally, whether this would actually represent a significant increase from current loading is unlikely, as the refuge can dry out for considerable periods under existing lake level management, as dictated by the NOAA Fisheries Service 2008 Biological Opinion, and therefore likely contributes nutrients in a similar fashion. Therefore, even if KBRA-related drying of Upper Klamath NWR wetland soils did increase the release phosphorus as hypothesized, the effect on water quality or algal blooms in the lake would be negligible compared to other sources and ongoing loading from the wetlands, and the increase from current conditions would also be negligible.

There are timing issues associated with the hypothesized loading as well, depending on management of Upper Klamath Lake under the WURP. If the wetlands dry from July to October, the release of nutrients would most likely occur in the fall when the soils are rewetted. This is after the most sensitive period in the lake, when algal blooms typically drive dissolved phosphorus concentrations to limiting levels and additional phosphorus could spur additional algal growth. Instead, added nutrients would have little effect on algal growth and might be largely exported from the lake during the winter.

In summary, conservative calculations based on available research for Upper Klamath Lake and surrounding wetland areas suggests that, if additional nutrients are released as a result of an increased frequency of drying events under KBRA, concentrations will be small compared to other loading sources, notably the large internal load that occurs in most summers, and would have minimal effect on the water quality or algal blooms in the lake. As noted previously, the hydrologic effect on the Upper Klamath Lake NWR under KBRA could be less than described by Mauser and Mayer (2011), hence any associated nutrient effect could also be less. Further, KBRA is analyzed in this EIS/EIR at the programmatic level and future environmental compliance would be necessary to implement the various projects. As part of these future analyses, measures to limit potential adverse effects would be developed and some of those measures could include keeping the refuge soils moist during the summer periods to minimize unintended release of phosphorus, or keeping the drying periods relatively short to reduce the amount of phosphorus released, possibly even compared to current conditions (i.e., provide a net benefit).

Since decreased irrigation and fallowing of crop land under WURP would decrease nutrient inputs via fertilizer use, while increased drying of wetland soils in Upper Klamath NWR would only slightly increase nutrient (phosphorus) input to the lake (or could have no effect), overall, the water quality improvements generated by the WURP in

Upper Klamath Lake would translate downstream to the Klamath River and would contribute to the long-term improvements anticipated from hydroelectric facility removal.

In the short~~-~~ term, there would be no change from existing conditions on water quality. The KBRA Water Use Retirement Program would decrease long-term water temperatures~~ and decrease~~, nutrients, and pesticides and herbicides in Upper Klamath Lake and would be beneficial.

Interim Flow and Lake Level Program

Implementation of the Interim Flow and Lake Level Program could result in long-term decreases in summer water temperature and nutrient inputs to Upper Klamath Lake. Under the KBRA, the Interim Flow and Lake Level Program (see KBRA Section 20.4) would be an interim program of water purchase and lease to further the goals of the fisheries programs during the interim period prior to full implementation of the On-Project ~~Allocation~~Plan and WURP. Because it is focused on reducing surface water use, it would have the same effects on water quality as the WURP. The water quality improvements generated by the Interim Flow and Lake Level Program would contribute to the long-term improvements anticipated from hydroelectric facility removal. **In the short~~-~~ term, there would be no change from existing conditions on water quality. The KBRA Interim Flow and Lake Level Program would decrease long-term water temperatures and decrease nutrients in Upper Klamath Lake and would be beneficial.**

Upper Klamath Lake and Keno Nutrient Reduction

Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program could result in long-term decreases in nutrient inputs, increases in seasonal dissolved oxygen, and decreases in concentrations of nuisance algal species in these waterbodies. KBRA (Appendix C-2, line 11) includes a program to study and reduce nutrient concentrations in the Keno Impoundment/Lake Ewauna and Upper Klamath Lake in order to reduce dissolved oxygen and nuisance algal problems in both water bodies. Restoration actions to control nutrients have not been developed, and there are many possible actions that could require construction of treatment wetlands, construction of facilities, or chemical treatments of bottom sediment, among other possibilities. A nutrient reduction program in the Keno Impoundment/Lake Ewauna and Upper Klamath Lake would be designed to improve water quality (increasing seasonally low dissolved oxygen and reducing seasonal algal blooms) and fish passage through the Keno Impoundment/Lake Ewauna in summer and fall months, however implementation of this nutrient reduction program will require future environmental compliance investigations and a determination on significance cannot be made at this time.

3.2.4.3.3~~–~~ Alternative 3: Partial Facilities Removal of Four Dams

The Partial Facilities Removal of Four Dams Alternative would remove enough of the material from each dam to allow the river to retain a free-flowing condition and volitional fish passage under all river stages and flow conditions. Some portion of each dam and much of the appurtenant infrastructure would remain, such as the dam foundations, power

houses, buildings, tunnels, and pipes. All tunnel openings would be sealed with concrete, remaining buildings would be fenced, and all hazardous materials would be removed from the site. This alternative would include the transfer of the Keno Facility to the ~~DOI~~Reclamation and implementation of the KBRA. The Partial Facilities Removal of Four Dams Alternative would result in the release of sediments trapped behind the dams and would have the same short-term (<2 years following dam removal) effects on suspended sediments, dissolved oxygen, nutrients, and inorganic and organic contaminant concentrations in both the Upper and Lower Klamath Basin as the Proposed Action, as follows:

- **The short-term increases in SSC~~s~~ in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a significant impact.**
- **The short-term decrease in dissolved oxygen concentrations would be a significant impact on the ~~lower~~Lower Klamath River from Iron Gate Dam to approximately Clear Creek (≈RM 100). There would be no change from existing conditions on the Klamath Estuary or the marine nearshore environment.**
- **The short-term increase in nutrients in the Hydroelectric Reach, the ~~lower~~Lower Klamath River, and the Klamath Estuary would be a less-than-significant impact.**
- **The short-term effects on organic and inorganic contaminants in the Hydroelectric Reach, the ~~lower~~Lower Klamath River, and the Klamath Estuary would be a less-than-significant impact.**

Dam deconstruction activities under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on suspended sediments in the Hydroelectric Reach, the ~~lower~~Lower Klamath River, and the Klamath Estuary as the Proposed Action and would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.

Construction activities associated with implementation of IMs 7 (J.C. Boyle Gravel Placement and/or Habitat Enhancement) and 16 (Water Diversions) would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact. There would be no change from existing conditions on the ~~lower~~Lower Klamath River, Klamath Estuary, or the marine nearshore environment.

~~**Construction activities for the Yreka Pipeline under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact. There would be no change from existing conditions on the lower Klamath River, Klamath Estuary, or the marine nearshore environment.**~~

Revegetation activities (i.e., hydroseeding) under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach and transport into the ~~lower~~Lower Klamath River and Klamath Estuary as the Proposed Action and would be beneficial. There would be no change from existing conditions on the marine nearshore environment.

Under the Partial Facilities Removal Alternative, interception and retention of sediments and nutrients behind the dams at the Four Facilities would no longer occur and would have the same long-term (2–50 years following dam removal) effects in both the ~~Upper~~ Upper and Lower Klamath Basin as the Proposed Action. **Long-term increases in suspended sediments and nutrients in the Hydroelectric Reach, the ~~lower~~Lower ~~Klamath~~ Klamath River, the Klamath Estuary, and the marine nearshore environment as ~~the~~ the Proposed Action and would be a less-than-significant impact.**

Additionally, elimination of the lacustrine environment of the reservoirs would have the same long-term (2–50 years following dam removal) effects on water temperature, dissolved oxygen, pH, algal toxins and chlorophyll-*a*, and inorganic and organic concentrations in both the Upper and Lower Klamath Basin as the Proposed Action, as follows:

- **The long-term increases in summer/fall water temperatures and ~~daily fluctuations~~ diel temperature variation in the J.C. Boyle ~~bypass reach~~Bypass Reach due to the elimination of hydropower peaking operations would be a less than significant impact. Slight decreases in long-term summer/fall water temperatures and less ~~daily fluctuation~~diel temperature variation in the J.C. Boyle ~~peaking reach~~ Peaking Reach would be beneficial. Downstream ~~of~~ from Copco 1 and Iron Gate Dams, the long-term increase in spring water temperatures would be ~~potentially~~less than significant, ~~while~~ and the decrease ~~in~~ in late summer/fall water temperatures would be beneficial for the Hydroelectric Reach and the ~~lower~~Lower Klamath River from Iron Gate Dam to the confluence with the Salmon River. There would be no direct effect on water temperature for Klamath River downstream ~~of~~ from the Salmon River, the Klamath Estuary, or the marine nearshore environment.**
- **Long-term increases in summer and fall dissolved oxygen concentrations in the Hydroelectric Reach and immediately downstream ~~of~~from Iron Gate Dam would be beneficial. There would be no change from existing conditions on dissolved oxygen by the confluence with the Trinity River.**
- **Long-~~term~~term slight summertime increases in pH and daily pH fluctuations at the Oregon-California State line and upstream and downstream reaches that are currently riverine would be ~~beneficial for~~less than significant. The decrease in high summertime daily pH fluctuations in the free-flowing reaches of the river that replace Copco 1 and Iron Gate Reservoirs in the Hydroelectric Reach ~~and~~would be beneficial. The summertime increases in**

pH in the ~~lower~~Lower Klamath River from Iron Gate Dam to the ~~confluence with the~~ Scott River would be less than significant. There would be no change from existing conditions on pH for Klamath River just downstream ~~of~~ from Seiad Valley, the Klamath Estuary, and the marine nearshore environment.

- **The long-term decrease in ~~production~~chlorophyll-*a* and substantial decrease or elimination of algal toxins and ~~chlorophyll-*a*~~ in the Hydroelectric Reach and subsequent transport into the ~~lower~~Lower Klamath River and the Klamath Estuary would be beneficial.**
- **Long-term effects on inorganic and organic contaminants in the Hydroelectric Reach, the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.**

~~3.2.4.3.3.1~~ Keno Transfer

Implementation of the Keno Transfer could cause adverse water quality effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the ~~DOI~~Reclamation. This transfer would not result in the generation of new impacts on water quality compared with existing facility operations. Following transfer of title, ~~DOI~~Reclamation would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (see KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

~~3.2.4.3.3.2~~ East and ~~West Side~~Westside Facilities – Programmatic Measure

Decommissioning the East and ~~West Side~~Westside Facilities could ~~cause adverse water quality effects.~~result in slight decreases in ammonia levels in the Keno Impoundment/Lake Ewauna. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA ~~will redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there will be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna.~~would have the same effect as described under the Proposed Action. **Therefore, implementation of the East and ~~West Side~~Westside Facility Decommissioning action would ~~result in no change from existing conditions~~be potentially beneficial due to slight decreases in ammonia levels.**

~~3.2.4.3.3.3~~ City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Construction activities for the Yreka Water Supply Pipeline under the *Partial Facilities Removal of Four Dams Alternative* would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact. There would be no change from existing

conditions on the Lower Klamath River, Klamath Estuary, or the marine nearshore environment.

KBRA – Programmatic Measures

KBRA Actions under the Partial Facilities Removal of Four Dams Alternative would be the same as those under the Proposed Action. **Therefore, under the *Partial Facilities Removal of Four Dams Alternative*, KBRA actions would accelerate long-term improvements in water quality (i.e., suspended sediment, water temperature, nutrients, and dissolved oxygen) anticipated under KHSA implementation (i.e., dam removal) and would be beneficial.**

3.2.4.3.4 Alternative 4: Fish Passage at Four Dams

The Fish Passage at Four Dams Alternative would provide upstream and downstream fish passage at the Four Facilities, but would not include implementation of the KBRA. The ongoing restoration actions, described in the No Action alternative, would continue. The alternative would incorporate the mandatory prescriptions from the Departments of the Interior and Commerce imposed during the FERC relicensing process, including fishway installation for both upstream and downstream migrations at all facilities and barriers to prevent juvenile salmonid entrainment into turbines. In addition to the fishways, there is a series of flow-related measures, including a condition that requires at least 40 percent of the inflow to the J.C. Boyle ~~reservoir~~ Reservoir to be released downstream. This alternative would limit generation of peaking power at J.C. Boyle Powerhouse to one day per week as water supplies allow, and would include recreation flows one day a week. The flow requirements would reduce the overall power generation.

Short-term ~~(<2 years following dam removal)~~ effects on water quality from construction activities associated with new fish passage facilities would occur, including increased suspended sediments and increased potential for inorganic and organic contaminants from hazardous materials associated with construction equipment. These short-term effects would be a significant impact. However, the impacts would be reduced through implementation of BMPs for construction activities that occur in or adjacent to the reservoirs and the Klamath River. BMPs would minimize in-water work and would minimize or eliminate the potential for sediment or toxic substances entering the water. The short-term effects would likely follow the schedule prescribed in the FERC relicensing process (see Table 2-26), which would allow downstream facilities to be installed prior to upstream passage facilities and would take place over a 4 to 8 year period. Accordingly, short-term construction related effects on water quality would occur in association with construction activities for each of the fish passage improvements (i.e., upstream fish passage, spillway modifications, tailrace barriers, screens and bypass structures).

Under the *Fish Passage at Four Dams Alternative*, short-term ~~(<2 years following construction of passage facilities)~~ increases in SSCs and potential inorganic and organic contaminants in the Hydroelectric Reach, the ~~lower~~Lower Klamath River, the Klamath Estuary and the marine nearshore environment due to construction activities would be a less-than-significant impact.

Under the Fish Passage at Four Dams Alternative, the ~~reduction in frequency of J.C. Boyle peaking operations (from daily to weekly) and~~ overall higher flow releases would result in more reservoir water entering the Bypass Reach and correspondingly warmer ~~and more variable~~ water temperatures ~~in the bypass reach~~ during summer and early fall, and cooler temperatures in late fall and winter. These effects would be similar to those under the Proposed Action ~~and would move this short reach away from support of core coldwater habitat during summer and early fall months~~; however, ~~water temperatures would approach the natural thermal regime of the river. As~~as with the Proposed Action, areas adjacent to the coldwater springs in the ~~bypass reach~~Bypass Reach would continue to serve as thermal refugia for aquatic species because the springs themselves would not

be affected by the Fish Passage at Four Dam Alternative. Since J.C. Boyle Reservoir, with its large thermal mass, would remain in place, effects on diel temperature variation in the Bypass Reach under the Fish Passage at Four Dams Alternative would be similar to those described for the No Action/No Project Alternative (i.e., reduced diel temperature variation). Similar to the Proposed Action, maximum water temperatures in the ~~peaking reach~~Peaking Reach would be slightly cooler and temperatures would be less artificially variable, also due to higher overall flows and the lower frequency of peaking operations at the J.C. Boyle Powerhouse. ~~Further downstream, at the Oregon-California state line, water temperatures would likely be similar to those under the No Action/No Project Alternative since large temperature effects of the peaking operations do not extend this far downstream.~~

Under the *Fish Passage at Four Dams Alternative*, long-term (2–50 years following construction of fish passage facilities) increases in summer/early fall water temperatures ~~and daily fluctuations~~ in the J.C. Boyle ~~bypass reach,~~ Bypass Reach, due to the ~~reduction in frequency of hydropower peaking operations and~~ higher overall ~~flows,~~flow releases would be a less than significant impact. ~~Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial. Long-term water temperature effects in the remainder of the Hydroelectric Reach~~ Continued reduced diel temperature variability in the Bypass Reach would be similar to those under the No Action/No Project Alternative (i.e., no change from existing conditions). Slight decreases in long-term maximum summer/fall water temperatures and less artificial diel temperature variation in the J.C. Boyle Peaking Reach would be beneficial. Long-term water temperature effects in the remainder of the Hydroelectric Reach (i.e., Copco 1 and Iron Gate Reservoirs) would be similar to those under the No Action/No Project Alternative (i.e., no change from existing conditions).

The altered (more stable) flow regime in the J.C. Boyle ~~peaking reach~~Peaking Reach may also affect dissolved oxygen, pH, and nutrients due to increased periphyton growth at this location. However, changes in these parameters are not certain; the role of photosynthesis and community respiration from periphyton growth in the ~~peaking reach~~Peaking Reach is unknown because nutrient cycling and resulting rates of primary productivity under the No Action/No Project Alternative are uncertain (see Section 3.2.1.1). Other than this potential and unknown effect related to the flow regime downstream ~~of~~ from J.C. Boyle Dam, the presence of fish passage facilities at each of the Four Facilities would not affect other long-term water quality parameters in the Hydroelectric Reach. **Under the *Fish Passage at Four Dams Alternative*, long-term (2–50 years following construction of passage facilities) effects on water quality in the Upper or Lower Klamath Basin would be the same as effects under the No Action/No Project Alternative (i.e., no change from existing conditions).**

~~3.2.4.3.4.1~~ Trap and Haul – Programmatic Measure

Implementation of the trap and haul measure could affect water quality during construction. In the short~~-~~ term (i.e., during construction activities), constructing fish handling facilities downstream from Keno Dam and at Link River Dam would involve

the use of construction equipment for site work and building construction. These activities could increase suspended sediments and increase the potential for inorganic and organic contaminants from hazardous materials associated with construction activities. Although negative short-term effects could occur, implementation of construction-related BMPs would reduce these effects. **Given these BMPs (see Appendix B.1.1 Water Quality), the short-term effects on water quality would be less-than-significant.**

3.2.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove ~~Copco~~ Copco 1 and Iron Gate

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative proposes to remove the two largest dams in the Hydroelectric Reach and install fishways for volitional fish passage on the remaining installations. Most of the mandatory prescriptions associated with fish passage would still apply to the remaining dams, including flow requirements and standards for fish passage facilities. Alternative 5 would include no peaking power generation or release of flow for recreation at J.C. Boyle Powerhouse because Copco 1 and Iron Gate Dams would not be present to reregulate flows downstream. For the purposes of this analysis, alternatives that would not result in full implementation of the KHSA do not include the KBRA as a connected action to the alternative. In the Hydroelectric Reach of the Upper Klamath Basin, this alternative would result in the release of sediments trapped behind Copco 1 and Iron Gate Dams. This release would have short-term (<2 years following dam removal/construction of fish passage facilities) effects on sediment and turbidity, dissolved oxygen, nutrients, and inorganic and organic contaminant concentrations in the Klamath River.

Interception and retention of sediments would still occur behind J.C. Boyle and Copco 2 Dams; this would have long-term (2–50 years following dam removal/construction of fish passage facilities) effects on sediment and turbidity. Additionally, elimination of the lacustrine environment of Copco 1 and Iron Gate Reservoirs under this alternative would have long-term effects on water temperature, dissolved oxygen, nutrients, pH, algal toxins and chlorophyll-*a* in the downstream river. The following sections provide detail regarding the anticipated effects of this alternative on water quality.

~~3.2.4.3.5.1~~ Water Temperature

~~Upper Klamath Basin~~

~~Since Alternative 5 would include no peaking power generation or release of flow for recreation at J.C. Boyle, water temperature effects in the J.C. Boyle bypass and peaking reaches would be the same as under the Proposed Action i.e., warmer and more variable water temperatures in the bypass reach during summer and early fall, and cooler temperatures in late fall and winter; and, slightly cooler and less variable water temperatures in the peaking reach during summer and early fall. Further downstream, at the Oregon-California state line, water temperatures would be similar to those under the No Action/No Project Alternative since large temperature effects of the peaking operations do not extend this far downstream.~~

~~Within the remainder of the Hydroelectric Reach, effects on water temperature under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative~~

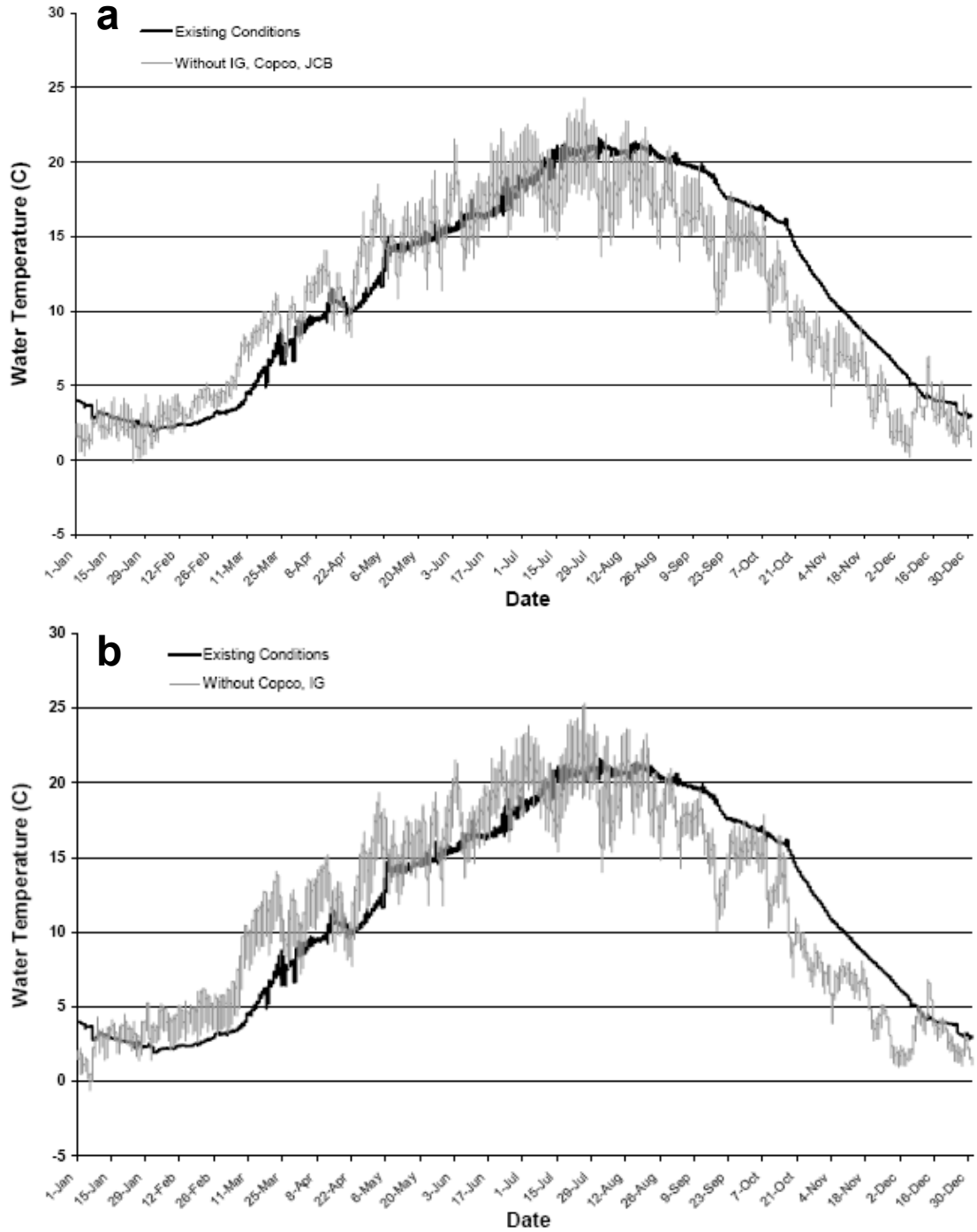
~~would be the same as effects for the Hydroelectric Reach under the Proposed Action. The effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under this alternative would be similar to effects for the lower Klamath River immediately downstream of Iron Gate Dam under the Proposed Action.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term (2–50 years following dam removal/construction of fish passage facilities) increases in summer/fall water temperatures and daily fluctuations in the J.C. Boyle bypass reach due to the elimination of hydropower peaking operations would be a significant impact. Slight decreases in long-term summer/fall water temperatures and less daily fluctuation in the J.C. Boyle peaking reach would be beneficial. From the J.C. Boyle peaking reach to Copco 1 Reservoir, long-term water temperature effects would be similar to those under the No Action/No Project Alternative (i.e., no change from existing conditions). From Copco 1 Reservoir to Iron Gate Reservoir, long-term increases in spring water temperatures would be potentially significant and decreases in late summer/fall water temperatures in the Hydroelectric Reach would be similar to the Proposed Action and would be beneficial.**~~

~~Lower Klamath Basin~~
~~While model results analyzed for the Proposed Action do not explicitly isolate the effects of the four individual reservoirs on water temperatures, the KRWQM includes a scenario in which only Iron Gate, Copco 1, and Copco 2 Dams are removed but J.C. Boyle remains in place ("WIGC" PacifiCorp 2004b, Dunsmoor and Huntington 2006, see also Appendix D). This scenario is analogous to the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative because Copco 2 Reservoir has no active storage and thus has a negligible effect on hydraulic residence time and water temperature. KRWQM WIGC results indicate that compared with removal of all four reservoirs ("WIGCJCB"), the long-term effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects on water temperature for the Lower Klamath Basin under the Proposed Action (see Figure 3.2-26).~~

~~This is not surprising because Copco 1 and Iron Gate Reservoirs are the two deepest and largest reservoirs, which stratify during summer months and affect downstream water temperature through the discharge of warm surface waters (see Section 3.2.3.1). Comparison of KRWQM model output for WIGC and WIGCJCB also indicates that springtime daily variability in water temperature may be somewhat greater under this alternative than under the Proposed Action, which may be due to assumptions regarding peaking operations at J.C. Boyle Powerhouse. However, overall, the effects of removing Iron Gate and Copco 1 Dams on water temperature in the Lower Klamath Basin would be similar to effects under the Proposed Action.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2-50 years following dam removal/construction of fish passage facilities) increases in spring water temperatures would be potentially significant and decreases in late summer/fall water temperatures would be beneficial for the lower Klamath River from Iron Gate Dam to the confluence with the Salmon River. There would be no change from existing conditions on water temperature for lower Klamath River downstream of the Salmon River, the Klamath Estuary, and the marine nearshore environment.**~~



~~Figure 3.2-26. Simulated Hourly Water Temperature Downstream of Iron Gate Dam (RM 190.1) Based on Year 2004 for Current Conditions Compared to Hypothetical Conditions: (a) without Iron Gate (IG), Copco 1 and 2, and J.C. Boyle (JCB) Dams and (b) without Iron Gate (IG) and Copco 1 and 2 Dams. Source: PacifiCorp 2004a.~~

~~3.2.4.3.5.2 Suspended Sediments~~

Upper Klamath Basin

Since the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include no peaking power generation or release of flow for recreation at J.C. Boyle Dam, water temperature effects in the J.C. Boyle Bypass Reach would be similar to those under the Fish Passage at Four Dams Alternative (see Section 3.2.4.3.4) because the Fish Passage at Four Dams Alternative also keeps J.C. Boyle Reservoir in place and includes significantly increased flow releases over the No Action/No Project Alternative, approaching the flow conditions for this alternative (i.e., no peaking power generation or release of recreation flows). Thus, the effects would be continued low diel temperature variation and overall warmer water temperatures in the Bypass Reach during summer and early fall, and cooler temperatures in late fall and winter. In the Peaking Reach, water temperature effects would be the same as under the Proposed Action (i.e., slightly lower maximum water temperatures and less artificial diel temperature variation during summer and early fall) since no peaking flows would occur and the effect of J.C. Boyle thermal mass on water temperatures does not extend this far downstream. The effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under this alternative would be similar to effects for the Lower Klamath River immediately downstream from Iron Gate Dam under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term (2–50 years following dam removal/construction of fish passage facilities) increases in summer/fall water temperatures in the J.C. Boyle Bypass Reach due to the elimination of bypass flows and increased dilution of cold spring water with warmer reservoir water would be a less than significant impact. Slight decreases in long-term maximum summer/fall water temperatures and less artificial diel temperature variation in the J.C. Boyle Peaking Reach would be beneficial. From Copco 1 Reservoir to Iron Gate Reservoir, long-term increases in spring water temperatures would be less than significant and decreases in late summer/fall water temperatures in the Hydroelectric Reach would be similar to the Proposed Action and would be beneficial.

Lower Klamath Basin

While model results analyzed for the Proposed Action do not explicitly isolate the effects of the four individual reservoirs on water temperatures, the KRWQM includes a scenario in which only Iron Gate, Copco 1, and Copco 2 Dams are removed but J.C. Boyle remains in place ("WIGC" PacifiCorp 2004b, Dunsmoor and Huntington 2006, see also Appendix D). This scenario is analogous to the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative because Copco 2 Reservoir has no active storage and thus has a negligible effect on hydraulic residence time and water temperature. KRWQM WIGC results indicate that compared with removal of all four reservoirs ("WIGCJCB"), the long-term effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects on water temperature for the Lower Klamath Basin under the Proposed Action (see Figure 3.2-26).

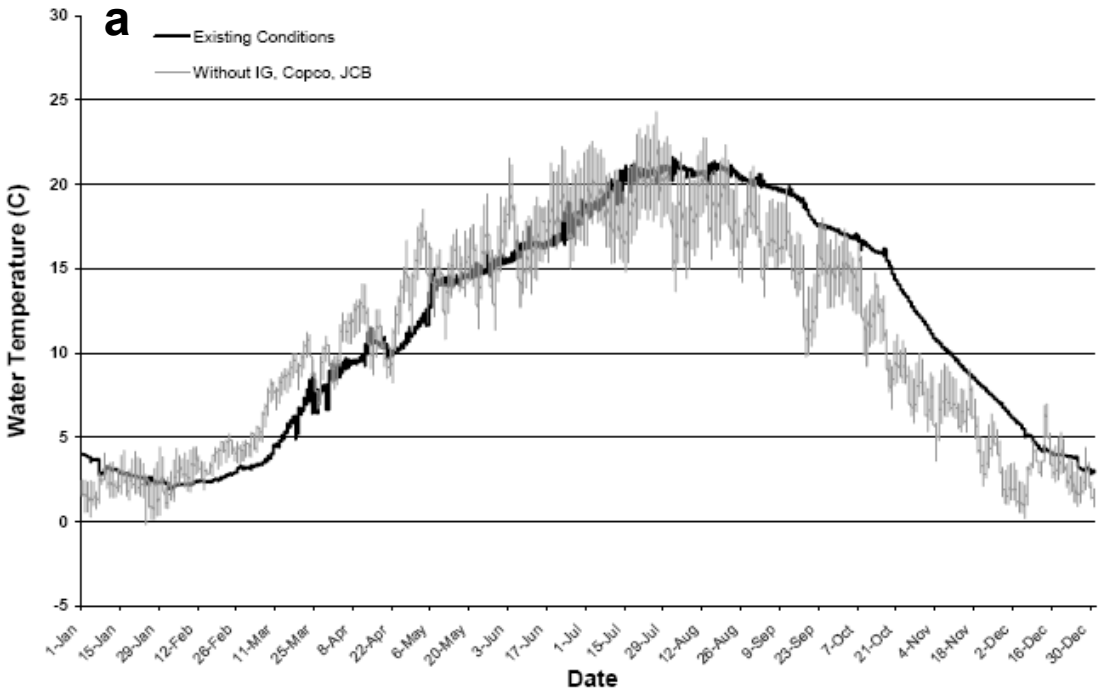
3.2.4.3.6 Suspended Sediments

Upper Klamath Basin

Upstream of Copco 1 Dam, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) SSCs under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as SSCs under the No Action/No Project Alternative. However, because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained with the reservoirs at the Four Facilities (CDM 2011), the short-term effects of sediment release on SSCs downstream ~~of~~from Copco 1 Dam under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects for the Hydroelectric Reach under the Proposed Action. Compared to the Proposed Action, there would be approximately 15 percent less sediment mobilized from the reservoirs at the Four Facilities (sediments in J.C. Boyle would remain in place) and short-term SSCs within the Hydroelectric Reach may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) increases in SSC~~s~~ in the Hydroelectric Reach due to mobilization of sediment deposits from Copco 1 Reservoir and Iron Gate Reservoir would be a significant impact.

Stormwater runoff from deconstruction activities under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 2 and Iron Gate Alternative may cause increases in suspended material in the Hydroelectric Reach during the deconstruction period. Dam deconstruction effects on suspended sediments would be limited to Copco 1 and Iron Gate Reservoirs and downstream river reaches, while fish passage construction effects would be limited to J.C. Boyle and Copco 2 Reservoirs and downstream river reaches. However, both dam deconstruction and fish passage construction activities would be complex and overlapping in terms of resulting river concentrations of suspended sediments and would require implementation of BMPs at each reservoir site. Therefore, dam deconstruction and fish passage construction activities in the Hydroelectric Reach under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be essentially the same as those for the Hydroelectric Reach under the Proposed Action.



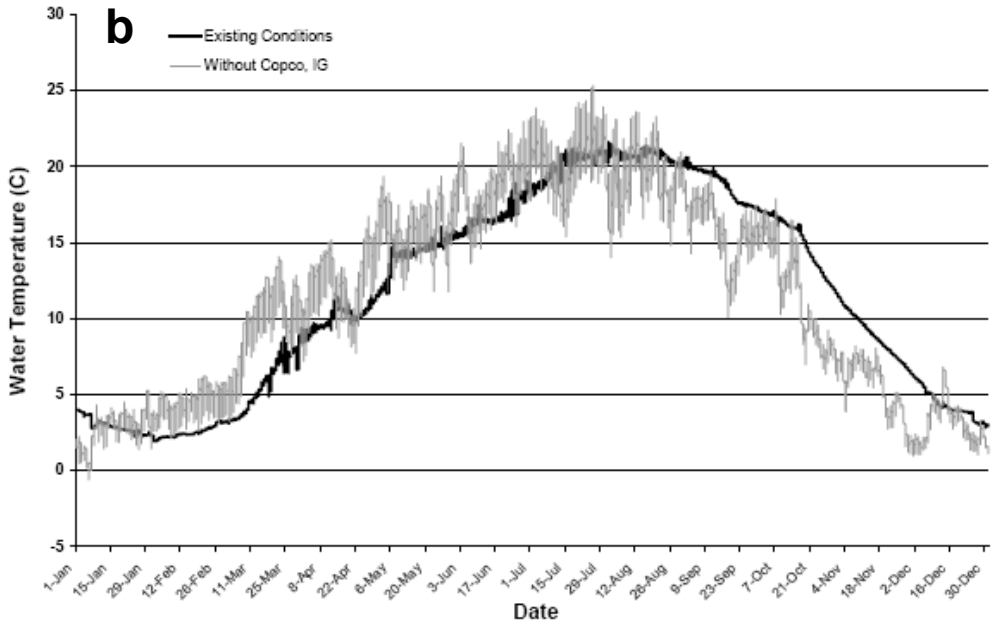


Figure 3.2-26. Simulated Hourly Water Temperature Downstream from Iron Gate Dam (RM 190.1) Based on Year 2004 for Current Conditions Compared to Hypothetical Conditions: (a) without Iron Gate (IG), Copco 1 and 2, and J.C. Boyle (JCB) Dams and (b) without Iron Gate (IG) and Copco 1 and 2 Dams. Source: PacifiCorp 2005.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) deconstruction-related increases in SSC~~s in the Hydroelectric Reach would be a less-than-significant impact.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, construction activities for the Yreka Pipeline would have the same short-term effects on suspended sediments** in the Hydroelectric Reach ~~as the Proposed Action and~~ would be a less-than-significant impact.~~

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, revegetation activities (i.e., hydroseeding) would have the same short-term (< 2 years following dam removal) effects on erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach as the Proposed Action and would be beneficial.

Due to the lack of continued interception and retention of mineral (inorganic) and algal-derived (organic) suspended materials behind Copco 1 and Iron Gate Dams under the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative, long-term (2-50 years following dam removal/construction of fish passage facilities) effects on SSCs for the Hydroelectric Reach would be similar to those for the Hydroelectric Reach under the Proposed Action. **Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term (2–50 years following dam removal/construction of fish passage facilities) increases in mineral (inorganic) and algal-derived (organic) suspended material in the Hydroelectric Reach would be a less-than-significant impact**.

Lower Klamath Basin

Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained with the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of suspended sediments in the Lower Klamath Basin under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those for the Lower Klamath Basin under the Proposed Action. Because there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place), short-term (<2 years following dam removal/construction of fish passage facilities) SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) increases in SSC~~s~~ in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

Stormwater runoff from deconstruction activities under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate alternative may cause increases in suspended material in the Klamath River downstream ~~of~~ from Iron Gate Dam during the deconstruction period. Dam deconstruction effects on suspended sediments would be limited to Copco 1 and Iron Gate Reservoirs and downstream river reaches, while fish passage construction effects would be limited to J.C. Boyle and Copco 2 Reservoirs and downstream river reaches. However, both dam deconstruction and fish passage construction activities would be complex and overlapping in terms of river SSCs and would require implementation of BMPs at each reservoir site. Therefore, dam deconstruction and fish passage construction activities would have the same effects on SSCs in the Lower Klamath Basin as the Proposed Action and the Fish Passage at Four Dams Alternative.

***Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, deconstruction-related increases in SSC~~s~~ in the ~~lower~~Lower Klamath River and the Klamath Estuary would be a less-than-significant impact. There would be no change from existing conditions on the marine nearshore environment.**

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, revegetation activities (i.e., hydroseeding) would have the same short-term (< 2 years following dam removal) effects on erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach and transport into the ~~lower~~Lower Klamath River and Klamath Estuary as the Proposed Action and would be beneficial. There would be no change from existing conditions on the marine nearshore environment.

Under this alternative, long-term (2–50 years following dam removal/construction of fish passage facilities) effects on mineral (inorganic) and algal-derived (organic) suspended materials in the Lower Klamath Basin due to the lack of continued interception and retention of sediment behind Copco 1 and Iron Gate Dams would be similar to those for the Lower Klamath Basin under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) increases on mineral (inorganic) and algal-derived (organic) suspended materials in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

~~3.2.4.3.5.3~~ Nutrients

Upper Klamath Basin

Upstream of Copco 1 Reservoir, effects on nutrients under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. However, Copco 1 and Iron Gate Reservoirs are the largest and deepest reservoirs in the Hydroelectric Reach with the longest residence times (FERC 2007), and the short-

term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams for the reach from Copco 1 Reservoir to Iron Gate Reservoir. Therefore, under this alternative, effects on nutrients

for the reach from Copco 1 Reservoir to Iron Gate Reservoir would be the same as effects for the ~~lower~~Lower Klamath River immediately downstream ~~of~~from Iron Gate Dam under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in nutrients in the Hydroelectric Reach would be a less-than-significant impact.

Lower Klamath Basin

Copco 1 and Iron Gate Reservoirs are the largest and deepest reservoirs in the Hydroelectric Reach with the longest residence times, so the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on nutrients would be the same as effects for the ~~lower~~Lower Klamath River under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in nutrients in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

~~3.2.4.3.5.4~~ Dissolved Oxygen

~~Upper Klamath Basin~~

~~Upstream of Copco 1 Dam, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) dissolved oxygen under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as dissolved oxygen under the No Action/No Project Alternative. However, because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term effects of sediment release on dissolved oxygen concentrations downstream of Copco 1 Dam under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects for the Hydroelectric Reach under the Proposed Action. Compared to the Proposed Action, there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place) and short-term SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect on dissolved oxygen. The short-term effects of sediment release on oxygen demand and dissolved oxygen concentrations in the Hydroelectric Reach under the Fish Passage at~~

~~J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be essentially the same as those for the Lower Klamath Basin under the Proposed Action.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) decreases in dissolved oxygen in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be a significant impact. The long-term (2-50 years following dam removal) increase in summer and fall dissolved oxygen concentrations in the Hydroelectric Reach would be beneficial.**~~

~~Lower Klamath Basin~~
~~Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of dissolved oxygen in the Lower Klamath Basin under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those for the Lower Klamath Basin under the Proposed Action. Because there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place), short-term SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks and dissolved oxygen demand may also decrease. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect on dissolved oxygen.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term (<2 years following dam removal/construction of fish passage facilities) decrease in dissolved oxygen concentrations would be a significant impact on the lower basin from Iron Gate Dam to approximately Clear Creek (≈RM 100), but would not affect dissolved oxygen in the Klamath Estuary or the marine nearshore environment. The long-term (2–50 years following dam removal) increases in summer and fall dissolved oxygen concentrations immediately downstream of Iron Gate Dam would be beneficial.**~~

~~**3.2.4.3.5.5 pH**~~

Upper Klamath Basin

Upstream of Copco 1 Dam, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) dissolved oxygen under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as dissolved oxygen under the No Action/No Project Alternative. However, because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term effects of sediment release on dissolved oxygen concentrations downstream from Copco 1 Dam under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to effects for the Hydroelectric Reach under the Proposed Action. Compared to the Proposed Action, there would be approximately 15 percent less sediment mobilized

(sediments in J.C. Boyle would remain in place) and short-term SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect on dissolved oxygen. The short-term effects of sediment release on oxygen demand and dissolved oxygen concentrations in the Hydroelectric Reach under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be essentially the same as those for the Lower Klamath Basin under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, short-term (<2 years following dam removal/construction of fish passage facilities) decreases in dissolved oxygen in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be a significant impact. The long-term (2-50 years following dam removal) increase in summer and fall dissolved oxygen concentrations in the Hydroelectric Reach would be beneficial.

Lower Klamath Basin

Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of dissolved oxygen in the Lower Klamath Basin under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those for the Lower Klamath Basin under the Proposed Action. Because there would be approximately 15 percent less sediment mobilized (sediments in J.C. Boyle would remain in place), short-term SSCs in the Lower Klamath Basin may exhibit somewhat lower peaks and dissolved oxygen demand may also decrease. However, the overall pattern and duration of high SSCs would be the same, as would the general magnitude of the effect on dissolved oxygen.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term (<2 years following dam removal/construction of fish passage facilities) decrease in dissolved oxygen concentrations would be a significant impact on the lower basin from Iron Gate Dam to approximately Clear Creek (≈RM 100), but would not affect dissolved oxygen in the Klamath Estuary or the marine nearshore environment. The long-term (2–50 years following dam removal) increases in summer and fall dissolved oxygen concentrations immediately downstream from Iron Gate Dam would be beneficial.

pH

Upper Klamath Basin

Upstream of Copco 1 Reservoir, effects on pH under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. The effects of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under this alternative would be similar to effects on pH for the ~~lower~~ Lower Klamath River immediately downstream ~~of~~from Iron Gate Dam under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in high summertime daily pH fluctuations in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be beneficial.

Lower Klamath Basin

Because J.C. Boyle Reservoir does not currently appear to substantially alter pH in the river downstream ~~of~~ from the dam (see Figure 3.2-22.) having this dam in place would not affect pH downstream ~~of~~ from the Hydroelectric Reach in the Lower Klamath Basin. However, apparent seasonal and daily pH fluctuations in Copco 1 and Iron Gate Reservoirs would be altered once these reservoir areas were converted to a free-flowing river. Therefore, effects on pH under this alternative would be similar to effects on pH for the ~~lower~~Lower Klamath River immediately downstream ~~of~~ from Iron Gate Dam under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term (2–50 years following dam removal/construction of fish passage facilities) summertime increases in pH would be less than significant for the ~~lower~~Lower Klamath River from Iron Gate Dam to the confluence with the Scott River. There would be no change from existing conditions on pH for the Klamath River just downstream ~~of~~from Seiad Valley, the Klamath Estuary, and the marine nearshore environment.

~~3.2.4.3.5.6~~ Chlorophyll-a and Algal Toxins

~~Upper Klamath Basin~~

~~Upstream of Copco 1 Reservoir, effects on algal toxins and chlorophyll-*a* under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. Copco 1 and Iron Gate Reservoirs are the largest reservoirs in the Hydroelectric Reach with the longest hydraulic residence times (FERC 2007) and potential for *in situ* algal growth, so the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on algal toxins and chlorophyll-*a* would be the same as effects for the Upper Klamath Basin under the Proposed Action.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in production of algal toxins and chlorophyll-*a* in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be beneficial.**~~

~~Lower Klamath Basin~~
~~Copco 1 and Iron Gate Reservoirs are the largest reservoirs in the Hydroelectric Reach with the longest residence times (FERC 2007) and hence potential for *in situ* algal growth, so the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on algal toxins and chlorophyll-*a* would be the same as effects for the Lower Klamath Basin under the Proposed Action.~~

~~**Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in production of algal toxins and chlorophyll-*a* in upstream reservoirs and subsequent transport into the lower Klamath River and the Klamath Estuary would be beneficial.**~~

~~**3.2.4.3.5.7 Inorganic and Organic Contaminants**~~

Upper Klamath Basin

Upstream of Copco 1 Reservoir, effects on algal toxins and chlorophyll-*a* under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects under the No Action/No Project Alternative because J.C. Boyle Dam would remain in place. Copco 1 and Iron Gate Reservoirs are the largest reservoirs in the Hydroelectric Reach with the longest hydraulic residence times (FERC 2007) and potential for *in situ* algal growth, so the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on algal toxins and chlorophyll-*a* would be the same as effects for the Upper Klamath Basin under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in chlorophyll-*a* and substantial decrease or elimination of algal toxins and in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir would be beneficial.

Lower Klamath Basin

Copco 1 and Iron Gate Reservoirs are the largest reservoirs in the Hydroelectric Reach with the longest residence times (FERC 2007) and hence potential for *in situ* algal growth, so the effects of removing them and converting the reservoir areas to a free-flowing river under this alternative would be similar to removing all four dams. Therefore, under this alternative, effects on algal toxins and chlorophyll-*a* would be the same as effects for the Lower Klamath Basin under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the long-term (2–50 years following dam removal/construction of fish passage facilities) decrease in production of algal toxins and chlorophyll-*a* in upstream reservoirs and subsequent transport into the Lower Klamath River and the Klamath Estuary would be beneficial.

Inorganic and Organic Contaminants

Upper Klamath Basin

Under this alternative, continued retention of sediments behind J.C. Boyle Dam and release of sediments trapped behind Copco 1 and Iron Gate Dams would occur. In J.C. Boyle Reservoir, short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) effects of sediment retention on concentrations of inorganic and organic contaminants, and the potential for bioaccumulation and/or toxicity to freshwater aquatic biota and humans, would be the same as those for the Hydroelectric Reach under the No Action/No Project Alternative. However, for the two largest reservoirs in the Hydroelectric Reach, Copco 1 and Iron Gate Reservoirs, short-term and long-term effects of sediment release on concentrations of inorganic and organic contaminants under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as those for the Hydroelectric Reach under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in potential inorganic and organic contaminants in the Hydroelectric Reach due to sediment release would be a less-than-significant impact.

Dam deconstruction and fish passage construction activities could cause increases in inorganic and organic contaminants from hazardous materials associated with construction equipment that could exceed applicable O~~regon~~ DEQ and North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the Hydroelectric Reach. These effects would be a significant impact. However, the impacts would be reduced through implementation of BMPs for deconstruction and construction activities that would occur in or adjacent to the Klamath. BMPs would minimize or eliminate the potential for toxic substances to enter the water.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the effects on inorganic and organic contaminants in the Hydroelectric Reach due to construction/deconstruction activities would be a less-than-significant impact.

Lower Klamath Basin

Under this alternative, release of the sediments trapped behind Copco 1 and Iron Gate Dams) would occur. Because Copco 1 and Iron Gate Reservoirs contain 85 percent of the total erodible sediment contained within the reservoirs at the Four Facilities (CDM 2011), the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) effects of sediment release on concentrations of inorganic and organic contaminants, and the potential for bioaccumulation and/or toxicity to freshwater aquatic biota, marine aquatic biota, and humans in the Lower Klamath Basin, would be similar to those for the Lower Klamath Basin under the Proposed Action.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) increases in potential inorganic and organic contaminants due to sediment release would be a less-than-significant impact.

Dam deconstruction and fish passage construction activities could cause increases in inorganic and organic contaminants from hazardous materials associated with construction equipment that could exceed applicable North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment. These effects would be a significant impact. However, the impacts would be reduced through implementation of BMPs for deconstruction and construction activities that would occur in or adjacent to the Klamath River. BMPs would minimize or eliminate the potential for toxic substances to enter the water.

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the increases in potential inorganic and organic contaminants due to construction/deconstruction activities would be a less-than-significant impact.

~~3.2.4.3.5.8~~ Trap and Haul – Programmatic Measure

The impacts from the trap and haul measure under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as those under the Fish Passage at Four Dams Alternative. **Therefore, under the *Fish Passage at J.C.~~-~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, the short-term effects on water quality would be less-than-significant because of implementation of BMPs (see Appendix B.1.1 Water Quality).**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, construction activities for the Yreka Water Supply Pipeline would have the same short-term effects on suspended sediments in the Hydroelectric Reach as the Proposed Action and would be a less-than-significant impact.

3.2.5~~–~~ Mitigation Measures

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects (i.e., high SSCs, low DO) (see also Section 2, Proposed Action and Description of the Alternatives). While the Alternatives Formulation Report identified the option of mechanical sediment removal as mitigation for sediment erosion impacts associated with removal of the Four Facilities, subsequent analysis found this measure to be infeasible (Lynch 2011).

3.2.5.1~~–~~ Mitigation Measures Associated with Other Resource Areas

Several other mitigation measures require construction, including mitigation measures H-2 (flood-proof structures), GW-1 (deepen or replace affected wells), WRWS-1 (modify or screen affected water intakes), PHS-4 (repair damaged roads), PHS-5 (construct water storage tanks for fire fighting), REC-1 (develop new recreational facilities and access to river), TR-6 (assess and improve roads to carry construction loads), and TR-7 (assess and improve bridges to carry construction loads). Short-term effects on water quality from construction activities may include increased suspended sediments and inorganic and organic contaminants from hazardous materials associated with construction equipment to enter nearby or adjacent water bodies. Implementation of deconstruction and/or construction-related BMPs would also apply to these construction efforts. **Implementation of BMPs would reduce effects of these mitigation measures to less-than-significant levels.**

3.2.6 Summary of Short-term and Long-term Impacts on Water Quality

Table 3.2-14 summarizes the short~~-~~ term (<2 years following dam removal/construction of fish passage facilities) and long-term (2–50 years following dam removal/construction of fish passage facilities) impacts of the Proposed Action and alternatives on water quality.

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~***Water Temperature***~~				
~~**Upper Klamath Basin**~~				
Water Temperature				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could cause short-term and long-term seasonal water temperatures that are shifted from the natural thermal regime of the river and do not meet applicable ODEQ and California Basin Plan water quality objectives and adversely affect beneficial uses in the Hydroelectric Reach.	1~~, 4,5~~	NCFEC	None	NCFEC
Dam removal and/or reduction or elimination of hydropower peaking operations at J.C. Boyle Powerhouse could cause short-term and long-term alterations in ~~daily~~overall water temperatures and ~~fluctuations~~diel temperature variation in the J.C. Boyle ~~bypass~~Bypass and ~~peaking reaches.~~Peaking Reaches.	2, 3, 4, 5	LTS for J.C. Boyle ~~bypass reach~~Bypass Reach in summer/fall B for J.C. Boyle ~~peaking reach~~Peaking Reach in summer/fall	***None***	LTS for J.C. Boyle ~~bypass reach~~Bypass Reach in summer/fall B for J.C. Boyle ~~peaking reach~~Peaking Reach in summer/fall
Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term increases in spring time water temperatures and decreases in late summer/fall water temperatures in the Hydroelectric Reach downstream ~~of~~from Copco 1 Reservoir.	2, 3, 5	LTS for springtime B for late summer/fall	***None***	LTS for springtime B for late summer/fall
~~**Lower Klamath Basin**~~				

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Lower Klamath Basin				
Draining the reservoirs and release of sediment could cause short-term and long-term increases in sediment deposition in the Klamath River or Estuary that could alter morphological characteristics and indirectly affect seasonal water temperatures.	2, 3, 5	NCFEC	None	NCFEC
Continued impoundment of water in the reservoirs could cause short-term and long-term seasonal water temperatures and diel temperature variation that are shifted from the natural thermal regime of the river and do not meet applicable California North Coast Basin Plan water quality objectives and adversely affect beneficial uses in the Klamath River downstream ~~of~~from Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free flowing river could result in short-term and long-term increases in spring water temperatures ~~and~~ , decreases in late summer/fall water temperatures, and increased diel temperature variation in the Lower Klamath River.	2, 3, 5	LTS – Iron Gate Dam to Salmon River for springtime and B – in late summer/fall NCFEC – Klamath River downstream ~~of~~from Salmon River, the Klamath Estuary, and marine near shore environment	None	LTS – Iron Gate Dam to Salmon River for springtime and B – in late summer/fall NCFEC – Klamath River downstream ~~of~~from Salmon River, the Klamath Estuary, and marine near shore environment

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~***Suspended Sediments***~~				
~~**Upper Klamath Basin**~~				
Suspended Sediments				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could result in short-term and long-term interception and retention of mineral (inorganic) suspended material by the KHP dams.	1, 4	NCFEC	None	NCFEC
Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach.	1~~,~~, 2 ,3	LTS	None	LTS
Implementation of IM 8, J.C. Boyle Bypass Barrier Removal, could result in short-term increases in mineral suspended material in the Hydroelectric Reach due to deconstruction activities.	1	LTS	None	LTS
Implementation of IM 16, Water Diversions, could result in short-term increases in mineral (inorganic) suspended material in the Hydroelectric Reach due to diversion screening deconstruction and construction activities.	2, 3	LTS	None	LTS
Continued impoundment of water in the reservoirs could cause short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the Hydroelectric Reach due to in-reservoir algal blooms.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term increases in suspended material in the Hydroelectric Reach downstream ~~of~~from J.C. Boyle Dam.	2, 3, 5	S	None	S
Construction/deconstruction activities could cause	2, 3, 4, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
short-term increases in suspended material in the Hydroelectric Reach due to stormwater runoff from construction/deconstruction areas.				
Removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline which could cause short-term increases in suspended material in the Hydroelectric Reach during the construction period.	2, 3, 5	LTS	None	LTS
Construction/deconstruction activities would include the demolition of various recreation facilities which could cause short-term increases in suspended material in the Hydroelectric Reach from stormwater runoff from the demolition areas.	2, 3, 5	LTS	None	LTS
Revegetation associated with management of the reservoir footprint area after dam removal could decrease the short-term erosion of fine sediments from exposed reservoir terraces in the Hydroelectric Reach.	2, 3, 5	B	None	B
Dam removal could eliminate the interception and retention of mineral (inorganic) suspended material behind the dams and result in long-term increases in suspended material in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Dam removal could eliminate the interception and retention of algal-derived (organic) suspended material behind the dams and result in slight long-term increases in suspended material in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Lower Klamath Basin				
Draining the reservoirs and release of sediment could cause short-term increases in suspended material in the ~~lower~~Lower Klamath River and the Klamath Estuary.	2, 3, 5	S	None	S

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Draining the reservoirs and release of sediment could cause short-term increases in sediment loads from the Klamath River to the Pacific Ocean and corresponding increases in concentrations of suspended material and rates of deposition in the marine nearshore environment.	2, 3, 5	LTS	None	LTS
Continued impoundment of water in the reservoirs could cause short-term and long-term interception and retention of mineral (inorganic) sediments by the dams and correspondingly low levels of suspended material immediately downstream ~~of~~from Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Continued impoundment of water in the reservoirs could result in short-term and long-term seasonal (April through October) increases in algal-derived (organic) suspended material in the KHP reservoirs and subsequent transport into the Klamath River downstream ~~of~~from Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Construction/deconstruction activities could cause short-term increases in suspended material in the ~~lower~~Lower Klamath River, Klamath Estuary, and marine nearshore environment due to stormwater runoff from construction/deconstruction areas.	2, 3, 5	LTS NCFEC (Marine Nearshore Environment	None	LTS
Revegetation associated with management of the reservoir footprint area after dam removal could decrease the short-term erosion of fine sediments from exposed reservoir terraces into the ~~lower~~Lower Klamath River and Klamath Estuary.	2, 3, 5	B NCFEC (Marine Nearshore Environment	None	B
Dam removal could eliminate the interception and retention of mineral (inorganic) suspended material behind the dams and result in long-term increases in	2, 3, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.				
Dam removal could eliminate the interception and retention of algal-derived (organic) suspended material behind the dams and result in long-term increases in suspended material in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS
~~***Nutrients***~~				
~~**Upper Klamath Basin**~~				
Nutrients				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could result in long-term interception and retention of ~~TP~~ TN and ~~TN~~ TP in the Hydroelectric Reach on an annual basis but release ~~(export)~~ of TP and, to a lesser degree TN ~~-~~from reservoir sediments on a seasonal basis.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term increases in sediment-associated nutrients in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
~~**Lower Klamath Basin**~~				
Lower Klamath Basin				
Continued impoundment of water in the reservoirs could cause long-term interception and retention of TP and TN on an annual basis ~~but~~ and release	1, 4	NCFEC	None	NCFEC

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
(export) of TP ~~and TN~~ on a seasonal basis				

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Draining the reservoirs and release of sediment to the ~~lower~~Lower Klamath River could cause short-term increases in sediment-associated nutrients in the river~~ and~~, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels in the ~~lower~~Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS
~~***Dissolved Oxygen***~~				
~~**Upper Klamath Basin**~~				
Dissolved Oxygen				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could cause long-term[~~14~~1] seasonal and daily variability in dissolved oxygen concentrations in the Hydroelectric Reach, such that levels do not meet O~~regon~~ DEQ and California North Coast Basin Plan water quality objectives and adversely affect beneficial uses.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term[~~15~~2] increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the Hydroelectric Reach downstream ~~of~~from J.C. Boyle Reservoir.	2, 3, 5	S	None	S
Dam removal and conversion of reservoir areas to	2, 3	B	None	B

~~[14] Long-term is defined as 2-50 years~~
~~[15] Short-term is defined as <2 years~~

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
free-flowing river conditions could cause long-term slight increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the Hydroelectric Reach downstream from J.C. Boyle Dam, and would eliminate seasonal extremes in dissolved oxygen (i.e., supersaturation in surface waters and oxygen depletion in bottom waters) in the riverine reaches replacing Copco1 and Iron Gate Reservoirs.				
~~Lower Klamath Basin~~ Dam removal and conversion of reservoir areas to free-flowing river conditions could cause long-term slight decreases in daily variability in dissolved oxygen in the Hydroelectric Reach at State line.	2, 3	LTS	None	LTS
~~Continued impoundment of water in the reservoirs could cause long-term seasonal and daily variability in dissolved oxygen concentrations in the Klamath River downstream of Iron Gate Dam, such that levels do not meet California North Coast Basin Plan and Hoopa Valley Tribe water quality objectives and adversely affect beneficial uses.~~	~~1, 4~~	~~NCFEC~~	~~None~~	~~NCFEC~~
~~Dam removal and sediment release Could cause short-term increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the lower Klamath River, the Klamath Estuary, and the marine nearshore environment.~~ **Lower Klamath Basin**				
Continued impoundment of water at the Four Facilities could result in continued release of water with seasonally low dissolved oxygen concentrations from Iron Gate Dam into the Klamath River such that levels immediately downstream from the dam do not meet California North Coast Basin Plan water quality objectives and adversely affect beneficial uses.	~~2, 3, 5~~1, 4	~~S (lower Klamath River from Iron Gate Dam to Clear Creek)~~ NCFEC ~~(Klamath Estuary or Marine Nearshore Environment)~~	None	~~S (lower Klamath River from Iron Gate Dam to Clear Creek)~~ NCFEC ~~(Klamath Estuary or Marine Nearshore Environment~~
Dam removal and ~~conversion of reservoir areas to a free-flowing river~~sediment release could cause	2, 3, 5	~~B~~S (Lower Klamath River from	None	~~B~~S (Lower Klamath River from

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
~~long~~short-term increases in oxygen demand (IOD and BOD) and reductions in dissolved oxygen~~, as well as increased daily variability in dissolved oxygen,~~ in the ~~lower~~Lower Klamath River, ~~particularly for~~ the ~~reach immediately downstream of Iron Gate Dam.~~ Klamath Estuary, and the marine nearshore environment.		Iron Gate Dam to Clear Creek) NCFEC (Klamath Estuary or Marine Nearshore Environment)		Iron Gate Dam to Clear Creek) NCFEC (Klamath Estuary or Marine Nearshore Environment
~~*pH*~~Dam removal and conversion of reservoir areas to a free-flowing river could cause long-term overall increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the Lower Klamath River, particularly for the reach immediately downstream from Iron Gate Dam.	2, 3, 5	B	None	B
~~**Upper Klamath Basin**~~				
~~Continued impoundment of water in the reservoirs could cause long-term elevated seasonal pH and daily variability in pH in the Hydroelectric Reach.~~	~~1, 4~~	~~NCFEC~~	~~None~~	~~NCFEC~~
~~Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term decreases in summertime pH in the Hydroelectric Reach.~~ ***pH***				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could cause long-term elevated seasonal pH and daily variability in pH due to large algal blooms in the reservoirs in the Hydroelectric Reach.	~~2, 3, 5~~1, 4	~~B~~NCFEC	None	~~B~~NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river could cause short-term and long-term slight increases in pH and daily pH fluctuations in riverine reaches in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Dam removal and conversion of the reservoir areas	2, 3, 5	B	None	B

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
to a free-flowing river could cause short-term and long-term decreases in high summertime daily pH fluctuations in the free-flowing reaches of the river that replace Copco 1 and Iron Gate Reservoirs in the Hydroelectric Reach.				
Lower Klamath Basin				
Continued impoundment of water in the reservoirs could cause long-term elevated seasonal pH and daily variability in pH in the ~~lower~~Lower Klamath River immediately downstream ~~of~~from Iron Gate Dam due to large algal blooms in the reservoirs in the Hydroelectric Reach.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river could cause ~~short-term and~~ long-term ~~decreases in~~ summertime increases in pH in the ~~lower~~Lower Klamath River~~, Klamath Estuary, and the marine nearshore environment~~ immediately downstream from Iron Gate Dam.	2, 3, 5	~~B~~LTS for Lower Klamath River from Iron Gate Dam to confluence with the Scott River NCFEC for the Lower – Klamath River downstream from the Scott River, the Klamath Estuary, and the Marine Nearshore Environment	None	~~B~~LTS for Lower Klamath River from Iron Gate Dam to confluence with the Scott River NCFEC for the Lower Klamath River downstream from the Scott River, the Klamath Estuary, and the Marine Nearshore Environment
~~Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term summertime increases in pH in the lower Klamath River downstream of Iron Gate Dam.~~	~~2, 3, 5~~	~~LTS (from Iron Gate Dam to confluence with the Scott River)~~ ~~NCFEC (Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the Marine Nearshore Environment~~	~~None~~	~~LTS (from Iron Gate Dam to confluence with the Scott River)~~ ~~NCFEC (Klamath River just downstream of Seiad Valley, the Klamath Estuary, and the Marine Nearshore Environment~~

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Chlorophyll-a and Algal Toxins				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could support long-term growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*, resulting in high seasonal concentrations of chlorophyll-*a* and algal toxins (i.e., microcystin) in the Hydroelectric Reach.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river would cause short-term and long-term decreases in levels of chlorophyll-a and substantially reduce or eliminate algal toxins (i.e., microcystin) in the Hydroelectric Reach.	2, 3, 5	B	None	B
Lower Klamath Basin				
Continued impoundment of water in the reservoirs could support long-term growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*, resulting in high seasonal concentrations of chlorophyll-a and algal toxins (i.e., microcystin) transported into the Klamath River from downstream ~~of~~from Iron Gate Dam to the Klamath Estuary, and ~~potentially~~likely to the marine nearshore environment.	1, 4	NCFEC	None	NCFEC
Dam removal and conversion of the reservoir areas to a free-flowing river would cause short-term and long-term decreases in levels of chlorophyll-a and substantially reduce or eliminate algal toxins (i.e., microcystin) in the ~~lower~~Lower Klamath River and the Klamath Estuary.	2, 3, 5	B	None	B
~~***Inorganic and Organic Contaminants***~~				
~~**Upper Klamath Basin**~~				

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Inorganic and Organic Contaminants				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs and associated interception and retention of sediments behind the dams could cause long-term low-level exposure to inorganic and organic contaminants for freshwater aquatic species in the Hydroelectric Reach.	1, 4, 5	NCFEC	None	NCFEC
Continued impoundment of water in the reservoirs and associated interception and retention of sediments behind the dams could cause long-term low-level exposure to inorganic and organic contaminants in the Hydroelectric Reach for humans through ~~human~~the consumption of resident fish tissue.	1, 4, 5	NCFEC	None	NCFEC
Draining the reservoirs and sediment release could cause short-term increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Draining the reservoirs and sediment release could cause short-term and long-term human exposure to contaminants from contact with deposited sediments on exposed reservoir terraces and river banks within the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
Construction/deconstruction activities could cause short-term increases in inorganic and organic contaminants from hazardous materials associated with construction and revegetation equipment in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Reservoir area restoration activities could include herbicide application which could cause short-term levels of organic contaminants in runoff that are toxic to aquatic biota in the Hydroelectric Reach.	2, 3, 5	LTS	None	LTS
~~**Lower Klamath Basin**~~				
Lower Klamath Basin				
Dam removal and sediment release could cause short-term and long-term increases in concentrations of inorganic and organic contaminants and result in low-level exposure for freshwater aquatic species in the ~~lower~~Lower Klamath River and aquatic species in the Klamath Estuary and marine nearshore environment.	2, 3, 5	LTS	None	LTS
Draining the reservoirs and sediment release could cause short-term and long-term human exposure to contaminants from contact with deposited sediments on exposed downstream river terraces and downstream river banks following reservoir drawdown.	2, 3, 5	LTS	None	LTS
Construction/deconstruction activities could cause short-term increases in suspended sediments and the potential for inorganic and organic contaminants from hazardous materials associated with construction equipment to be transported into the ~~lower~~Lower Klamath River, Klamath Estuary, and the marine nearshore environment.	2, 3, 4, 5	LTS for Lower Klamath River and the Klamath Estuary NCFEC for Marine Nearshore Environment	None	LTS
Trip and Haul Operations				
Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan would affect water quality during construction.	4, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Keno Transfer				
Implementation of the Keno Transfer could cause adverse water quality effects.	2, 3	NCFEC	None	NCFEC
East and West Side Facilities				
Decommissioning the East and West Side Facilities could ~~cause adverse water quality effects.~~result in slight decreases in ammonia levels in the Keno Impoundment/Lake Ewauna.	2, 3	~~NCFEC~~B	None	~~NCFEC~~B
~~***KBRA***~~				
KBRA				
Implementation of the Phase I Fisheries Restoration Plan could result in short-term construction-related increases in suspended materials and long-term reductions in fine sediment inputs, reduced summer water temperatures, improved nutrient interception, and increased dissolved oxygen levels. .	2, 3	LTS (short-term) B (long-term)	None	LTS (short-term) B (long-term)
Implementation of the Phase II Fisheries Restoration Plan under the KBRA (KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same short-term (i.e., during construction activities) and long-term impacts as Phase I.	2, 3	LTS (short-term) B (long-term)	None	LTS (short-term) B (long-term)
Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan could affect water quality during construction.	2, 3	LTS	None	LTS
Implementation of Wood River Wetland Restoration could result in short-term construction-related increases in suspended materials and long-term warmer spring water temperatures and reduced fine	2, 3	LTS (short-term) B (long-term)	None	LTS (short-term) B (long-term)

Table 3.2-14. Summary of Short-~~Term~~term (<2 years) and Long-~~Term~~term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
sediment and nutrient inputs to Upper Klamath Lake.				
Implementation of Water Diversion Limitations could result in decreased summer water temperatures in the Klamath River upstream of the Hydroelectric Reach.	2, 3	NCFEC (short-term) B (long-term)	None	NCFEC (short-term) B (long-term)
Implementation of the Water Use Retirement Program could result in decreases in summer water temperature and nutrient inputs to Upper Klamath Lake.	2, 3	NCFEC (short-term) B (long-term)	None	NCFEC (short-term) B (long-term)
Implementation of the Interim Flow and Lake Level Program could result in decreases in summer water temperature and nutrient inputs to Upper Klamath Lake.	2, 3	NCFEC (short-term) B (long-term)	None	NCFEC (short-term) B (long-term)
Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program could result in long-term decreases in nutrient inputs, increases in seasonal dissolved oxygen, and decreases in concentrations of nuisance algal species in these waterbodies.	2, 3	Not determined at this time	None	Not determined at this time

~~Key:~~
~~NCFEC = No change from existing conditions; B = Beneficial; LTS = Less than significant; S = Significant~~ [1] Long term is defined as 2-50 years.
[2] Short term is defined as <2 years.

Key:
NCFEC = No change from existing conditions; B = Beneficial; LTS = Less than significant; S = Significant
CEQA = California Environmental Quality Act

3.2.7 References

~~Armstong N, and Ward G. 2008. Coherence of nutrient loads and AFWO Klamath River grab sample water quality database. Technical Report. Prepared for USFWS, Arcata Fish and Wildlife Office, Arcata, California.~~

~~Asarian E and Kann J. 2006a. Evaluation of PacifiCorp's Klamath River water quality model predictions for selected water quality parameters. Technical Memorandum. Prepared by Kier Associates, Blue Lake and Arcata, California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Yurok Tribe Environmental Program, Klamath, California.~~

~~Asarian E and Kann J. 2006b. Klamath River nitrogen loading and retention dynamics, 1996–2004. Final Technical Report Prepared by Kier Associates, Blue Lake and Arcata California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Yurok Tribe Environmental Program, Klamath, California.~~

~~Asarian E, Kann J, and Walker WW. 2009. Multi-year nutrient budget dynamics for Iron Gate and Copco Reservoirs, California. Prepared by Riverbend Sciences and Kier Associates, Eureka, California, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon, and William Walker, Concord, Massachusetts for the Karuk Tribe, Department of Natural Resources, Orleans, California.~~

~~Asarian E, Kann J, and Walker WW. 2010. Klamath River nutrient loading and retention dynamics in free-flowing reaches, 2005–2008. Prepared by Kier Associates, Eureka, California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Yurok Tribe Environmental Program, Klamath, California.~~

Aldous, A., McCormick, P., Ferguson, C., Graham, S., and Craft, C. 2005. Hydrologic regime controls soil phosphorus fluxes in restoration and undisturbed wetlands. Restoration Ecology 13: 341–347.

Aquatic Scientific Resources. 2005. Preliminary research on *Aphanizomenon flos-aquae* at Upper Klamath Lake, Oregon. Investigations to set direction for research of factors with potential for influencing *Aphanizomenon* growth at Upper Klamath Lake. Prepared by Aquatic Scientific Resources, Portland, Oregon for Klamath Basin Ecosystem Restoration Office, Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon.

Armstong, N. and Ward, G. 2008. Coherence of nutrient loads and AFWO Klamath River grab sample water quality database. Technical Report. Prepared for USFWS, Arcata Fish and Wildlife Office, Arcata, California.

Asarian, E. and Kann, J. 2006a. Klamath River nitrogen loading and retention dynamics, 1996–2004. Final Technical Report Prepared by Kier Associates, Blue Lake and Arcata

California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Yurok Tribe Environmental Program, Klamath, California.

Asarian, E. and Kann, J. 2006b. Evaluation of PacifiCorp's Klamath River water quality model predictions for selected water quality parameters. Technical Memorandum. Prepared by Kier Associates, Blue Lake and Arcata, California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Yurok Tribe Environmental Program, Klamath, California.

Asarian, E., Kann, J., and Walker, W.W. 2009. Multi-year nutrient budget dynamics for Iron Gate and Copco Reservoirs, California. Prepared by Riverbend Sciences and Kier Associates, Eureka, California, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon, and William Walker, Concord, Massachusetts for the Karuk Tribe, Department of Natural Resources, Orleans, California.

Asarian, E., Kann, J., and Walker, W.W. 2010. Klamath River nutrient loading and retention dynamics in free-flowing reaches, 2005–2008. Prepared by Kier Associates, Eureka, California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Yurok Tribe Environmental Program, Klamath, California.

Barr~~ BR~~, B.R., Koopman~~ ME~~, M.E., Williams~~ CD~~, C.D., Vynne~~ SJ~~, S.J., Hamilton, R., and Doppelt, B. 2010. Preparing for climate change in the Klamath basin. National Center for Conservation Science & Policy and The Climate Leadership Initiative. ~~http://www.geosinstitute.org/images/stories/pdfs/Publications/ClimateWise/KlamathBasinCFFReport_Final_Long_20100901.pdf. [~~Available at: http://www.geosinstitute.org/images/stories/pdfs/Publications/ClimateWise/KlamathBasinCFFReport_Final_Long_20100901.pdf. Accessed on~~ 21~~: January 21, 2011~~]~~.

Bartholow, J. 2005. Recent water temperature trends in the ~~lower~~Lower Klamath River, California. North American Journal of Fisheries Management 25: 152–162.

Bradbury, J.P., Colman, S.M., and Reynolds, R.L. 2004. The history of recent limnological changes and human impact on Upper Klamath Lake, Oregon. Journal of Paleolimnology 31: 151–161.

Borgeld~~ JC~~, J.C., Crawford ,G., Craig~~ SF~~, S.F., Morris~~ ED~~, E.D., David, B~~, and~~ ., Anderson~~ DG. 2008. 2008. California Marine Life Protection Act. Master Plan for Marine Protected Areas. California Department of Fish and Game, Sacramento, California.~~ , D.G., McGary, C., and Ozaki, V. 2007. Assessment of coastal and marine resources and watershed conditions at Redwood National and State Parks, California. Natural Resource Technical Report, NPS/NRWRD/NRTR-2007/368. National Park Service, Fort Collins, Colorado.

Bureau of Land Management (BLM). 2010. Final environmental impact statement. Vegetation treatments using herbicides on BLM lands in Oregon. Volume 2-

Appendices. FES 10-23 BLM/OR/WA/AE-10/077+1792. Prepared by BLM, Pacific Northwest Region, Portland, Oregon.

~~BLM.~~Bureau of Land Management. 2011.~~ Klamath River Gravel Placement and Bypass Barrier Removal Environmental Assessment.~~ Klamath River gravel placement and bypass barrier removal environmental assessment. Klamath Falls Resource Area, Lakeview District. August 2011.

~~CDM. 2011. Klamath settlement process, sediment interpretive report. Internal Working Draft, 2011.~~

Bureau of Reclamation (Reclamation). 2010. Revision 2. Quality assurance project plan: sediment contaminant study, Klamath River sediment sampling program, J.C. Boyle, Copco-1, Copco-2, and Iron Gate reservoirs; Klamath River Estuary. Prepared by Bureau of Reclamation, Mid-Pacific Region, Branch of Environmental Monitoring, MP-157.

_____. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River dam removal and basin restoration, Klamath River, Oregon and California~~-~~, Mid-Pacific Region. Technical Report No. SRH-2011-02. Prepared for Bureau of Reclamation, Mid-Pacific Region, Technical Service Center, Denver, Colorado.

Butche,r J. 2008. Nutrient dynamics in the Klamath. Memorandum from J. Butcher, Tetra Tech, Inc., Research Triangle Park, North Carolina to the Klamath TMDL Technical Team. February 12.

CDM. 2011. Screening-level evaluation of contaminants in sediments from three reservoirs and the estuary of the Klamath River, 2009–2011. Prepared for the U.S. Department of ~~Fish and Game, 2008.~~the Interior, Klamath River Secretarial Determination, Water Quality Sub Team, Sacramento, California~~ Marine Life Protection Act Master Plan for Marine Protected Areas. Revised Draft January 2008.~~ .

California MLPA Master Plan Science Advisory Team. 2011. Methods used to evaluate marine protected area proposals in the North Coast study region. Marine Life Protection Act Initiative, Sacramento, California.

California Resources Agency. 2010. Title 14 National Resources, Division 6 Resources Agency, Chapter 3 Guidelines for implementation of the California Environmental Quality Act. Appendix G. Environmental checklist form.

~~Chorus I~~Carlson, K., and Foster, K. 2008. Water quality monitoring during turbine venting tests at the Iron Gate Powerhouse, Klamath Hydroelectric Project. Final Report. Prepared by CH2M HILL and Mason, Bruce, and Girard for PacifiCorp Energy, Portland, Oregon.

Chorus, I., and Cavalieri, M. 2000. Cyanobacteria and algae. ~~Pages~~pp. 219–271 *in* Bartram J, and Rees G, editors. Monitoring bathing waters: a practical guide to the design and implementation of assessments and monitoring programmes. World Health Organization Report. E & FN Spon, London and New York.

Colman, S.M., Bradbury, J.P., and Rosenbaum, J.G. 2004. Paleolimnology and paleoclimate studies in Upper Klamath Lake, Oregon. Journal of Paleolimnology 31: 129–138.

Connelly, M~~,~~. and Lyons, L. 2007. Upper Sprague watershed assessment. Prepared by Klamath Basin Ecosystem Foundation, Klamath Falls, Oregon and Oregon State University Klamath Basin Research and Extensions Center with technical assistance from E&S Environmental Chemistry, Inc., Corvallis, Oregon.

Creager, C., Butcher, J., Welch, E., Wortham, G., and Roy, S. 2006. Technical approach to develop nutrient numeric endpoints for California. Prepared by Tetra Tech, Inc., Lafayette, California and Research Triangle Park, North Carolina for U.S.~~.~~ EPA, Region IX and California State Water Resource Control Board; Planning and Standards Implementation Unit.

Curran ~~KJ~~, K.J., Hill ~~PS~~, P.S., and Milligan, T.G. 2002. Fine-grained suspended sediment dynamics in the Eel River flood plume. Continental Shelf Research 22: 2,537–2,550.

Davis ~~JA~~, J.A., Melwani ~~AR~~, A.R., Bezalel ~~SN~~, S.N., Hunt ~~JA~~, J.A., Ichikawa, G., Bonnema, A., Heim ~~WA~~, W.A., Crane, D., Swensen, S., Lamerdin, C., and Stephenson, M. 2010. Contaminants in fish from California lakes and reservoirs, 2007–2008. Summary report on a two-year screening survey. Prepared for Surface Water Ambient Monitoring Program, California State Water Resources Control Board, Sacramento, California.

Deas ~~ML~~, M. 2008. Nutrient and organic matter fate and transport in the Klamath River: June to September 2007. Prepared by Watercourse Engineering, Inc., Davis, California, for PacifiCorp, Portland, Oregon.

Deas, M.L. and Orlob, G.T. 1999. Klamath River modeling project. Report No. 99-04. Prepared by Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, Water Resources Modeling Group, University of California, Davis.

~~Department of the Interior (DOI). 2010. Revision 2. Quality assurance project plan: sediment contaminant study, Klamath River sediment sampling program, J.C. Boyle, Copco-1, Copco-2, and Iron Gate reservoirs; Klamath River Estuary. Prepared by U.S. Bureau of Reclamation, Mid-Pacific Region, Branch of Environmental Monitoring, MP-157.~~

Dillon, J. 2008. Subject: Dioxin in sediments behind the dams on the Klamath River. Technical memorandum to B. Cluer, Team Leader, Scientific Support Team and S. Edmondson, Northern California Habitat Supervisor, from J. Dillon, Water Quality Program Coordinator, National Marine Fisheries Service, Southwest Region, Santa Rosa, California. ~~8~~ April 8, 2008.

Dunsmoor ~~LK~~, L.K., and Huntington, C.W. 2006, revised. Suitability of environmental conditions within upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Prepared by Klamath Tribes, Chiloquin, Oregon and Clearwater BioStudies, Inc., Canby, Oregon.

Eilers ~~JM,~~, J..M. and Gubala, C.P. 2003. Bathymetry and sediment classification of the Klamath Hydropower Project impoundments. Prepared by J. C. Headwaters, Inc. for PacifiCorp, Portland, Oregon.

Eilers, J.M., Kann, J., Cornett, J., Moser, K., and St. Amand, A. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, USA. Hydrobiologia 520: 7–18.

Falconer, I., Bartram, J., Chorus, I., Kuiper-Goodman, T., Utkilen, H., Burch, M., and Codd, G.A. 1999. "Safe levels and safe practices~~. Pages 155–177~~" *in* ~~Chorus I and Bartram J, editors.~~ Toxic cyanobacteria in water: a guide to their public health consequence~~.~~, World Health Organization Report, I. Chorus and J. Bartram, editors. pp. 155–177. E~~&~~ &FN Spon, London and New York.

Farnsworth ~~KL,~~, K.L. and Warrick, J.A. 2007. Sources, dispersal, and fate of fine sediment supplied to coastal California. U.S. Geological Survey Scientific Investigations Report 2007-5254.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for hydropower license. Klamath Hydroelectric Project (FERC Project No. 2082-027). ~~http://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp~~Available at: http://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp.

Gathard Engineering Consulting (GEC). 2006. Klamath River dam and sediment investigation. Prepared by GEC, Seattle, Washington.

Gearheart ~~RA~~, R.A., Anderson ~~JK~~, J.K., Forbes ~~MG~~,M.G., Osburn, M., and Oros, D. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon. Volumes I–III. Humboldt State University, Arcata, California.

Geyer ~~WR~~, W.R., Hill, P., Milligan, T., and Traykovski, P. 2000. The structure of the Eel River plume during floods. Continental Shelf Research 20: 2,067–2,093.

~~Greimann BP, Varyu D, Godaire J, Russell K, Lai G, and Talbot R.~~GeoEngineers. 2011. ~~Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River dam removal and basin restoration, Klamath River, Oregon and California, Mid-Pacific Region. Draft Technical Report No. SRH-2011-02.~~ Oregon background metals report, Phase 2. Task Order No. 58-08-38, File No. 2787-050-01. Prepared for ~~DOI. Bureau of Reclamation (Reclamation), Mid-Pacific Region, Technical Service Center, Denver, Colorado~~Oregon Department of Environmental Quality, Portland, Oregon.

Gray, J.R., Glysson ,G.D., Turcios, L.M., and Schwarz, G.E. 2000. Comparability of suspended-sediment concentration and total suspended solids data. Water Resources Investigations Report 00-4191.U. S. Geological Survey, Reston, Virginia. Available at: http://water.usgs.gov/pubs/wri/wri004191.

Griggs GB, G.B., and JR Hein, J.R. 1980. Sources, dispersal, and clay mineral composition of fine-grained sediment off central and northern California. Journal of Geology 88: 541 – 566.

Hamilton, J.G., Rondorf, D., Hampton, M., Quinones, R., Simondet, J., and Smith, T. 2011. Synthesis of the effects to fish species of two management scenarios for the Secretarial Determination on removal of the lower four dams on the Klamath River. Prepared by the Biological Subgroup for the Secretarial Determination regarding potential removal of the lower four dams on the Klamath River.

Hiner, M. 2006. Seasonal water quality in the Klamath River estuary and surrounding sloughs, 2001–2003.

Hoopa Valley Tribe Environmental Protection Agency (HVTEPA). 2008. Water quality control plan Hoopa Valley Indian Reservation. Approved 11 September 11, 2002, Amendments Approved 14 February 14, 2008. Hoopa Valley Tribal Environmental Protection Agency, Hoopa, California.

Horne, A., and Goldman, C. 1994. Limnology. McGraw-Hill, New York.

Huang JV, J.V., and B Greimann, B. 2010. User's manual for SRH-1D V2.6. Sedimentation and river hydraulics-one dimension. DOI. Bureau of Reclamation (Reclamation), Technical Service Center, Sedimentation and River Hydraulics Group, Denver, Colorado.

Kann, J. 1993. Chapter 3: limnological trends in Agency Lake, Oregon-1992. Pagespp. 91–98 *in* Campbell S.G., editor. Environmental research in the Klamath Basin, Oregon, 1992 Annual Report R-93-16. Applied Sciences Branch, Research and Laboratory Services Division, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Kann, J. 2006. *Microcystis aeruginosa* occurrence in the Klamath River system of southern Oregon and northern California. Technical Memorandum.

Kann, J. 2008. Microcystin bioaccumulation in Klamath River fish and freshwater mussel tissue: preliminary 2007 results. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Karuk Tribe of California, Orleans, California.

Kann, J. 2010. Compilation of Klamath Tribes upper Klamath Lake water quality data, 1990–2009. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Klamath Tribes Natural Resources Department, Chiloquin, Oregon.

Kann, J., and Corum, S. 2009. Toxigenic *Microcystis aeruginosa* bloom dynamics and cell density/chlorophyll a relationships with microcystin toxin in the Klamath River, 2005–2008. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

Kann, J., and Walker, W.W. 1999. Nutrient and hydrologic loading to Upper Klamath Lake, Oregon, 1991–1998. Draft Report. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Klamath Tribes Natural Resources Department, ~~U.S.~~ Bureau of Reclamation Cooperative Studies.

Kann, J., Corum, S., and Fetcho, K. 2010. Microcystin ~~Bioaccumulation~~ bioaccumulation in Klamath River ~~Freshwater Mussel Tissue:~~freshwater mussel tissue: 2009 ~~Results.~~results. Prepared by Aquatic Ecosystem Sciences, LLC~~.~~, the Karuk Tribe Natural Resources Department, and the Yurok Tribe Environmental Program~~:23 pp. + appendices~~.

Kann, J., Bowater, L., Johnson, G., and Bowman, C. 2011. Preliminary 2010 microcystin bioaccumulation results for Klamath River salmonids. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences LLC for the Karuk Tribe Department of Natural Resources, Orleans California.

Karuk Tribe of California. 2001. Karuk aboriginal territories Indian Creek and Elk Creek water quality monitoring report for the fall 2000 monitoring period. Prepared by the Karuk Tribe of California, Department of Natural Resources, Orleans, California.

Karuk Tribe of California. 2002. Water quality monitoring report, Water Year 2000 and 2001. Karuk Tribe of California, Water Resources, Department of Natural Resources, Orleans, California.

Karuk Tribe of California. 2003. Water quality monitoring report, Water Year 2002. Karuk Tribe of California, Water Resources, Department of Natural Resources, Orleans, California.

Karuk Tribe of California. 2007. 2007 Water quality assessment report for Klamath River, Salmon River, Scott River, Shasta River, Ti-Bar Creek, and Irving Creek. Prepared by Karuk Tribe of California, Water Resources, Department of Natural Resources, Orleans, California.

Karuk Tribe of California. 2009. 2008 Water quality assessment report for Klamath River, Salmon River, Scott River, Shasta River, and Bluff Creek. Prepared by Karuk

Tribe of California, Water Quality, Department of Natural Resources, Orleans, California.

Karuk Tribe of California. 2010. Water quality report for the mid-Klamath, Salmon, Scott, and Shasta rivers: May–December 2009. Prepared by Karuk Tribe of California, Water Quality Program, Department of Natural Resources, Orleans, California.

Kirk, S., Turner, D., and Crown, J. 2010. Upper Klamath and Lost River sub-basins total maximum daily load (TMDL) and water quality management plan (WQMP). Oregon Department of Environmental Quality, Bend, Oregon.

Klasing, S~~,~~. and Brodberg, R. 2008. Development of fish contaminant goals and advisory tissue levels for common contaminants in California sport fish: chlordane, DDTs, dieldrin, methylmercury, PCBs selenium, and toxaphene.~~–~~ Prepared by Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Lopez, C.B., Jewett, E.B., Dortch, Q., Walton, B.T., and Hudnell, H.K. 2008. Scientific assessment of freshwater harmful algal blooms. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology, Washington, DC.

Lynch, D.D. 2011. ~~Feasibility of Mechanical Sediment Removal (In Progress)~~Subject: Infeasibility of the mechanical removal of reservoir bottom sediments if Klamath River dams are removed in 2020. Memorandum to the Record from Dennis D. Lynch, Program Manager, Klamath Secretarial Determination.

MacDonald, L.H. 1994. Developing a monitoring project. Journal of Soil and Water Conservation May–June: 221–227. ~~Available at: http://wvlc.uwaterloo.ca/biology447/modules/module1/1g_t3.htm~~Available at: http://wvlc.uwaterloo.ca/biology447/modules/module1/1g_t3.htm.

Mauser, D., and Mayer, T. 2010. Effects of the Klamath Basin restoration agreement on Lower Klamath, Tule Lake, and Upper Klamath national wildlife refuges. U.S. Fish and Wildlife Service, Tulelake, California.

Miller, M.A., Kudela ~~RM~~, R.M., Mekebri, A., Crane, D., Oates ~~SC, and~~ , S.C., et al. 2010. Evidence for a novel marine harmful algal bloom: cyanotoxin (microcystin) transfer from land to sea otters. PLoS ONE 5: e12576. doi:10.1371/journal.pone.0012576.

McGary ,C., and Ozaki, V. 2007. Assessment of coastal and marine resources and watershed conditions at Redwood National and State Parks, California. Natural Resource Technical Report NPS/NRWRD/NRTR-2007/368. National Park Service, Fort Collins, Colorado.

Mulder T, and Syvitski JPM. 1995. Turbidity currents generated at river mouths during exceptional discharges to the world oceans. Journal of Geology 103: 285–299.

~~NOAA Fisheries (NOAA Fisheries - National Marine Fisheries Service).~~Mulholland, P.J. 1996. "Role in nutrient cycling in streams" *in* Algal ecology-freshwater benthic ecosystems. J.R. Stevenson, M.L. Bothwell, and R.L. Lowe, editors. pp. 609–639. Academic Press, Inc., San Diego, California.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Services. 2010. Biological opinion for the operation of the Klamath Project between 2010 and 2018. File Number 151422SWR2008AR00148. Consultation conducted by NOAA Fisheries - National Marine Fisheries Service, Southwest Region.

~~NRC (~~National Research Council~~). 2003.~~ (NRC). 2004. Endangered and threatened fishes in the Klamath Basin~~,~~: causes of decline and strategies for recovery.~~ Prepared by the Committee on Endangered and Threatened Fishes in the Klamath Basin, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council of the National Academies.~~ The National Academies Press, Washington, D~~.~~C. Available at: http://www.nap.edu/openbook.php?isbn+0309090970.

North Coast Regional Water Quality Control Board (NCRWQCB). 2005. Salmon River, Siskiyou County, California total maximum daily load for temperature and implementation plan. NCRWQCB Resolution No. R1-2005-0058. NCRWQCB, Santa Rosa, California.

North Coast Regional Water Quality Control Board. 2006~~a. Water Quality Control Plan for the North Coast region (Basin Plan). Santa Rosa, California.~~

~~North Coast Regional Water Quality Control Board. 2006b~~. Staff report for the action plan for the Shasta River watershed temperature and dissolved oxygen total maximum daily loads. Santa Rosa, California.

North Coast Regional Water Quality Control Board. 2007. ~~Scott River total maximum daily load implementation workplan.~~ Shasta River dissolved oxygen and temperature TMDL implementation actions. Draft Workplan. Prepared by NCRWQCB~~, Santa Rosa, California. http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/scott_river/ [Accessed on~~. September 26, 2007. Available at: http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/shasta_river/070320/070320_shasta_workplan_draft.pdf. Accessed September 2010~~]~~.

North Coast Regional Water Quality Control Board. 2008. Surface water ambient monitoring program (SWAMP) summary report for the North Coast Region (RWQCB-1) for years 2000–2006. Prepared by North Coast Regional Water Quality Control Board, Santa Rosa, California.

North Coast Regional Water Quality Control Board. 2010a. Klamath River total maximum daily loads (TMDLs) addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in California, the proposed site specific dissolved oxygen objectives for the Klamath River in California, and the Klamath River and Lost River implementation plans. Final Staff Report. North Coast Regional Water Quality Control Board, Santa Rosa, California.

North Coast Regional Water Quality Control Board. 2010b. USEPA Region 9 review of the TMDLs for the Klamath River in California addressing nutrients, temperature, organic enrichment/low dissolved oxygen.

North Coast Regional Water Quality Control Board. 2011. Water Quality Control Plan for the North Coast region (Basin Plan). Santa Rosa, California.

Oregon Climate Change Research Institute. 2010. Oregon climate assessment report. K.D. Dello ~~KD,~~ and P.W. Mote ~~PW,~~ editors. College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon. ~~www.occri.net/OCAR~~Available at: http://www.occri.net/OCAR.

Oregon ~~DEQ.~~Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake drainage total maximum daily load (TMDL) and water quality management plan (WQMP). Portland, Oregon.

Oregon ~~DEQ.~~Department of Environmental Quality. 2004. Water quality program rules, Division 041: water quality standards. Water temperature criteria tables and figures. Adopted by the Oregon Environmental Quality Commission and approved by the U.S~~.~~ . Environmental Protection Agency. Oregon Department of Environmental Quality, Portland, Oregon. ~~http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm~~Available at: http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm.

Oregon ~~DEQ.~~Department of Environmental Quality. 2007. Guidance for assessing bioaccumulative chemicals of concern in sediment. Final Report, 07-LQ-023A. Prepared by Oregon Department of Environmental Quality, Environmental Cleanup Program, Portland, Oregon.

Oregon Department of Environmental Quality. 2011. ODEQ harmful algal bloom (HAB) strategy. Prepared by Oregon Department of Environmental Quality, Portland, Oregon.

O'Meara, S., Greimann, B., Godaire, J., Cluer, B., and Snyder, R. 2010. Reservoir area management plan for the secretary's determination on Klamath River Dam removal and basin restoration, Klamath River, Oregon and California. Draft Report. Prepared by Bureau of Reclamation, NOAA Fisheries -National Marine Fisheries Service, and Bureau of Land Management.

PacifiCorp. 2004a. Water resources for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Prepared by PacifiCorp, Portland, Oregon.

PacifiCorp. 2004b. Analysis of potential Klamath Hydroelectric Project effects on water quality aesthetics for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Prepared by PacifiCorp, Portland, Oregon.

PacifiCorp. 2004c. Screening level determination of chemical contaminants in fish tissue in selected KHP reservoirs for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Prepared by PacifiCorp, Portland, Oregon.

PacifiCorp. 2005. Response to FERC AIR AR-2, anadromous fish restoration for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report, with figures. Portland, Oregon.

PacifiCorp. 2006a. Causes and effects of nutrient conditions in the upper Klamath River for the Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon.

PacifiCorp. 2006b. PacifiCorp positions on important topics, Klamath Hydroelectric Project No. 2082. PacifiCorp, Portland, Oregon.

PacifiCorp. 2008. 2008 Iron Gate turbine venting study of dissolved oxygen improvement. PacifiCorp, Portland, Oregon.

PacifiCorp. 2009. Final datasonde data from below Iron Gate Dam. Water quality preliminary raw data collected with a YSI 6600 Datasonde on the Klamath River downstream ~~of~~ from Iron Gate Dam (RM 189.7) from January 16, 2009 through December 31, 2009. Collected by PacifiCorp, Portland, Oregon. ~~http://www.pacificorp.com/es/hydro/hl/kr.html# [~~Available at: http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Klamath_River/YSIData2009FINAL.xls. Accessed on ~~12 December 2010].~~September 18, 2012.

PacifiCorp. 2011. PacifiCorp Klamath Hydroelectric Project Interim operations habitat conservation plan for coho salmon. Prepared by PacifiCorp Energy, Inc., Portland, Oregon submitted to the National Marine Fisheries Service, Arcata Area Office, Arcata, California.

Perry, R.W., Risley ~~JC~~, J.C., Brewer ~~SJ~~, S.J., Jones ~~EC~~, E.C., and Rondorf, D.W. 2011. Simulating water temperature of the Klamath River under dam removal and climate change scenarios. U.S. Geological Survey Open File Report 2011-~~XXXX.~~1243. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.

Pullen, J.D~~.~~., and ~~J.S.~~ Allen ,J.S. 2000. Modeling studies of the coastal circulation off Northern California: shelf response to a major Eel ~~river Food~~River flood event. Continental Shelf Research 20:~~2213-2~~ 2,213–2,238

Rabe, A., and Calonje, C. 2009. Lower Sprague-lower Williamson watershed assessment. Prepared by Rabe Consulting, with maps and figures by E&S Environmental Chemistry, Inc., Corvallis, Oregon.

Raymond, R. 2008. Water quality conditions during 2007 in the vicinity of the Klamath Hydroelectric Project. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon for PacifiCorp Energy, Portland, Oregon.

Raymond, R. 2009. Water quality conditions during 2008 in the vicinity of the Klamath Hydroelectric Project. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon for ~~CH2M~~CH2M Hill, Portland, Oregon and PacifiCorp Energy, Portland, Oregon.

Raymond, R. 2010. Water quality conditions during 2009 in the vicinity of the Klamath Hydroelectric Project. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon for PacifiCorp Energy, Portland, Oregon.

Regional Sediment Evaluation Team (RSET). 2009. Sediment evaluation framework for the Pacific Northwest. Prepared by Regional Sediment Evaluation Team: U.S. Army Corps Of Engineers-Portland District, Seattle District, Walla Walla District, and Northwestern Division; U.S. Environmental Protection Agency, Region 10; Washington Department of Ecology; Washington Department of Natural Resources; Oregon

Department of Environmental Quality; Idaho Department of Environmental Quality; National Marine Fisheries Service; and U.S. Fish and Wildlife Service.

Risley, J.C. 2010. Watershed scale response to climate change: Sprague River basin, Oregon. ABSTRACT. Restoration: Principles, Practices, and Case Studies 1. Klamath Basin Science Conference, Medford, Oregon. 1–5 February 2010.

Scheiff, T., and Zedonis, P. 2011. The influence of Lewiston Dam releases on water temperatures of the Trinity and Klamath rivers, California. April to October, 2010. Arcata Fisheries Data Series Report Number DS 2011-22. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Shannon & Wilson, Inc. 2006. Sediment sampling, geotechnical testing and data review report: segment of Klamath River, Oregon and California. Prepared by Shannon & Wilson, Inc., Seattle, Washington for California Coastal Conservancy, Oakland, California.

Sinnott, S. 2007. 2007 Klamath River nutrient summary report. Final Report. Prepared by the Yurok Tribe Environmental Program, Water Division, Klamath, California.

Sinnot,t S. 2010. 2009 Klamath River datasonde report. Final Report. Prepared by Yurok Tribe Environmental Program, Klamath, California.

Sinnott, S. 2011. 2010 Klamath River nutrient summary report. Final Report. Prepared by Yurok Tribe Environmental Program, Water Division, Klamath, California.

Smith, D. 2012. Written communication to C. Anderson, USGS, Portland, Oregon, from D. Smith, USGS, Denver, Colorado. June 25, 2012.

Smith, D.B., Woodruff, L.G., O'Leary, R.M., Cannon, W.F., Garrett, R.G., Kilburn, J.E., and Goldhaber, M.B. 2009. Pilot studies for the North American soil geochemical landscapes project - site selection, sampling protocols, analytical methods, and quality control protocols. Applied Geochemistry 24: 1,357–1,368.

Snyder~~ DT~~, D.T., and Morace, J.L. 1997. Nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath and Agency Lakes, Oregon. Water-Resources Investigations Report 97-4059. U.S. Department of the Interior, U.S. Geological Survey, Denver, Colorado in cooperation with the Bureau of Reclamation.

State Water Resources Control Board (SWRCB). 2001. California ocean plan; water quality control plan, ocean waters of California. Sacramento, California.

~~SWRCB~~State Water Resources Control Board, California Department of Public Health and Office of Environmental Health and Hazard Assessment (SWRCB et al.). 2010. Cyanobacteria in California recreational water bodies: providing voluntary guidance about harmful algal blooms, their monitoring, and public notification. Blue Green Algae

Work Group of the State Water Resources Control Board, the California Department of Public Health, and Office of Environmental Health and Hazard Assessment.

Stillwater Sciences. 2008. Klamath River dam removal study: sediment transport DREAM-1 simulation. Technical Report. Prepared by Stillwater Sciences, Arcata, California for California Coastal Conservancy, Oakland, California.

Stillwater Sciences. 2009. Dam removal and Klamath River water quality: a synthesis of the current conceptual understanding and an assessment of data gaps. Technical Report. Prepared by Stillwater Sciences, Berkeley, California for State Coastal Conservancy, Oakland, California.

Stillwater Sciences. 2010. Anticipated sediment release from Klamath River dam removal within the context of basin sediment delivery. Final Report. Prepared by Stillwater Sciences, Berkeley, California for State Coastal Conservancy, Oakland, California.

Stillwater Sciences. 2011. Model development and estimation of short-term impacts of dam removal on dissolved oxygen in the Klamath River. Final Report. Prepared by Stillwater Sciences, Berkeley, California for the U.S. Department of the Interior, Klamath Dam Removal Water Quality Subteam, Klamath River Secretarial Determination.

Streeter ~~HW~~, H.W., and Phelps, E.B. 1925. Study of the pollution and natural purification of the Ohio River. Public Health Bulletin No. 146 (reprinted 1958). U.S. Public Health Service, Washington, D~~.~~C.

~~Sullivan AB, Deas ML, Asbill J, Kirshtein JD, Butler K, Stewart MA, Wellman RE, and Vaughn J. 2008. Klamath River water quality and acoustic doppler current profiler data from Link River Dam to Keno Dam, 2007. Open-File Report 2008-1185. Prepared by U.S. Department of Interior, U.S. Geological Survey, Reston, Virginia in cooperation with the Bureau of Reclamation.~~

~~Sullivan AB, Deas ML, Asbill J, Kirshtein JD, Butler K, and Vaughn J. 2009. Klamath River water quality data from Link River Dam to Keno Dam, Oregon, 2008. U.S. Geological Survey Open File Report 2009-1105. Prepared by the U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.~~

~~Sullivan AB, Snyder DM, and Rounds SA. 2010. Controls on biochemical oxygen demand in the upper Klamath River, Oregon. Chemical Geology 269: 12–21.~~

~~Sturdevant D.~~Sturdevan, D. 2010. Water quality standards review and recommendations: arsenic, iron, and manganese. Draft Report. Prepared by O~~regon~~ DEQ, Water Quality Standards Program, Portland, Oregon.

Sullivan, A.B., Deas, M.L., Asbill, J., Kirshtein, J.D., Butler, K., Stewart, M.A., Wellman, R.E., and Vaughn, J. 2008. Klamath River water quality and acoustic doppler

current profiler data from Link River Dam to Keno Dam, 2007. Open-File Report 2008-1185. Prepared by U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia in cooperation with the Bureau of Reclamation.

Sullivan, A.B., Deas, M.L., Asbill, J., Kirshtein, J.D., Butler, K., and Vaughn, J. 2009. Klamath River water quality data from Link River Dam to Keno Dam, Oregon, 2008. U.S. Geological Survey Open File Report 2009-1105. Prepared by the U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.

Sullivan, A.B., Snyder, D.M., and Rounds, S.A. 2010. Controls on biochemical oxygen demand in the upper Klamath River, Oregon. Chemical Geology 269: 12–21.

Sullivan, A.B., Rounds, S.A., Deas, M.L., Asbill, J.R., Wellman, R.E., Stewart, M.A., Johnston, M.W., and Sogutlugil, I.E. 2011. Modeling hydrodynamics, water temperature, and water quality in the Klamath River upstream of Keno Dam, Oregon, 2006-09. Scientific Investigations Report 2011-5105. Prepared by U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia in cooperation with the Bureau of Reclamation.

Tetra Tech, Inc. 2008. Nutrient ~~Numeric Endpoint Analysis~~numeric endpoint analysis for the Klamath River, California. Prepared by Tetra Tech, Inc., for the U.S. Environmental Protection Agency Region 9 and Region 10, North Coast Regional Water Quality Control Board, and Oregon Department of Environmental Quality.

Tetra Tech, Inc. 2009.~~–~~ Model configuration and results: Klamath River model for TMDL development.~~–~~ Prepared by Tetra Tech, Inc., for the U.S. Environmental Protection Agency Region 9 and Region 10, North Coast Regional Water Quality Control Board, and Oregon Department of Environmental Quality.

U.S~~.~~ Environmental Protection Agency (USEPA). 1978. National eutrophication survey. Report on Iron Gate Reservoir, Siskiyou County, California. EPA Region 9. Working Paper No. 749.

U.S. Environmental Protection Agency. 1986. Ambient water quality criteria for dissolved oxygen. Office of Water, EPA 440/5-86-003.

U.S. Environmental Protection Agency. 1987. The enhanced stream water quality models QUAL2E and QUAL2E-UNCAS.

U.S. Environmental Protection Agency. 1991. Risk assessment guidance for Superfund. Volume I: human health evaluation manual (Part B, development of risk-based preliminary remediation goals). Interim Report, EPA/540/R-92/003. USEPA, Office of Solid Waste and Emergency Response, Washington, D~~.~~C.

U.S. Environmental Protection Agency. 1998. South Fork Trinity River and Hayfork Creek sediment total maximum daily loads. EPA, Region 9. ~~http://www.epa.gov/region9/water/tmdl/trinityso/fsftmdl.pdf [Accessed on September 2010].~~October 11, 2010. Available at: http://www.epa.gov/region9/water/tmdl/trinityso/fsftmdl.pdf.

U.~~-~~S. Environmental Protection Agency. 2000. National guidance: guidance for assessing chemical contaminant data for use in fish advisories. Volume 2: risk assessment and fish consumption limits. Third edition. EPA 823-B-00-008. Office of Science and Technology, Office of Water, USEPA, Washington, D~~.~~C.

U.S. Environmental Protection Agency. 2001. Trinity River total maximum daily load for sediment. EPA, Region 9. ~~http://www.epa.gov/region9/water/tmdl/trinity/finaltrinitytmdl.pdf [Accessed on~~

~~September 2010].~~October 11, 2010. Available at: http://www.epa.gov/region9/water/tmdl/trinity/finaltrinitytmdl.pdf.

U.S. Environmental Protection Agency. 2008. Lost River, California total maximum daily loads; nitrogen and biochemical oxygen demand to address dissolved oxygen and pH impairments. Final Report. U.S. Environmental Protection Agency, Region IX.

U.S. Environmental Protection Agency. 2010a. Review of California's 2008–2010 Section 303(d) list. Enclosure to letter from Alexis Strauss, U.S. Environmental Protection Agency, Region IX, San Francisco, California to Thomas Howard, State Water Resources Control Board, Sacramento, California. ~~11~~ October 11, 2010.

U.S. Environmental Protection Agency. 2010b. Subject: ~~compilation~~Compilation and discussion of sediment quality values for dioxin, and their relevance to potential removal of dams on the Klamath River. Memorandum from B. Ross, Region 9 Dredging and Sediment Management Team and E. Hoffman, Region 10 Environmental Review and Sediment Management Unit, USEPA, San Francisco, California to D. Lynch, USGS, ~~-~~and R.~~-~~ Graham, ~~USBR~~Bureau of Reclamation.

U.S. Environmental Protection Agency. 2011. Subject: Draft Environmental Assessment: authorization for incidental take and implementation of the PacifiCorp Klamath Hydroelectric Project interim operations habitat conservation plan for coho salmon. Letter to L. Roberts, Fisheries Biologist, National Marine Fisheries Service, Northern California Office, Arcata, California from K.M. Goforth, Manager, Environmental Review Office, Communities and Ecosystems Division, USEPA, Region IX, San Francisco, California.

U.S. Fish and Wildlife Service (USFWS). 2008. ~~Corrected Sonde database. http://www.fws.gov/arcata/fisheries/activities/waterQuality/klamathWQ_reports.html [Accessed on July 2008]~~Formal consultation on the Bureau of Reclamation's proposed Klamath project operations from 2008 to 2018. April 2, 2008.

VanderKooi~~-SP~~, S.P., Burdick~~-SM~~, S.M., Echols~~-KR~~, K.R., Ottinger ~~CA~~,C.A., Rosen ~~BH~~, B.H., and Wood~~-TM.~~, T.M. 2010. Algal toxins in upper Klamath Lake, Oregon: ~~Linking~~ linking water quality to juvenile sucker health. U.S. Geological Survey Fact Sheet 2009-3111. U.S. Geological Survey, Western Fisheries Research Center, Seattle, Washington. Available at: http://pubs.usgs.gov/fs/2009/3111/pdf/fs20093111.pdf.

Wallace, M. 1998. Seasonal water quality monitoring in the Klamath River estuary, 1991–1994. Administrative Report No. 98-9. California Department of Fish and Game, Inland Fisheries, Arcata, California.

Walker, W.W. 2001. Development of phosphorus TMDL for Upper Klamath Lake, Oregon. Prepared for Oregon Department of Environmental Quality, Bend, Oregon.

Ward, G., and Armstrong, N. 2010. Assessment of primary production and associated kinetic parameters in the Klamath River. Draft Report. Prepared for the USFWS, Arcata Fish and Wildlife Office, Arcata, California.

Watercourse Engineering, Inc. 2011. Klamath River baseline water quality sampling, 2009 Annual Report. Prepared for the KHSA Water Quality Monitoring Group.

Wheatcroft ~~RA~~, R.A., Sommerfield ~~CK~~, C.K., Drake ~~DE~~,D.E., Borgeld ~~JC~~,J.C., and Nittrouer, C.A. 1997. Rapid and widespread dispersal of flood sediment on the northern California margin. Geology 25: 163–166.

Wong, S., Barry, M., Aldous, A., Rudd ,N., Hendrixson, H., and Doehring, C. 2011. Nutrient release from a recently flooded delta wetland: comparison of field measurements to laboratory results. Wetlands 31: 433–443.

World Health Organization (WHO). 1999. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring an-d management. E & FN Spon, London, England.

Yurok Tribe Environmental Program (YTEP). 2005. Water year 2004 (WY04) report, ~~1~~ October 1, 2003–~~30~~ September 30, 2004. Final Report. Prepared by Yurok Tribe Environmental Program, Klamath, California.

3.3 Aquatic Resources

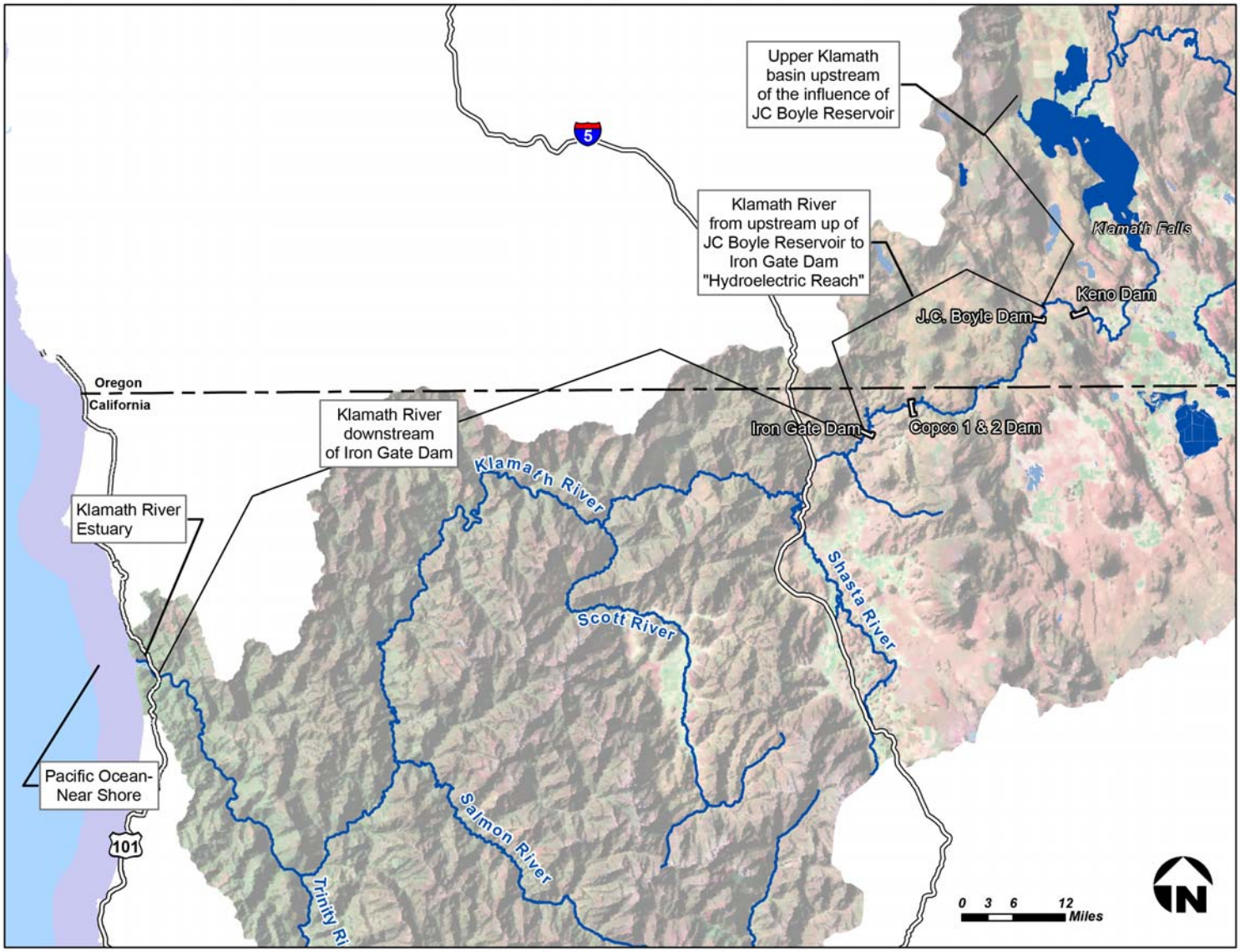
This section describes the effects that the Proposed Action and alternatives would have on aquatic resources, and specifically fish, freshwater mussels, and aquatic macroinvertebrates.

3.3.1 Areas of Analysis

This section of the Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) analyzes impacts on fish populations, fish species recovery, and changes to habitat in the Klamath River watershed, excluding the Lost River watershed, Tule Lake watershed, and most of the Trinity River. However, because the lower quarter-to-half mile of the Trinity River could be used as a refuge by Klamath River fish attempting to avoid exposure to sediment pulses that would result from dam removal, this use of the Trinity River was considered in the analysis.

The Lead Agencies assessed potential impacts within and across five study reaches of the Klamath Basin separated by changes in physiography (e.g., Upper and Lower Klamath Basins), the presence of Klamath Hydroelectric Project facilities, and degree of marine influence (~~Figure 3.3-1~~Figure 3.3-1). The five study reaches ~~with~~within the area of analysis are as follows:

1. Upper Klamath River: upstream of the influence of J.C. Boyle Reservoir, including the following:
   a. Upper Klamath Lake, Agency Lake, Keno Impoundment/Lake Ewauna, and Tule Lake
   b. Tributaries to Upper Klamath Lake (~~Sycan~~Sprague, Wood, and Williamson ~~Rivers~~rivers)
   c. Bureau of Reclamation (Reclamation) Klamath Project facilities (e.g., Link River Dam)
2. Hydroelectric Reach: from the upstream end of J.C. Boyle Reservoir to Iron Gate Dam, including the following:
   a. Tributaries to the Klamath River (examples include Jenny, Spencer, ~~Slate,~~ Shovel, and Fall Creeks)
   b. J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs
   c. J.C. Boyle Bypass and Peaking Reaches
   ~~d. Klamath downstream of the~~ Copco 2 ~~tailrace~~
   d. Bypass Channel
3. Lower Klamath River: downstream ~~of~~from Iron Gate Dam, including the following:
   a. Major tributaries to the Klamath River (Shasta, Scott, and Salmon Rivers)
   b. Minor tributaries to the Klamath River (examples include Bogus, Beaver, Humbug, and Cottonwood Creeks)
   c. The lower portion of the Trinity River
4. Klamath River estuary
5. Pacific Ocean nearshore environment


Upper Klamath basin upstream of the influence of JC Boyle Reservoir
Klamath River from upstream up of JC Boyle Reservoir to Iron Gate Dam "Hydroelectric Reach"
Klamath Falls
Keno Dam
J.C. Boyle Dam
Oregon
California
Klamath River downstream of Iron Gate Dam
Iron Gate Dam
Copco 1 & 2 Dam
Klamath River
Klamath River Estuary
Shasta River
Scott River
Pacific Ocean-Near Shore
Salmon River
Trinity Ri
5
101
0 3 6 12 Miles
N

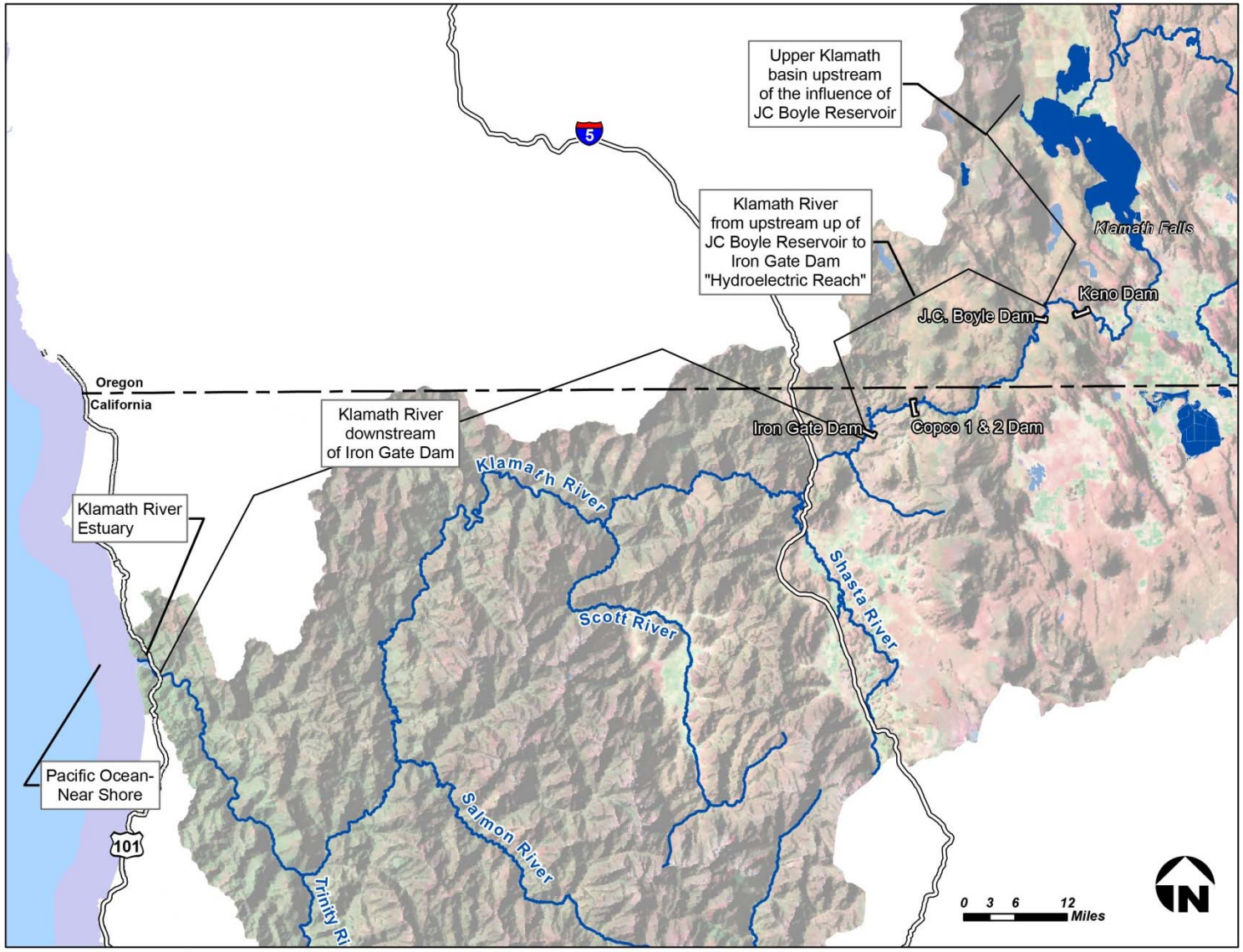


Figure 3.3--1. Five Study Reaches within the Area of Analysis for the Aquatic Resources Analysis.

INTERNAL WORKING DOCUMENT - NOT FOR DISTRIBUTION

The Klamath Basin has traditionally been divided into the Upper and Lower Klamath Basins at Iron Gate Dam (Natural Resources Council [NRC] 2004, 2008). For purposes of this evaluation, the Upper Basin was subdivided into two reaches at the upstream influence of J.C. Boyle Reservoir. The area upstream of the influence of J.C. Boyle Reservoir could experience some changes in flow in riverine reaches or water surface elevation in lakes and reservoirs due to changes in Reclamation's Klamath Project operations under some of the alternatives, but the physical structure of the habitat would remain similar to existing conditions (with the exception of habitat restoration efforts described for some alternatives). The Hydroelectric Reach encompasses the four dams proposed for removal. Under several of the alternatives, the physical structure of some or all reservoir habitat within the Hydroelectric Reach would be changed from lacustrine (lake) to riverine habitat. The Lower Klamath River: downstream ~~of~~from Iron Gate Dam corresponds to the traditional "Lower Basin" designation.

3.3.2 Regulatory Framework

Aquatic species within the area of analysis are regulated by several ~~federal~~ Federal and ~~state~~State laws and regulations, which are listed below.

3.3.2.1 Federal Authorities and Regulations

- Federal Endangered Species Act
- Fish and Wildlife Coordination Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Wild and Scenic Rivers Act
- Federal Power Act
- Coastal Zone Management Act

3.3.2.2 State Authorities and Regulations

- California Endangered Species Act
- California Fish and Game Code
- Oregon Endangered Species Act
- Oregon Removal-Fill Law
- Oregon Statewide Planning Program
- Oregon Threatened and Endangered Species
- Oregon Wildlife and Commercial Fishing Codes
- Oregon Fish Passage Law
- Oregon Screening and By Pass Devices Law
- Oregon Klamath River Basin Fish Management Plan
- Oregon Native Fish Conservation Policy
- Oregon Fish and Wildlife Habitat Mitigation Policy
- Oregon Klamath River Basin Anadromous Re-Introduction Plan
- Oregon - Reauthorization of Hydroelectric Projects.
- Oregon Wildlife Policy

3.3.2.3 Local Authorities and Regulations

- Klamath Act

The regulation and protection of water quality as related toincluding beneficial uses andfor aquatic species is discussed in Section 3.2, Water Quality.

3.3.3 Existing Conditions/Affected Environment

This section describes existing conditions in the area of analysis, including discussion of aquatic species (Section 3.3.3.1); physical habitat, water bodies within the different regions for the analysis (Section 3.3.3.2); and important factors affecting aquatic resources that the Lead Agencies anticipate would likely change if the Proposed Action or the alternatives are implemented (Section 3.3.3.3).

The species descriptions include a brief account of the current and historical distribution, life-history patterns, and habitat requirements of aquatic species. This section is subdivided into anadromous fish, native riverine fish, introduced species, estuarine species, and listed species. The last category includes species that would otherwise be included in the anadromous, riverine, or estuarine species.

The description of physical habitat provides information on the physical structure of the habitat. It contains a brief description of the water quality and other factors that may limit fish production in those water bodies, and describes the species that occur in these water bodies. This section also describes Federal Endangered Species Act (ESA) critical habitat and Magnuson-Stevens Fishery Conservation Management Act Essential Fish Habitat (EFH) occurring within the area of analysis.

Section 3.3.3.3, *FactorsHabitat Attributes Expected to be Affected by the Project*, provides a more detailed description of existing conditions for factors that are thought to have a major influence on aquatic resources. These factors form the basis for the effects evaluation in Section 3.3.4.

3.3.3.1 Aquatic Species

3.3.3.1.1 Fish

Numerous fish species use the Klamath Basin during all or some portion of their lives, including salmonids, lamprey, sturgeon, suckers, minnows, and sculpin. Many other species are present in the estuary. Species that have been introduced into the basinBasin include non-native yellow perch, largemouth bass, spotted bass, sunfish, and catfish. The species include introduced resident species, estuarine species, and species listed under the federalFederal or stateState ESAs. The number of species prohibits evaluation of each species. To address the impacts and benefits of the Proposed Action, target species have been selected for analysis based on their legal status or importance for tribal, commercial or recreational fisheries, and based on adequate data to conduct analysis. These target species are discussed below.

Anadromous Fish Species

~~The Klamath Basin provides habitat for many species of anadromous fish, many of which are salmonids, but which also include green sturgeon (*Acipenser medirostris* Ayres), Pacific lamprey, and American shad (non-native). Anadromous fish within the Klamath River watershed are nearly all in decline (Table 3.3-1). Green sturgeon appear to be in less decline than other fish species. Van Eenennaam et al. (2006) carefully suggests that the Klamath River green sturgeon population appears strong and stable, while cautioning against conclusions based on short time frames relative to their life history.~~

~~**Table 3.3-1. Declines in Klamath River Anadromous Fish**~~

~~Species~~	~~Historical Level~~	~~Percent Reduction from Historical Levels (estimates of individual runs)~~	~~Source~~
~~Pacific Lamprey~~	~~Unknown~~	~~98% (Represents reduction in tribal catch per effort)~~	~~Petersen Lewis 2009~~
~~Steelhead~~	~~400,000[1]~~	~~67% (130,000)~~	~~Leidy and Leidy 1984; Busby et al. 1994~~
~~Coho salmon~~	~~15,400-20,000~~	~~52% to 95% (760 to 9,550)~~	~~Moyle et al. 1995; Ackerman et al. 2006~~
~~Fall-run Chinook salmon~~	~~500,000[3]~~	~~92% to 96% (20,000-40,000)~~	~~Moyle 2002~~
~~Shasta River Chinook salmon[4]~~	~~20,000-80,000~~	~~88% to 95% (A few hundred to a few thousand)~~	~~Moyle 2002~~
~~Spring-run Chinook salmon~~	~~100,000~~	~~98% (2,000)[2]~~	~~Moyle 2002~~

~~This estimate is~~The Klamath Basin provides habitat for many species of anadromous fish, many of which are salmonids, but which also include green sturgeon (*Acipenser medirostris* Ayres), Pacific lamprey, and American shad (non-native). Anadromous fish within the Klamath River watershed have nearly all declined compared to their historical abundance (Table 3.3-1). Although historical data are not available, green sturgeon appear to be in less decline than other fish species. Van Eenennaam et al. (2006) carefully suggests that based on reports of sturgeon captures during Yurok Tribal Chinook salmon gill-net fishery, the Klamath River green sturgeon population appears strong and stable, while cautioning against conclusions based on short time frames relative to their life history.

Table 3.3-1. Declines in Klamath River Anadromous Fish

Species	Historical run estimate	Reduction from historical numbers	Current run estimate	Source
Pacific lamprey	Unknown	98% (percent reduction in tribal catch per effort)	Unknown	Petersen Lewis 2009
Steelhead	400,000[1]	67%	130,000	Leidy and Leidy 1984; Busby et al. 1994
Coho salmon	15,400–20,000	52% to 95%	760 to 9,550	Moyle et al. 1995; Ackerman et al. 2006
Fall-run Chinook salmon	500,000[3]	92% to 96%	20,000–40,000	Moyle 2002
Shasta River Chinook salmon[4]	20,000–80,000	88% to 95%	A few hundred to a few thousand	Moyle 2002
Spring-run Chinook salmon	100,000	98%	2,000[2]	Moyle 2002

[1] Estimate from 1960.~~-~~ Anadrom numbers were already in decline in the early ~~20th century~~1900s (Snyder 1931)

[2] Includes Klamath River and Tr River Chinook salmon

[3] Excludes hatchery-influenced escapement

[4] Shasta River is a subset of the Klamath River Chinook salmon population

Anadromous salmonids in the Klamath River include fall- (including late-fall) and spring-run Chinook salmon; coho salmon; fall-, winter-, and summer-run steelhead; and coastal cutthroat trout. Anadromous salmonids share many similar life-history traits, but the timing of their upstream migrations, habitat preferences, and distributions differ. All anadromous salmonids spawn in gravel or cobble substrates that are relatively free of fine sediment with suitable surface and subsurface flow to carry oxygen to the eggs and carry metabolic waste away from the eggs. Once suitable spawning habitat is found, the ~~adult~~ adult female digs one or more nests and deposits up to 3,000 eggs. Her mate(s) will simultaneously fertilize the eggs and fend off other males and egg-eating predators. The female continues digging upstream of the nest, which forms a distinctive pit just upstream and a protective mound of gravel and cobble over the eggs. The female will continue the mound-building process and defend her nest location until her demise. Steelhead and coastal cutthroat trout have similar life histories, but may survive spawning, re-enter the ocean, and return to spawn the following year(s). The eggs hatch several weeks or months ~~later~~after spawning, depending on species and water temperature. The resulting yolk-sac fry, also referred to as alevins, reside in the gravel for several more weeks until their yolk sac is depleted. The fry then emerge from the redd and seek slow shallow areas near shoreline or vegetative cover, gradually moving into deeper and faster water as they grow. Anadromous salmonids are generally considered "juveniles" when they have grown to a size of approximately 55 milimeters (mm). Juveniles feed and grow on their way downstream and may also rear for some time in the estuary prior to entering the ocean, but before entering brackish or salt water, they must undergo a physiological process called smoltification. After entering the ocean, smolts range up and down the coast as they grow to adulthood. Most adult salmonids return to spawn in the stream where they were born, although some straying does occur. Specific details of life history and distribution are described for each run of anadromous salmonid in the following section.

Chinook Salmon

Two Chinook salmon Evolutionarily Significant Units (ESUs) occur in the Klamath Basin—the Southern Oregon and Northern California Coastal ESU, which includes all naturally spawned Chinook salmon in the ~~lower~~Lower Klamath River downstream from its confluence with the Trinity River, and the Upper Klamath and Trinity Rivers ESU, which includes all naturally spawned populations of Chinook salmon in the Klamath and Trinity rivers upstream of the confluence of the Klamath and Trinity Rivers. A status review in 1999 determined that neither ESU warranted listing (National Oceanic and Atmospheric Administration Fisheries Service (NOAA~~)~~ Fisheries Service 1999a). ~~A~~

Another petition to list Chinook salmon in the Upper Klamath and Trinity Rivers ESU under the Endangered Species Act was submitted to the NOAA Fisheries Service in January 2011 (Center for Biological Diversity (CBD) et al. 2011~~);~~). In the petition NOAA

Fisheries Service was asked to consider one of three alternatives for the listing of Chinook salmon in the Upper Klamath and Trinity River ESU: 1) list spring-run only as a separate ESU, 2) list spring-run as a distinct population segment within the Upper Klamath and Trinity River Chinook Salmon ESU, or 3) list the entire Chinook salmon Upper Klamath and Trinity River ESU including both spring-run and fall-run populations. In April 2011, NOAA Fisheries Service announced that the petition contained substantial scientific information warranting ~~federal~~Federal review ~~and that a finding~~ as to whether ~~they~~ Chinook salmon within the Upper Klamath and Trinity River ESU should be listed as threatened or endangered ~~will be made by January 28, 2012~~ (http://www.noaanews.noaa.gov/stories2011/20110411_chinook.html). ~~Two races of Chinook salmon occur in the Klamath River: fall-run and spring-run. Although wild spring-run Chinook salmon in the Klamath River system differs from fall-run Chinook salmon genetically, as well as in terms of life history and habitat requirements (NRC 2004), both runs are included within these ESUs (~~As a result, the NOAA Fisheries Service formed a Biological Review Team (BRT) to assess the biological status of the species and determine if listing under the Endangered Species Act may be necessary. The BRT (Williams et al. 2011) found that recent spawner abundance estimates of both fall-run and spring-run Chinook salmon returning to spawn in natural areas are generally low compared to historical estimates of abundance; however, the majority of populations have not declined in spawner abundance over the past 30 years (i.e., from the late 1970s and early 1980s to 2010) except for the Scott and Shasta rivers where there have been modest declines (Williams et al. 2011). In addition, Williams et al. (2011) found that hatchery returns did not track escapement to natural spawning areas and they concluded that there has been little change in the abundance levels, trends in abundance, or population growth rates since the review conducted by Myers *et al.* (1998). ~~Both races~~The BRT also noted that recent abundance levels of some populations are low, especially in the context of historical abundance estimates. This was most evident with respect to two of the three spring-run population units that were evaluated (Salmon River and South Fork Trinity River). Although current levels of abundance are low when compared to historical estimates of abundance, the current abundance levels do not constitute a major risk in terms of ESU extinction.

The BRT also concluded that spring-run Chinook salmon did not warrant designation as a separate ESU or distinct population segment within the Upper Klamath and Trinity River ESU. This finding was based in part on new genetic evidence that indicates that spring-run and fall-run life histories have evolved on multiple occasions across different coastal watersheds located north and south of the Klamath River. Kinziger et al. (2008) found that there are four genetically differentiated and geographically separated groups of Chinook salmon populations in the Upper Klamath and Trinity River basins and that spring-run and fall-run Chinook life histories have evolved independently and in parallel within both the Salmon and Trinity rivers. In addition, spring-run and fall-run populations in the Salmon River were nearly indistinguishable genetically and spring and fall-run populations in the South Fork Trinity were extremely similar to each other and to Trinity River hatchery stocks. Williams et al. (2011) concluded that spring-run and fall-run Chinook salmon within the Upper Klamath and Trinity River basins are genetically similar to each other and that the two runs are not substantially reproductively isolated

from each other. In addition, ocean type and stream type life history strategies are exhibited by both run types, further suggesting that spring-run Chinook salmon in the Upper Klamath and Trinity River basins do not represent an important component in the evolutionary legacy of the species.

Regardless of the determination that spring-run and fall-run Chinook salmon comprise a single ESU, these two runs have different life history strategies and habitat requirements (NRC 2004) and a more detailed discussion of the two run types is described below.

Fall-Run Chinook Salmon. Fall-run Chinook salmon (*Oncorhynchus tshawystcha*) are distributed throughout the Klamath River downstream ~~of~~ from Iron Gate Dam. Historical records reviewed by Hamilton et al. (2005) and genetic information obtained from archaeological sites analyzed by Butler et al (2010) indicate that prior to the construction of Copco 1 Dam, Chinook salmon (both fall- and spring-run) spawned and were abundant in ~~the~~ tributaries ~~upstream~~ of the Upper Klamath ~~Lake~~Basin, including Jenny, Fall, and Shovel Creeks, as well as the Sprague, Williamson, and Wood ~~Rivers.~~

rivers (Administrative Law Judge 2006).

Adult upstream migration through the estuary and ~~lower~~Lower Klamath River peaks in early September and continues through late October (Moyle 2002; ~~Federal Energy Regulatory Commission [~~FERC~~]~~ 2007; Strange ~~2009~~2008). Spawning peaks in late October and early November, and fry begin emerging from early February through early April (Stillwater Sciences 2009a), although timing may vary somewhat depending on temperatures in different years and tributaries.

Fall-run Chinook salmon in the Klamath Basin exhibit three juvenile life-history types: Type I (ocean entry at age 0[1] in early spring within a few months of emergence), Type II (ocean entry at age 0 in fall or early winter), and Type III (ocean entry at age 1 in spring) (Sullivan 1989). Based on outmigrant trapping at Big Bar on the Klamath River from 1997 to 2000, 63 percent of natural Chinook salmon outmigrants are Type I, 37 percent are Type II, and less than 1 percent are Type III (Scheiff et al. 2001). Although, trapping efforts are not equal among seasons, the results are consistent with scale analysis of adult returns by Sullivan (1989).

Critical stressors on fall-run Chinook salmon in the basin include water quality and quantity in the mainstem and within spawning tributaries. Downstream ~~of~~ from Iron Gate Dam, the mainstem Klamath River undergoes seasonal changes in flows, water temperature, dissolved oxygen, and nutrients, as well occasional blooms of *Microcystis aeruginosa*. During outmigration, juvenile Chinook salmon are vulnerable to contracting disease from pathogens, including the bacterium *Flavobacterium columnare*, and myxozoan parasites *Parvicapsula minibicornis* and *Ceratomyxa shasta*.

~~1~~ [1] A fish emerging in spring is designated as age 0 until January 1st of the following year, when it is designated as age 1 until January 1st of the next year, when it is designated age 2.

Spring-Run Chinook Salmon. Spring-run Chinook salmon in the Klamath Basin are distributed mostly in the Salmon and Trinity Rivers and on the mainstem ~~below~~downstream from these tributaries during migratory periods, although a few fish are occasionally observed in other areas (Stillwater Sciences 2009a). Based on data from 1992 to 2001 (California Department of Fish and Game [CDFG], unpublished data 2004), the Salmon River contributions to the overall escapement ranged from 1 to 20 percent of the total escapement, and from 2 to 35 percent of the natural escapement. No spawning has been observed in the mainstem Klamath River (Shaw et al. 1997). ~~Historically, the spring run may have been as abundant as the fall run (Moyle 2002). Large~~As described above, the BRT (Williams et al. 2011) concluded that while abundance is low compared with historical abundance (Table 3.3-1), the current Chinook salmon population (which includes hatchery fish) appear to have been fairly stable for the past 30 years. However, the BRT noted, as did Myers et al. (1998), that the recent spawner abundance levels of two of the three spring-run population components (Salmon River and South Fork Trinity River) are very low compared to historical abundance (less than 1,000 fish). The BRT was concerned about the relatively few populations of spring-run Chinook salmon and the low numbers of ~~Chinook salmon once spawned in the basin above Klamath Lake in the Williamson, Sprague, and Wood Rivers, but the completion of Copco Dam in 1917 eliminated these runs (Snyder 1931, as cited in NRC 2004). It is believed that spring~~spawners within those populations (Williams et al. 2011).

The BRT (Williams et al. 2011) found the decline in spring-run fish especially troubling given that the spring-run population may have been equal to, if not larger than the fall-run (Barnhart 1994). Huntington (2006) reasoned that spring-run Chinook salmon likely accounted for the majority of the Upper Klamath Basin's actual salmon production under historical conditions. Spring Chinook salmon spawned in the tributaries of the ~~upper basin~~Upper Klamath Basin (Moyle 2002; Hamilton et al. 2005~~; Butler et al. 2010~~ with large numbers of Chinook salmon spawning in the basin above Klamath Lake in the Williamson, Sprague, and Wood Rivers (Snyder 1931). Large runs of spring Chinook salmon also returned to the Shasta, Scott, and Salmon rivers (Moyle et al. 1995). The runs in the Upper Klamath Basin are thought to have been in substantial decline by the early 1900s, and then were eliminated by the completion of Copco Dam in 1917 (Snyder 1931). The cause of the decline of the Klamath River spring-run Chinook salmon prior to Copco 1 Dam has been attributed to dams, overfishing, irrigation, and largely to commercial hydraulic mining operations (Coots 1962; Snyder 1931). These large scale mining operations occurred primarily in the late 1800's, and along with overfishing, left spring-run Chinook salmon little chance to recover prior to dam construction in early 1900's. Dam construction eliminated much of the historical spring-run spawning and rearing habitat and was partly responsible for the extirpation of at least seven spring-run populations from the Klamath-Trinity River system (Myers et al. 1998). The construction of Dwinnell Dam on the Shasta River in 1926 was soon followed by the disappearance of the spring Chinook salmon run in that tributary~~.~~ (Moyle et al. 1995).

Wild spring-run Chinook salmon from the Salmon River appear to primarily express a Type II life history, based on scale analyses of adults returning from 1990 to 1994 in the Salmon River (Olson 1996), as well as otolith analyses of Salmon River fry and adults

(Sartori 2006). A small number of fish employ the Type III life history, although apparently not nearly as prevalent as the Type II.

Spring-run Chinook salmon upstream migration is observed during two time periods—spring (April through June) and summer (July through August) (Strange 2008). Snyder (1931) also describes a run of Chinook salmon occurring in Klamath River during July and August under historical water quality and temperature conditions. Adults spawn from mid-September to late-October in the Salmon River and from September through early November in the South Fork Trinity River (Stillwater Sciences 2009a). Emergence takes place from March and continues until early-June (West et al. 1990). Age-0+ juveniles rearing in the Salmon River emigrate at various times of the year, with one of the peaks of outmigration occurring in April through May (Olson 1996), which would be considered Type I life history. Based on outmigrant trapping from April to November in 1991 at three locations in the South Fork Salmon River, Olson (1996) reported that the greatest peak in outmigration of age-0+ juveniles (69 percent) was in mid-October, which would be considered Type II life history. Scale circuli patterns of adults with an identified Type II life history were consistent with those from juveniles outmigrating in mid-October. Sullivan (1989) reported that outmigration of Type II age-0+ juveniles can occur as late in the year as early-winter. On the South Fork Trinity River outmigration occurs in late-April and May with a peak in May (Dean 1994, 1995), although it is not possible to differentiate between spring and fall race juveniles and so the spring-run may have different run timing. Age-1 juveniles (Type III) have been found to outmigrate from the South Fork Trinity River during the following spring (Dean 1994, 1995).

It is unclear how much time outmigrating age-0+ juveniles spend in the Klamath River mainstem and estuary before entering the ocean. Sartori (2006) did identify a period of increased growth (estimated mean of 24 days) just prior to reaching an estuarine environment based on otolith analyses of returning adults to the Salmon River, but this period was never clearly linked to mainstem residence. From March to May, there were fair numbers of age-1 juvenile outmigrants captured in the Klamath River estuary (Wallace 2004). Most were identified to be hatchery age-1 juvenile fall-run Chinook salmon, but nearly half were identified to be of natural origin, based on tag expansions.

Stressors on spring-run Chinook salmon related to water quality and quantity are similar to those for fall-run Chinook salmon in the mainstem Klamath River. Although water quality tends to improve in the mainstem downstream ~~of~~from the confluence with the Salmon River (the upstream-most spawning tributary), degradation of water quality (especially temperature and dissolved oxygen) can create critically stressful conditions for spring-run Chinook salmon for much of the summer (June through September). Production in the Salmon River is primarily controlled by high water temperatures that reduce adult holding and summer rearing habitat in the mainstem Salmon River, while increased fine sediment input within the watershed reduces spawning and rearing habitat quality in some locations (Elder et al. 2002).

Steelhead

Klamath Basin summer steelhead and winter steelhead (*O. mykiss irideus*) populations both belong to the Klamath Mountain Province ESU. NOAA Fisheries Service (2001) status review found that this ESU was not in danger of extinction or likely to become so in the foreseeable future, based on estimated populations for the ESU and lower estimates of genetic risk from naturally spawning hatchery fish than estimated in previous reviews, and consideration of existing conservation efforts that are benefiting steelhead in the ESU (NOAA Fisheries Service 2001).

Summer Steelhead. Summer steelhead are distributed throughout the Klamath River downstream ~~of~~ from Iron Gate Dam and in its tributaries, and ~~genetic information obtained from archaeological sites analyzed by Butler et al (2010) suggests that steelhead~~ historically used habitat upstream of Upper Klamath Lake prior to the construction of Copco 1 Dam (Hamilton et al. 2011). Based on available escapement data, approximately 55 percent of summer steelhead spawn in the Trinity River and other lower-elevation tributaries. Most remaining summer steelhead are believed to spawn in tributaries between the Trinity River (River Mile [RM] 43) and Seiad Creek (RM 129), with high water temperatures limiting their use of tributaries farther upstream (NRC 2004). The mainstem Klamath River is used primarily as a migration corridor for adult summer steelhead to access holding and spawning habitat in tributaries to the Klamath River.

Summer steelhead adults enter and migrate up the Klamath River from March through June while sexually immature (Hopelain 1998), then hold in cooler tributary habitat until spawning begins in December (United States Fish and Wildlife Service [USFWS] 1998). Forty to 64 percent of summer steelhead in the Klamath River exhibit repeat spawning, with adults observed to migrate downstream to the ocean after spawning (also known as "runbacks") (Hopelain 1998). Summer steelhead in the basin also have a "half-pounder" life-history pattern, in which an immature fish emigrates to the ocean in the spring, returns to the river in the fall, spends the winter in the river, then emigrates to the ocean again the following spring (Busby et al. 1994; Moyle 2002).

Juvenile summer steelhead in the Klamath Basin may rear in freshwater for up to 3 years before outmigrating. Although many juveniles migrate downstream at age 1+ (Scheiff ~~et~~ et al. 2001), those that outmigrate to the ocean at age 2+ appear to have the highest survival (Hopelain 1998). Juveniles outmigrating from tributaries at age 0+ and age 1+ may rear in the mainstem or in non-natal tributaries (particularly during periods of poor water quality) for 1 or more years before reaching an appropriate size for smolting. Age-0 juvenile steelhead have been observed migrating upstream into tributaries, off-channel ponds, and other winter refuge habitat in the ~~lower~~Lower Klamath River (Stillwater Sciences 2010b). Juvenile outmigration can occur from the spring through fall. Smolts are captured in the mainstem and estuary throughout the fall and winter (Wallace 2004), but peak smolt outmigration normally occurs from April through June, based on estuary captures (Wallace 2004). Temperatures in the mainstem are generally suitable for juvenile steelhead, except during periods of the summer, especially upstream of Seiad Valley (for more species information see USFWS 1998; Moyle 2002; NRC 2004; and

Stillwater Sciences 2009a). Critical limiting factors for summer steelhead are believed to include degraded habitats, fish passage, predation, and competition (Moyle et al. 2008).

Winter Steelhead. Moyle (2002) describes steelhead in the Klamath Basin as having a summer- and winter-run. Some divide the winter-run into fall and winter runs (Barnhart 1994; Hopelain 1998; USFWS 1998; Papa et al. 2007). In this ~~report~~section, "winter steelhead" refers to both fall and winter runs except in cases when the distinction is pertinent to the discussion. Effects on winter-and fall-run steelhead were differentiated wherever data was sufficient to analyze them separately.

Winter steelhead are widely distributed throughout the Klamath River and its tributaries downstream ~~of~~ from Iron Gate Dam, and ~~are believed to have~~ historically used habitat upstream of Upper Klamath Lake (~~Butler~~Hamilton et al. ~~2010~~2011). The Trinity, Scott, Shasta, and Salmon Rivers are the most important spawning streams for winter steelhead. Winter steelhead adults generally enter the Klamath River from July through October (fall run) and from November through March (winter run) (USFWS 1998; Stillwater Sciences 2010b). Winter steelhead primarily spawn in tributaries from January through April (USFWS 1998), with peak spawn timing in February and March (ranging from January to April) (NRC 2004). Adults may repeat spawning in subsequent years after returning to the ocean. Half-pounders typically utilize the mainstem Klamath River until leaving the following March (NRC 2004), although they also utilize larger tributaries such as the Trinity River (Dean 1994, 1995).

Fry emerge in spring (NRC 2004), with fry observed in outmigrant traps in Bogus Creek and Shasta River from March through mid-June (Dean 1994). Age-0+ and 1+ juveniles have been captured in outmigrant traps in spring and summer in tributaries to the Klamath River above Seiad Creek (CDFG 1990a, ~~1990b, as cited in USFWS 1998~~b). These fish are likely rearing in the mainstem or non-natal tributaries before leaving as age-2+ outmigrants.

Juvenile outmigration appears to primarily occur between May and September with peaks between April and June, although smolts are captured in the estuary as early as March and as late as October (Wallace 2004). Most adult returns (86 percent) originate from fish that smolt at age 2+, representing 86 percent of adult returns; in comparison with only 10 percent for age-1 juveniles and 4 percent for age 3+ juveniles (Hopelain 1998).

Similar limiting factors listed for summer steelhead also affect winter steelhead populations, including degraded habitats, decreased habitat access, fish passage, predation, and competition (for more species information see USFWS 1998; NRC 2004; Wallace 2004; and Stillwater Sciences 2009a).

Coastal Cutthroat Trout

Klamath River coastal cutthroat trout (*Oncorhynchus clarki clarki)* belong to the Southern Oregon California Coasts ESU. In a 1999 status review, NOAA Fisheries Service determined that the Southern Oregon California Coasts ESU did not warrant ESA listing (Johnson et al. 1999). Coastal cutthroat trout are distributed primarily within

smaller tributaries to the lower 22 miles of the Klamath River mainstem above the estuary (NRC 2004), but also within tributaries to the Trinity River (Moyle et al. 1995).

Cutthroat trout have not been extensively studied in the Klamath ~~basin~~Basin, but it has been noted that their life history is similar to fall and winter steelhead in the Klamath River (NRC 2004). Both resident and anadromous life histories are observed in the Klamath Basin. Anadromous adults enter the river to spawn in the fall. Generally, spawning of anadromous and resident coastal cutthroat trout may occur from September to April (Moyle 2002). Sea-run adults may either return in summer to feed, or return in September or October to spawn and/or possibly overwinter (NRC 2004). Moyle (2002) noted that upstream migration in northern California spawning streams tends to occur from August to October after the first substantial rain.

Juveniles may spend anywhere from one to three years in freshwater to rear. Juveniles outmigrate during April through June, at the same time as Chinook salmon juvenile downstream migration (~~Hayden and Gale 1999, as cited in NRC 2004;~~ Moyle 2002; NRC 2004). Juveniles also appear to spend at least some time rearing in the estuary. Wallace (2004) found that estuary residence time ranged from 5 to 89 days, with mean of 27 days, based on a mark-recapture study.

Pacific Lamprey

Pacific lamprey are the only anadromous lamprey species in the ~~basin. It is not clear whether residual populations of this species still exist above Iron Gate Dam~~Basin. Pacific lamprey, along with three other lamprey species, was petitioned for ESA listing in 2003 (Nawa 2003). Although the USFWS halted species status review in December 2004 due to inadequate information (~~NOAA Fisheries Service~~USFWS 2004), efforts to list Pacific lamprey are anticipated to resume as more information is obtained. No current status assessments are available for any Klamath lampreys and little is known of their biology or sensitivity to environmental changes in the Klamath drainage (Hamilton et al. 2011).

Pacific lamprey are found in Pacific coast streams from Alaska to Baja California. They occur throughout the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam and its major tributaries: the Trinity, Salmon, Shasta, and Scott River Basins (Stillwater Sciences 2009a). ~~The extent of their historical upstream distribution is uncertain due to~~ Although the ~~occurrence of several resident species of lamprey in~~evidence is inconclusive as to whether Pacific lamprey were historically present above Iron Gate Dam, the ~~upper parts of the Klamath Basin (FERC 2007~~record evidence shows that access to habitat would benefit that species of fish by providing it with additional spawning and rearing grounds (Administrative Law Judge 2006). Pacific lamprey are capable of migrating long distances, and show similar distributions to anadromous salmon and steelhead (Hamilton et al. 2005). ~~Preliminary results of radio telemetry studies by the Yurok Tribe show an extended period of time for adult presence in the river (Yurok Tribe 2011, unpublished data).~~

Pacific lamprey are anadromous nest builders that die shortly after spawning. They enter the Klamath River during all months of the year, with peak upstream migration occurring from December through June (Stillwater Sciences 2009a). Spawning occurs at the upstream edge of riffles in sandy gravel from mid-March through mid-June (Stillwater Sciences 2009a). After lamprey eggs hatch, the larvae (ammocoetes) drift downstream to backwater areas and burrow into the substrate, feeding on algae and detritus (FERC 2007). Based on observations and available habitat, most ammocoete rearing likely occurs in the Salmon, Scott, and Trinity Rivers, as well as in the mainstem Klamath River. The Klamath River upstream of the Shasta River appears to have less available spawning and rearing habitat, and Pacific lamprey are not regularly observed there. Juveniles remain in freshwater for 5 to 7 years before they migrate to the ocean and transform into adults (Moyle 2002). They spend 1 to 3 years in the marine environment, where they parasitize a wide variety of ocean fishes, including Pacific salmon, flatfish, rockfish, and pollock. For more species information see Close et al. 2010; Stillwater Sciences 2009a; and PacifiCorp 2004a.

Major factors believed to be affecting their populations include barriers to upstream migration at dams, dewatering of larval habitat through flow regulation, stranding due to rapid downramping, reducing larval habitat by increasing water velocity and/or reducing sediment deposition areas, and mortality due to exposure to contaminants in the larval stage (Close et al. 2002, as cited in Hamilton et al. 2011).

Green Sturgeon

Green sturgeon (*Acipenser medirostris Ayres*) are an anadromous species that occurs in coastal marine waters from Mexico to the Bering Sea. NOAA Fisheries Service has identified two distinct population segments (DPSs): the Northern Green Sturgeon DPS, which includes populations spawning in coastal watersheds from the Eel River north, which is not listed as threatened or endangered but is on NOAA Fisheries ~~Service'~~Service's Species of Concern list, and the Southern Green Sturgeon DPS, encompassing coastal or Central Valley populations spawning in watersheds south of the Eel River, which is listed as threatened under the ~~federal~~Federal ESA (NOAA Fisheries Service 2006a). Although the Southern DPS is considered a separate population from the Northern DPS based on genetic data and spawning locations, their ranges outside of the spawning season tend to overlap (CDFG 2002b; Israel et al. 2004; Moser and Lindley 2007). The Klamath Basin may support most of the spawning population of green sturgeon (Adams et al. 2002). Although Southern DPS green sturgeon may enter west coast estuaries to feed in the summer and fall, ~~but~~ there has been no evidence of them entering the Klamath River estuary (Reclamation 2010).

Northern DPS green sturgeon in the Klamath River sampled during their spawning migration ranged in age from 16 to 40 years (Van Eenennaam et al. 2006). It is believed that in general green sturgeon have a life span of at least 50 years, and spawn every 4 years on average after around age-16, for a total of around eight spawning efforts in a lifetime (Klimley et al 2007). Green sturgeon enter the Klamath River to spawn from March through July. Green sturgeon spawn primarily in the lower 67 miles of the mainstem Klamath River (downstream ~~of~~ from Ishi Pishi Falls), in the Trinity River, and

occasionally in the lower Salmon River (Klamath River Basin Fisheries Task Force [KRBFTF] 1991; Adams et al. 2002; Benson et al. 2007). Most green sturgeon spawning occurs from the middle of April to the middle of June (NRC 2004). After spawning, around 25 percent of green sturgeon migrate directly back to the ocean (Benson et al. 2007), and the remainder hold in mainstem pools in the Klamath River from ~~river mile (~~RM~~)~~ 13 to ~~65~~ 65 through November.

During the onset of fall rainstorms and increased river flow, adult sturgeon move downstream and leave the river system (Benson et al. 2007). Juvenile green sturgeon may rear for 1 to 3 years in the Klamath River system before they migrate to the estuary and ocean (NRC 2004; FERC 2007; CALFED 2007), usually during summer and fall (Emmett et al. 1991, as cited in CALFED 2007; CH2M Hill 1985; Hardy and Addley 2001).

The timing and magnitude of high flows downstream from Iron Gate Dam that are related to Project operations have the potential to reduce green sturgeon survival in the mainstem. Adult green sturgeon that have held over the summer in the river after spawning appear to migrate downstream in conjunction with increases in discharge in the fall. Attenuation of high flows downstream from Iron Gate Dam may affect a key environmental cue used to stimulate the fall outmigration of adult green sturgeon that have remained in holding pools over the summer (Benson et al. 2007). This lower portion of the river was quite responsive to discharge increases related to rainfall events; the timing of peak flows changed significantly following the construction of the Project (Balance Hydrologics, Inc. 1996). Under existing conditions, the Project results in higher flows in October compared with historical conditions and lower flows in late spring and summer (Balance Hydrologics, Inc. 1996). Because temperatures in the lower river are close to lethal for eggs and embryos in dry years, reductions in flows related to the Project may exacerbate the effects of temperature on reproductive survival in these years, as would any temperature increases occurring as a result of climate change in the future. Shifts in the timing of seasonal life-history cues could also affect survival rates by changing the timing of their entry into habitats, such as entry of juveniles into the estuary.

Resident Riverine Fish Species

Rainbow and Redband Trout

Rainbow trout (*Oncorhynchus mykiss*) exhibit a wide range of life-history strategies, including anadromous forms (steelhead, described above) and resident forms, described here. The Klamath Basin has two subspecies of rainbow trout. Behnke (1992) identifies the inland form as the Upper Klamath redband trout, *Oncorhynchus mykiss newberrii*, but considers steelhead and resident rainbow trout downstream ~~of~~ from Upper Klamath Lake to be primarily coastal rainbow trout, *Oncorhynchus mykiss irideus*. Since construction of Copco 1 Dam and Iron Gate Dam, resident trout upstream of Iron Gate Dam are considered redband trout, and resident trout downstream ~~of~~ from Iron Gate Dam are considered coastal rainbow trout (FERC 2007). Behnke (2002) indicates that two distinct groups of redband trout may be in the ~~upper basin~~Upper Klamath Basin: one that is

adapted to lakes and another that is adapted to streams. The area upstream of Iron Gate Dam, and particularly Upper Klamath Lake, ~~support~~ supports populations of redband trout. These fish support a substantial recreational fishery.

The Upper Klamath ~~Lake~~ Basin supports the largest and most functional adfluvial redband trout population of Oregon's interior basins (Hamilton et al. 2011). Adfluvial adult redband trout migrate from lake habitats into tributaries to spawn. Peak spawning occurs in December and January, but redband trout in Spring Creek have been documented to spawn nearly year-round, in all months from October through August. Their progeny typically spend one year rearing in tributaries before migrating back to the lake. In the Hydroelectric Reach, most redband trout spawning is thought to occur in Spencer and Shovel Creeks. Redband trout need to migrate among habitats, mainstem, tributaries, and reservoirs to meet their life-history requirements. Redband trout are not susceptible to *C. shasta* or other diseases potentially brought upstream by anadromous fishes (Hamilton et al. 2011). For more species information, see USFWS (1998); USFWS (2000); Behnke (2002); Moyle (2002); NRC (2004); PacifiCorp (2004a); Starcevich et al. (2006); Messmer and Smith (2007); and Stillwater Sciences (2009a).

Resident Lampreys

In addition to the anadromous Pacific lamprey, described above, at least five or six resident species are present in the Klamath Basin (PacifiCorp 2006; Hamilton et al. 2011):

- Pit-Klamath brook lamprey (*Entosphenus lethophagus*)
- Modoc brook lamprey (*Entosphenus folletti*)
- Western brook lamprey (*Lampetra richardsoni*)
- Klamath River lamprey (*Entosphenus similis*)
- Miller Lake lamprey (*Entosphenus minima*)
- "Klamath Lake lamprey," an undescribed, parasitic species

All lamprey species have a similar early life history where ammocoetes drift downstream to areas of low velocity with silt or sand substrate and proceed to burrow into the stream bottom and live as filter feeders (USFWS 2004). After they transform into adults, the non-parasitic species do not feed, while the parasitic species feed on a variety of fish species (FERC 2007).

Klamath River lamprey are found both upstream and downstream ~~of~~ from Iron Gate Dam, from Spencer Creek downstream, and are common in the ~~lower~~Lower Klamath River and the low-gradient tributaries there (NRC 2004). They are also found in the Trinity River, and in the Link River of the Upper Klamath Basin (Lorion et al. 2000, as cited ~~by~~ in Close et al. 2010). "Klamath Lake lamprey," an as yet undescribed species, reside in Upper Klamath Lake and migrate upstream in the Sprague River to spawn (Close et al. 2010). Klamath Lake lamprey ammocoetes are reported to metamorphose in the fall, spend 12 to 15 months in Upper Klamath Lake parasitizing fish, and then spawn in the spring in the Sprague River (FERC 2007).

Cyprinids

The blue chub (*Gila coerulea)* and tui chub (*Gila bicolor*) are both found in the Klamath Basin. These species prefer habitat with quiet water, well-developed beds of aquatic plants, and fine sediment or sand bottoms. Although chubs can withstand a variety of conditions including cold, clear lake water, and can also tolerate low dissolved oxygen levels, they are most often found in habitats with summer water temperatures higher than 20°C. These fish are omnivores and can play an important role in nutrient cycling. Chub spawning takes place from April through July, in shallow rocky areas in temperatures of 15 to 18°C (Moyle 2002).

Sculpin

Several sculpin (*Cottidae*) species are found in coastal streams and rivers from Alaska to southern California. At least 7 species of sculpin are known to occur in the Klamath River or its estuary, including Pacific staghorn, prickly, slender, sharpnose, coastrange, marbled, and Klamath Lake sculpin. Mainstem river habitat may be important to sculpin populations as it can provide an important migration corridor (White and Harvey 1999). Pacific staghorn sculpin are found predominantly in brackish waters of the estuary. Coastal populations of prickly and coastrange sculpin are generally assumed to be estuary-dependent for part of their early life history (White and Harvey 1999). The marbled sculpin (*Cottus klamathensis*) is a relatively wide-ranging species found in a variety of habitats in northern California and southern Oregon (Daniels and Moyle 1984). Marbled sculpin are found mainly in low gradient, spring-fed streams and rivers where the water temperature is less than 20°C in the summer and in habitat with fine substrate that can support beds of aquatic plants. They are typically found in 60 to 70 centimeters (cm) of water and are in velocities around 23 centimeters per second (cm/sec) (Moyle 2002).

Smallscale ~~sucker~~

Sucker

The Klamath smallscale sucker (*Catostomus rimiculus*) is common and widely distributed in the Klamath River and its tributaries ~~below~~ downstream from the city of Klamath Falls, Oregon, and in the Rogue River (Moyle 2002). They tend to inhabit deep, quiet pools in mainstem rivers and slower-moving reaches in tributaries; however, they can be found in faster-flowing habitats when feeding or breeding (Moyle 2002). McGinnis (1984) reported that this species spawns in small tributaries to the Klamath and Trinity Rivers. Spawning in tributaries to Copco Reservoir has been observed from mid-March to late April (~~Knudsen and Mills 1980, as cited in~~ Moyle 2002). Juveniles are most commonly found in the streams that are used for spawning. This species does not achieve a large size and is relatively long-lived. Fish measuring 45 cm have been aged through scale analysis as being 15 years old (Scoppetone 1988, as cited in Moyle (2002). Moyle (2002) speculated that dams and diversions have benefitted this species by increasing the availability of its preferred warmer, low-velocity habitat.

Electrofishing by PacifiCorp and Oregon Department of Fish and Wildlife (ODFW) in the J.C. Boyle Peaking Reach revealed the existence of a good population of smallscale

suckers in moderate velocity habitat—smallscale sucker dominated the fish assemblage in most samples (W. Tinniswood, June 2011, pers. comm.). The dams have increased reservoir habitat that does not appear to be conducive to a riverine sucker species such as smallscale suckers. The J.C. Boyle Dam blocks the migration of suckers to spawning habitat in Spencer Creek. Spawning now occurs in the mainstem Klamath River where smallscale suckers are exposed to flow fluctuations that can displace their broadcast eggs or ~~dessicated~~desiccated them during power peaking (Dunsmoor 2006). Electrofishing in Jenny Creek revealed adult smallscale suckers occupying deep, moderate-velocity habitat among boulders (W. Tinniswood, June 2011, pers. comm.). ~~**The reservoirs themselves do not appear to provide habitat for smallscale sucker.**~~

Non-native Fish Species

Goldfish

Goldfish (*Carassius auratus)* are abundant in J.C. Boyle Reservoir and Keno Impoundment/Lake Ewauna; in September 2010, they were the most abundant species captured during ODFW electrofishing surveys.

Yellow Perch

Yellow perch (*Perca flavescens*) prefer weedy rivers and shallow lakes. They are found in reservoirs and ponds along the Klamath River. Optimal temperature for growth is 22–27°C but yellow perch can survive in temperatures up to 30–32°C. They can survive low levels of dissolved oxygen (less than 1 milligram per liter [mg/L]) but are most abundant in areas with high water quality, as they are visual feeders. Larval and juvenile yellow perch feed on zooplankton; adults are opportunistic predators that may feed on larger invertebrates and small fish (Knight et al. 1984). The preferred habitat of the yellow perch includes large beds of aquatic plants for spawning and foraging. Their spawning takes place in 7 to 19°C water in April and May and usually occurs in their second year (Moyle 2002).

Bass and Sunfish

Several species of bass (*Micropterus* spp.) and sunfish (*Lepomis* spp.) have been introduced into the Klamath Basin, including largemouth bass, ~~spotted bass,~~ white and black crappie, bluegill, pumpkinseed and green sunfish. Largemouth bass and sunfish (*Centrarchidae*) prefer lakes, ponds, or low-velocity habitat in rivers. They prefer habitats with aquatic vegetation and will spawn in a variety of substrates. They prefer water temperatures above ~~27ºC~~27 degrees Celsius (ºC). Juvenile and adult largemouth bass tend to feed on larger invertebrates and fish (Moyle 2002). Smaller members of the family, such as sunfish, are opportunistic feeders and eat a variety of aquatic insects, fish eggs, and planktonic crustaceans (Moyle 2002).

Sacramento Perch

Sacramento Perch (*Archoplites interruptus)* occur in J.C. Boyle Reservoir and Keno Impoundment/Lake Ewauna. The species is native to the Sacramento-San Joaquin watershed of California's Central Valley, from which they were extirpated.

Catfish

Several species of catfish have been introduced into the Klamath Basin, including black, brown, and channel catfish, and yellow bullhead (~~Logan and Markle 1993;~~ NRC 2004). Catfish prefer slow moving, warm water habitat. Brown bullhead (*Ameiurus nebulosus*) can tolerate a wide range of salinities and live at temperatures of 0 to 37°C, but their optimum temperature range is 20 to 33°C. Brown bullhead are most active at night and form feeding aggregations. Catfish are opportunistic omnivores and scavenge off the bottom of their habitat (Moyle 2002).

Trout

Brook trout (*Salvelinus fontinalis)* is an introduced species in the Upper Klamath Basin (FERC 2007) found in clear, cold lake and stream habitats. They prefer temperatures between 14 and 19°C but can survive in temperatures ranging from 1 to 26°C. Brook trout feed predominantly on terrestrial insects and aquatic insect larvae, though they may also opportunistically feed on other types of prey such as crustaceans, mollusks, and other small fish. Brook trout spawn in the fall and prefer habitats with small-sized gravel and nearby cover (Moyle 2002).

Brown trout (*Salmo trutta*) has also been introduced to the Klamath River and are found in both the Upper and Lower Klamath Basin. Brown trout prefer clear, cold water and can utilize both lake and stream habitats. Like brook trout, they spawn in the fall in streams with areas of clean gravel. Brown trout become piscivorous (fish eaters) once they reach a size where their gape can accommodate small fish available as prey.

Kokanee

Kokanee are landlocked sockeye salmon *(Oncorhynchus nerka)* that have been found in Upper Klamath Lake and Fourmile Creek.

American Shad

American shad (*Alosa sapidissima*) are an introduced, anadromous fish species that enjoys some popularity as a sport fish.

Fathead Minnow

Fathead minnow (*Pimephales promelas*) are an introduced bait fish widely distributed in the Upper Klamath Basin; however, it is thought that their introduction into the upper Klamath lakes may be a result of their use for pollution bioassays (Simon and Markle 1997, Moyle 2002).

Estuarine Species

The estuary is the mixing zone for freshwater and ocean water. The balance of fresh and saltwater changes over the course of the day with tides and is also strongly influenced by river flows. Because of this, both marine and freshwater species can often be found in different portions of the estuary at different times. All anadromous fish pass through the estuary during their migrations from freshwater to the sea and back again, and juvenile salmonids may rear in the estuary for varying periods of time, prior to moving into the ocean. CDFG surveys in the freshwater portion of the estuary commonly find Klamath speckled dace, Klamath smallscale sucker, prickly sculpin, and Pacific staghorn sculpin. Other fairly common species include northern anchovy, saddleback gunnel, and bay

pipefish. Other species in the estuary include federally listed eulachon, ~~state~~State listed longfin smelt (described under listed species), silversides, surf smelt, stickleback, and several gobies. Impacts to the estuarine species were assessed based on effects on ~~essential fish habitat~~EFH for groundfish and pelagic fish, as described in subsequent sections.

3.3.3.1.2 Freshwater Mollusks

Four species of native freshwater mussels have been observed within the Klamath Basin (FERC 2007; Westover 2010). PacifiCorp surveys in 2002 and 2003 found Oregon floater (*Anodonta oregonensis*), California floater (*A. californiensis*) and western ridged mussel (*Gonidia angulata*) along Klamath River reaches from the Keno Impoundment/ Lake Ewauna to the confluence of the Klamath and Shasta Rivers. Westover (2010) found western pearlshell mussel (*Margaritifera falcata*) in addition to these species along the Klamath River from Iron Gate Dam to the confluence of the Klamath and Trinity Rivers.

Anodonta spp. are habitat generalists, more tolerant of lentic conditions than other native species (Nedeau et al. 2005). *Anodonta* spp. are also more tolerant of siltier substrates, as their thin shells allow individuals to "float," or rest on top of silt-dominated streambeds (these species are commonly referred to as "floaters"). *G. angulata* is the largest and most common type of freshwater mussel found within the Klamath Basin~~, although little is known about their life history or habitat preferences~~ (Nedeau et al. 2005). Known fish hosts include hardhead (*Mylopharodon conocephalus*), Pit sculpin (*Cottus pitensis*), and tule perch (*Hysterocarpus traski*), but a full list of host fish species for *G. angulata* is unknown (Jepsen et al. 2010). *G. angulata* is known to prefer cold, clean water, but can tolerate seasonal turbidity, and can be found in aggrading, or depositional areas as it can partially bury itself within bed sediments without affecting filter feeding (Vannote and Minshall 1982; Westover 2010). A full understanding of *G. angulata*'s former and current distribution is particularly lacking, but it is believed to have been extirpated in central and southern California and has probably declined in many other watersheds, including the Columbia and Snake River basins (Jepsen et al. 2010). The Klamath River appears unusual in that *G. angulata* dominates its mussel community, unlike other rivers in the Pacific Northwest (Westover 2010). *M. falcata* has also been observed within the Klamath Basin downstream ~~of~~ from Iron Gate Dam, though in lesser abundance than other species (Westover 2010). *M. falcata* occupies low shear stress habitats (e.g., pools and near banks) and interstices within bedrock and cobble (Howard and Cuffey 2003).

Adult freshwater mussels are generally found wedged into gravel, rock substrate or partially buried in finer substrates, using a muscular foot to maintain position. Freshwater mussels filter feed on plankton and other organic material suspended in the water column.

While life history traits of individual species of freshwater mussels have not been fully studied, the general life cycle is as follows. Eggs within female freshwater mussels are fertilized by sperm that is brought into the body cavity. From April through July

thousands of tiny larvae, called glochidia, are released into the water where they must encounter a host fish for attachment within hours, otherwise they perish (Haley et al. 2007). Most juvenile freshwater mussels from these species drop off the fish hosts to settle from June to early August. They may spend an undetermined amount of time buried in the sediment where they grow to the point where they can maintain themselves at or below the substrate surface in conditions that are optimal for filter feeding (Nedeau et al. 2009). Freshwater mussels are fed upon by muskrats, river otters, and sturgeon (Nedeau et al. 2009). They were also a food of cultural significance for the Karuk Tribe (Westover 2010) and The Klamath Tribes.

Seven to eight species of fingernail clams and peaclams (Family: Sphaeriidae) were also found in the Hydroelectric Reach and from Iron Gate Dam to Shasta River during re-licensing surveys. One of the clam species, the montane peaclam (*Pisidium ultramontanum)*, has special status as a ~~federal~~Federal species of concern and a United States Forest Service (USFS) sensitive species. The montane peaclam is generally found on sand-gravel substrates in spring-influenced streams and lakes, and occasionally in large spring pools. The original range included the Klamath and Pit Rivers in Oregon and California, as well as some of the larger lakes (Upper Klamath, Tule, Eagle, and possibly, lower Klamath lakes). On USFS lands they are currently present or suspected in streams and lakes of Lassen and Shasta-Trinity National Forests. Fingernail clams and peaclams are relatively short-lived (1 to 3 years) compared to freshwater mussels (10 to 15 years or 100 plus years for some species). These small clams live on the surface or buried in the substrate in lakes, ponds or streams. They bear small numbers of live young several times throughout the spring and summer (Thorp and Covich 2001).

There are also many species of freshwater snails, some of which are endemic to the Klamath Basin and have restricted ranges, often associated with cold-water springs. Several of these have recently been petitioned for listing. However, based on their restricted distribution outside of any areas that could be affected by the Proposed Action they were considered, but not included in any additional analysis.

3.3.3.1.3 Benthic Macroinvertebrates

Benthic macroinvertebrates (BMIs) include immature, aquatic stages of insects such as midges, mayflies, caddisflies, stoneflies, dragonflies, and damselflies. They also include immature and adult stages of aquatic beetles; crayfish, amphipods and isopods (crustaceans); clams and snails; aquatic worms and other major invertebrate groups. Many ~~benthic macroinvertebrates (~~BMIs~~)~~ are the primary consumers in riverine food webs, feeding on primary producers—algae, aquatic plants, phytoplankton, bacteria, as well as leaves and other materials from terrestrial plants, and detritus. By converting organic material into biomass available to a wide variety of consumers, these organisms form an important component of the aquatic food web. Some BMIs are secondary consumers, feeding on the primary consumers. Together the BMIs are the primary food source for most fish species, and changes in abundance, distribution, or community structure can negatively affect fish populations. BMIs are also used as general indicators of water quality in indices of biological integrity based upon the richness or diversity of pollution tolerant and resistant species. BMIs are also particularly sensitive to changes in

fine and coarse sediment load, which could occur under the Proposed Action and alternatives. Food supply can limit growth of salmonids, and this is especially true at higher temperatures; i.e., as water warms, a fish needs more food to sustain growth (Brett 1971; ~~Elliott 1981;~~ McCullough 1999). Growth is critical to juvenile salmonids because a larger size often confers a survival advantage during the overwintering period, smolt outmigration, or ocean residence. If fish are chronically exposed to warmer temperatures and food availability is low, growth may cease, fish may experience physiological stress, and mortality from disease, parasites, and predation may increase. But in a productive system with high densities of macroinvertebrates or forage fish, a high rate of growth can be sustained at temperatures higher than would be considered optimal under conditions where food is limiting.

Relicensing studies evaluated BMIs from Link River Dam to the Shasta River and on Fall Creek in 2002 and 2003 (FERC 2007). These studies show that macroinvertebrates are abundant, with densities of 4,000 to 8,000 individuals per square meter.

Macroinvertebrate densities in fall of 2002 ranged from a low of 4,000 per square meter ~~below~~downstream from the powerhouse on the Klamath River to 21,000 per square meter below Keno Dam (PacifiCorp 2004b). Abundance of macroinvertebrates in the peaking reach of the Klamath River was as low as 500 per square meter in the spring of 2003. Dominant species in the riverine areas were caddisflies, blackflies, midges, beetles, and mayflies. The reservoirs had high abundance of invertebrates but low diversity, and were dominated by species tolerant of impaired water quality conditions.

3.3.3.1.4 Listed Species

Coho Salmon

The Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*) ESU is listed as federally threatened (NOAA Fisheries Service 1997a). This ESU includes all naturally spawning populations between Punta Gorda, California and Cape Blanco, Oregon, which encompasses the Trinity and Klamath Basins (NOAA Fisheries Service 1997a). Three artificial propagation programs are considered to be part of the ESU: the Cole Rivers Hatchery, Trinity River Hatchery, and Iron Gate Hatchery coho salmon programs. NOAA Fisheries Service has determined that these artificially propagated stocks are no more than moderately diverged from the local natural populations. In addition, coho salmon in the Klamath Basin have been listed by the California Fish and Game Commission as threatened under the California Endangered Species Act (CESA) (CDFG 2002a).

Coho salmon are native to the Klamath Basin. Williams et al. (2006) described nine historical coho salmon populations within the Klamath Basin, including the ~~upper~~Upper Klamath River, Shasta River, Scott River, Salmon River, ~~mid~~Mid-Klamath River, ~~lower~~Lower Klamath River, and three population units within the Trinity River watershed (upper Trinity River, lower Trinity River, and South Fork Trinity River). Although coho salmon are native to the Klamath River, documentation of coho salmon in the Klamath River is scarce prior to the early 1900's due, in part, to the apparent difficulty in recognizing there were different species of salmon inhabiting the rivers of the area

(Snyder 1931). Snyder (1931) reported that coho salmon were said to migrate to the headwaters of the Klamath River to spawn, but that most people did not distinguish between the species. During 2006 administrative hearings it was concluded that coho salmon migrated past the present site of Iron Gate Dam based on historical records and tribal accounts (Administrative Law Judge 2006).

Coho salmon are currently widely distributed in the Klamath River downstream ~~of~~from Iron Gate Dam (RM 190), which blocks the upstream migration of coho salmon to historically available habitat in the upper watershed. Before the construction of the dams, coho salmon were apparently common and widely distributed throughout the watershed, probably in both mainstem and tributary reaches up to and including Spencer Creek at RM 228 (NRC 2004, as cited in NOAA Fisheries Service 2007; Hamilton et al. 2005). Coho salmon utilize the mainstem Klamath River for some or all of their life history stages (spawning, rearing and migration). However, the majority of returning adult coho salmon spawn in the tributaries to the mainstem (Magneson and Gough 2006, NOAA Fisheries Service 2010a).

Coho salmon adults in the Klamath Basin migrate upstream ~~from~~ of September through late December, peaking in October and November. Spawning occurs mainly in November and December, with fry emerging from the gravel in the spring, 3 to 4 months after spawning (Trihey and Associates 1996; NRC 2004).

Some fry and age-0+ juveniles enter the mainstem in the spring and summer following emergence (Chesney et al. 2009). Large numbers of age-0 juveniles from tributaries in the mid-Klamath River move into the mainstem in the fall (October through November) (Soto et al. ~~2009~~2008; Hillemeier et al. 2009). Juvenile coho salmon have been observed to move into non-natal rearing streams, off-channel ponds, the ~~lower~~Lower Klamath River, and the estuary for overwintering (Soto et al. ~~2009~~2008; Hillemeier et al. 2009). Some proportion of juveniles generally remain in their natal tributaries to rear.

Age 1+ coho salmon migrate from tributaries into the mainstem Klamath River from February through mid-June with a peak in April and May, which often coincides with the descending limb of the spring hydrograph (NRC 2004; Chesney and Yokel 2003; Scheiff et al. 2001). Once in the mainstem, smolts appear to move downstream rather quickly; Wallace (2004) reported that numbers of coho salmon smolts in the Klamath River estuary peaked in May, the same month as peak outmigration from the tributaries.

The major activities identified as responsible for the decline of coho salmon in Oregon and California and/or degradation of their habitat included logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, artificial propagation, overfishing, water withdrawals, and unscreened diversions for irrigation (NOAA Fisheries Service 1997a). In 2007, NOAA Fisheries Service published a Klamath River Coho Salmon Recovery Plan to comply with Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (not equivalent to recovery plans under ESA~~), including~~); the plan includes the following actions identified as high priority for recovery:

- Complete and implement the NOAA Fisheries Service recovery plan for the SONCC coho salmon under the ESA.
- Restore access for coho salmon to the Upper Klamath Basin by providing passage beyond existing mainstem dams.
- Fully implement the Trinity River Restoration Program.
- Provide incentives for private landowners and water users to cooperate in (1) restoring access to tributary streams that are important for coho spawning and rearing; and (2) enhancing mainstem and tributary flows to improve instream habitat conditions.
- Continue to improve the protective measures already in place to address forestry practices and road building/maintenance activities that compromise the quality of coho salmon habitat.
- Implement restorative measures identified through fish disease research results to improve the health of Klamath River coho salmon populations.

Eulachon

Eulachon (*Thaleichthys pacificus*) is an anadromous fish that occurs in the lower portions of certain rivers draining into the northeastern Pacific Ocean, ranging from northern California to the southeastern Bering Sea in Bristol Bay, Alaska (~~Hubbs 1925; Schultz and DeLacy 1935;~~ McAllister 1963; Scott and Crossman 1973; Willson et al. 2006, as cited in ~~BRT 2010~~NOAA Fisheries Service 2010b). The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California (NOAA Fisheries Service 2009a). On March 18, 2010, NOAA Fisheries Service listed the southern DPS of eulachon as threatened under the ESA (NOAA Fisheries Service 2010b). ~~The~~ Final critical habitat was designated in October of 2011 (NOAA Fisheries Service 2011).

Historically, the Klamath River ~~is near~~was described as the southern limit of the range of eulachon (~~Hubbs 1925, Schultz and DeLacy 1935, both as cited in BRT 2010). Large~~Gustafson et al. 2010). Other accounts have described large spawning aggregations of eulachon ~~historically occurred~~ occurring regularly in the Klamath River (Fry 1979, Moyle et al. 1995, Larson and Belchik 1998, Moyle 2002, Hamilton et al. 2005), and occasionally in the Mad River (Moyle et al. 1995~~;~~, Moyle 2002) and Redwood Creek (~~Ridenhour and Hofstra 1994;~~ Moyle et al. 1995). ~~CDFG sampled in the Klamath River from 1989 to 2003 with no~~In addition, small numbers of eulachon ~~captures (Wallace, pers. comm., 2011). The Yurok Tribe sampled extensively for~~have been reported from the Smith River (Moyle 2002). The only reported commercial catch of eulachon in ~~early 2011 and, although they did not capture eulachon~~ northern California occurred in 1963 when a combined total of 25 metric tons (56,000 lbs) was landed from the Klamath River ~~itself,~~, the Mad River, and Redwood Creek (Odemar 1964). Since 1963, the run size has declined to the point that only a few individual fish have been caught in recent years. Moyle (2002) indicates that eulachon have been scarce in the Klamath River since the 1970s, with the exception of three years: they were plentiful in 1988 and again in 1989 and 1998. After 1998, they were thought to be extinct in the Klamath Basin until a small run was observed in the estuary in 2004. According to accounts of Yurok Tribal elders, the last noticeable runs of eulachon were observed in the Klamath River in 1988 and

1989 by Tribal fishermen (Larson and Belchik 1998). Larson and Belchik (1998) reported that eulachon have not been of commercial importance in the Klamath in recent years and that their current run strength is unknown. However, in

January 2007, six eulachon were reportedly caught by tribal fishermen ~~did recover eulachon from the surf zone~~on the Klamath River. Another seven were captured between January and April of 2011 at the mouth of the ~~river (M. Belchik, pers. comm. 2011). The Tribe will be sampling for eulachon in the lower Klamath River again next winter~~Klamath River (NOAA Fisheries Service 2011).

Historically, eulachon runs in northern California were said to start as early as December and January and peak in abundance during March and April. Historically, large numbers of eulachon migrated upstream in March and April to spawn, but they rarely moved more than 8 miles inland (NRC 2004). Spawning occurs in gravel riffles, with hatching about a month later. The larvae generally move downstream to the estuary following hatching.

Southern ~~DPS~~ Green Sturgeon DPS

The Southern Green Sturgeon DPS is listed as threatened under the ~~federal~~Federal ESA (NOAA Fisheries Service 2006a). Juvenile and adult Southern Green Sturgeon enter many estuaries along the West Coast during the summer months to forage, but their use of the Klamath River estuary ~~is unknown. The Yurok Tribe~~ has not been documented. No sturgeon tagged ~~many Green Sturgeon of~~ by the ~~Southern DPS with acoustic tags. They have been detected immediately offshore (~1/2 mile) on marine ultrasonic receivers, but there have been no detections~~ Yurok Tribe within the ~~estuary despite the fact that there are receivers there (M. Belchik, pers. comm., 2011). They are not known to use areas of the~~ Klamath River ~~upstream of the estuary, and~~have ever been detected in the range of Southern Green Sturgeon DPS (primarily San Francisco Bay) despite the presence of numerous receivers that would have detected Klamath River tagged fish if they ~~have not been observed to spawn~~had ventured there (McCovey 2011). No Southern Green Sturgeon tagged in the Sacramento/San Joaquin and/or San Francisco Bay region have ever been detected in the Klamath River~~.~~. Southern Green Sturgeon have been detected immediately offshore of the Klamath River, but have not been detected in the Klamath River estuary or mainstem despite the presence of functioning acoustic receivers in the Klamath River estuary (McCovey 2011). Overall, it appears unlikely that sturgeon from the Southern Green Sturgeon DPS currently occur within the Klamath River.

Lost River and Shortnose Suckers

Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers are endemic to the Upper Klamath Basin of southern Oregon and northern California (Moyle 2002). These species are listed as endangered under the ESA (USFWS 1988), and are endangered under CESA, as well as fully protected species under California Fish and Game ~~code section~~Code Section 5515(a)(3)(b)(4) and (6), respectively; thus any take of these species is prohibited. Threats to the population include: the damming of rivers, instream flow diversions, hybridization, competition and predation by exotic species, dredging and draining of marshes, water quality problems associated with timber harvest, the removal of riparian vegetation, livestock grazing, agricultural practices, and low lake elevations, particularly in drought years. Reduction and degradation of lake and stream

habitats in the ~~upper~~Upper Klamath Basin is considered by USFWS to be the most important factor in the decline of both species (USFWS 1993).

The Lost River sucker historically occurred in Upper Klamath Lake (Williams et al. 1985) and its tributaries and the Lost River watershed, Tule Lake, Lower Klamath Lake, and Sheepy Lake (Moyle 1976). Shortnose suckers historically occurred throughout Upper Klamath Lake and its tributaries (Williams et al. 1985; Miller and Smith 1981). The present distribution of both species includes Upper Klamath Lake and its tributaries (Buettner and Scoppettone 1990), Clear Lake Reservoir and its tributaries (USFWS 1993), Tule Lake and the Lost River up to Anderson-Rose Dam (USFWS 1993), and the Klamath River downstream to Copco Reservoir ~~(Beak Consultants 1987)~~ and probably to Iron Gate Reservoir (USFWS 1993). Shortnose sucker occur in Gerber Reservoir and its tributaries, but Lost River sucker do not.

Lost River and shortnose suckers are lake-dwelling, but spawn in tributary streams or springs (USFWS 1988). They spawn from February through May, depending on water depth and stream temperature (Buettner and Scoppettone 1990; Andreasen 1975, USFWS 2008). When spawning occurs over cobble and armored substrate, eggs fall between crevices or are swept downstream (Buettner and Scoppettone 1990). Larval Lost River and shortnose suckers spend relatively little time in tributary streams, migrating back to the lake shortly after emergence, typically in May and early June (Buettner and Scoppettone 1990). Adults return to Upper Klamath Lake soon after spawning. Lake fringe emergent vegetation is the primary habitat used by larval suckers (Cooperman and Markle 2004). Juvenile suckers utilize a wide variety of near-shore habitat including emergent vegetation, non-vegetated areas and off-shore habitat (Hamilton et al. 2011). Refugial areas of relatively good water quality are important for fish in Upper Klamath Lake during the summer and early fall, when dissolved oxygen and pH levels can be stressful or lethal in much of the lake (Coleman and McGie 1988). A recovery plan for Lost River and shortnose suckers was completed in 1994~~. A new recovery plan is currently in development~~ and ~~is expected to be published~~revised in 2011 (~~Sada, pers. comm., 2011), along with~~USFWS 2011a). Critical habitat was proposed ~~critical habitat~~but not finalized in 1994 (USFWS 1994) and reproposed for the two species on December 7, 2011 (USFWS 2011b). More detailed information for this species can be found in USFWS (2008).

Bull Trout

Bull trout (*Salvelinus confluentus*) are listed as threatened under the ESA in 1999 (USFWS 1999), and a recovery plan for the Klamath River Bull Trout DPS was published in 2002 (USFWS 2002). Historically, bull trout occurred throughout the Klamath Basin in Oregon. Currently bull trout are found in two streams in the Upper Klamath Lake watershed (Sun and Threemile creeks), six streams in the Sprague River watershed (Deming, Brownsworth, Leonard, Boulder, Dixon, North Fork Sprague), and one stream in the Sycan River watershed (Long Creek).

The distribution and numbers of bull trout are believed to have declined in the Klamath Basin due to habitat isolation, loss of migratory corridors, poor water quality, and the introduction of nonnative species. The geographic isolation of the Klamath populations

places them at greater risk of genetic effects and extirpation (NRC 2004). Bull trout exhibit two basic life-history strategies: resident and migratory. Migratory bull trout live in larger river and lake systems and migrate to small stream headwaters to spawn. In general, migratory fish are larger than resident fish. Research indicates that various types of bull trout interbreed at times, which helped maintain viable populations throughout the fish's range (Rieman and McIntyre 1993).

Bull trout reach sexual maturity in 5 to 7 years and spawn from the end of August through November. Spawning may occur annually for some populations, and every other year for the rest. Bull trout require particularly clean gravel substrates for spawning. High sediment levels suffocate eggs by reducing dissolved oxygen (Rieman and McIntyre 1996). Bull trout eggs incubate over the winter and hatch in the late winter or early spring. Emergence usually requires an incubation period of 120 to 200 days.

Juvenile bull trout migrate upstream ~~from~~ of spawning areas to grow and take advantage of cool headwater temperatures. Bull trout less than 1 year old are generally found in areas along stream margins and inside channels. Most migratory juvenile bull trout remain in headwater tributaries for 1 to 3 years before emigrating downstream to larger stream reaches. Emigration usually takes place from June to August (Rieman and McIntyre 1996).

Southern Resident Killer Whale

The Southern Resident Killer Whale (*Orcinus orca*) DPS is designated as endangered under the ESA (NOAA Fisheries Service 2005). This DPS primarily occurs in the inland waters of Washington State and southern Vancouver Island, particularly during the spring, summer, and fall, although individuals from this population have been observed off coastal California in Monterey Bay, near the Farallon Islands, and off Point Reyes (Heimlich-Boran 1988; Felleman et al. 1991; Olson 1998; Osborne 1999; NOAA Fisheries Service 2005). Southern Resident Killer Whale survival and fecundity are correlated with Chinook salmon abundance (Ward et al. 2009; Ford et al. 2009). Southern Resident Killer Whales could potentially be affected by changes in salmon populations in the Klamath River caused by the Proposed Action (food abundance is one of the elements of their critical habitat, as described in the Critical Habitat Section). Hanson et al. (2010) found that Southern Resident Killer Whale stomach contents included several different ESUs of salmon, including Central Valley fall-run Chinook salmon.

Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) are a state-listed threatened species throughout their range in California ~~(CDFG 2009)~~, but the USFWS denied the petition for ~~federal~~Federal listing because the population in California (and specifically San Francisco Bay) was not believed to be sufficiently genetically isolated from other populations (USFWS 2009). This species generally has a 2 year lifespan, although 3-year-old fish have been observed (Moyle 2002). They typically live in bays, estuaries and have sometimes been observed in the nearshore ocean from San Francisco Bay to Prince William Sound, Alaska, including the Klamath River. They prefer salinities of 15 to 30

ppt, although they can tolerate salinities from freshwater to full seawater. They prefer temperatures of 16 to 18°C and generally avoid temperatures higher than 20°C. Longfin smelt may occur in the Klamath River throughout the year. They would only be expected to use the estuary and the lowest reaches of the river. Longfin smelt spawning occurs primarily from January to March, but may extend from November into June, in fresh or slightly brackish water over sandy or gravel substrates. Temperatures during spawning in the San Francisco estuary are 7 to 14.~~5~~5 ºC. Embryos hatch in 40 days in ~~7~~7 ºC water temperature (25 days in 10.~~6~~6 ºC water) and are quickly swept downstream by the current to more brackish areas. The importance of ocean rearing is unknown. Little is known about longfin smelt populations in the Klamath River, except that they are presumably small.

3.3.3.2 Physical Habitat Descriptions

3.3.3.2.1 Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

Aquatic habitat in the Upper Klamath Basin includes both lacustrine and riverine habitats, and also includes large, thermally stable coldwater springs. The ~~upper~~Upper Klamath River upstream of Iron Gate Dam once supported large populations of anadromous salmon and steelhead by providing spawning and rearing habitat (Hamilton et al. 2005). Further, Butler et al. (2010) documented fish remains from six archaeological sites located upstream of Upper Klamath Lake to provide an independent record of Chinook salmon ~~and steelhead in~~ the Upper Klamath Basin.

Upper Klamath Lake is the most prominent feature in this part of the ~~basin~~Basin, although other lakes and reservoirs are also present. Lake Ewauna, another lake on the Klamath River mainstem, is connected to Upper Klamath Lake via the Link River. The Keno Impoundment/Lake Ewauna is formed by Keno Dam, which regulates water surface elevations in the impoundment to facilitate agricultural diversions. Implementation of the Klamath Hydroelectric Settlement Agreement (KHSA) and the Klamath Basin Restoration Agreement (KBRA) would result in the reintroduction of anadromous fish into these lakes and their tributary streams. The KBRA has substantial funding designated to improve water quality above Keno Dam.

Lower Klamath Lake, Tule Lake, Clear Lake and Gerber Reservoir in the Upper Klamath Basin could be affected by changes in water management associated with the Proposed Action and alternatives. The KBRA includes provisions for specific water allocations and delivery obligations for the Lower Klamath Lake and Tule Lake National Wildlife Refuges, which will increase availability and reliability of water supplies above historical refuge use in most years (Hetrick et al. ~~2010~~2009). These two refuges contain important habitat for Pacific Flyway waterfowl and waders (see Section 3.5). Tule Lake, Clear Lake, and Gerber Reservoir support populations of shortnose and Lost River suckers (FERC 2007; USFWS 2007a, b; NRC 2008).

Upper Klamath Lake and Lake Ewauna are affected by poor water quality conditions ~~as described in Section 3.2, Water Quality. Each summer~~. During the summer months these water bodies exhibit episodic high pH, broad daily shifts in dissolved oxygen, and ~~high~~elevated ammonia concentrations (Hamilton et al. 2011). In Upper Klamath Lake several incidents of mass adult mortality of shortnose and Lost River sucker have been associated with low dissolved oxygen levels (~~Buchanan~~Perkins et al. ~~2011a~~2000, Banish et al. 2009). Instances of pH levels above 10 and extended periods of pH levels greater than 9 lasting for several weeks ~~have been~~ are associated with large algal blooms occurring in the lake (Kann 2010). On a diel basis, algal photosynthesis can elevate pH levels during the day, with changes exceeding 2 pH units over a 24-hour period. During November–April (non-growing season) pH levels in Upper Klamath Lake are near neutral (Aquatic Scientific Resources 2005). Additional detail is provided in Section 3.2, Water Quality.

Fish passage over Link Dam is provided by a ladder. This ladder is designed to modern standards to allow the passage of shortnose and Lost River suckers, salmonids and other migratory fish, including anadromous salmonids and Pacific lamprey, if present. Keno Dam is equipped with a 24-pool weir and orifice type fish ladder, which rises 19 feet over a distance of 350 feet, designed to pass trout and other resident fish species (FERC ~~2006~~2007). The fishway at Keno Dam currently complies with passage criteria for salmonid fish, but plans are being developed to have the fishway rebuilt to criteria for lamprey and for greater anadromous salmonid runs if the Keno facility is transferred to the government as part of settlement (T. Hepler, Reclamation, pers. comm., as cited in Hamilton et al. 2011). Although suckers have been observed to use the Keno Dam fish ladder, the ladder was not designed for sucker passage and is considered generally inadequate for sucker passage (Reclamation 2002).

The Williamson and Wood Rivers are the largest tributaries to Upper Klamath Lake, with the Williamson River being the largest tributary. The Sprague River is tributary to the Williamson River, and the Sycan River is tributary to the Sprague River (Hamilton et al. 2011). These tributaries currently provide habitat for redband trout, bull trout, shortnose sucker and Lost River sucker, as well as other species. Historically these tributaries provided substantial habitat for Chinook salmon and steelhead (Hamilton et al. 2005, 2011). ~~Substantial~~Important flow contributions from springs into these tributaries provide cool summer baseflows with water temperatures and dissolved oxygen ~~(DO)~~ levels generally adequate to support coldwater fish habitat requirements (Hamilton et al. 2011); though these tributaries suffer from some water quality impairments as described in Section 3.2, Water Quality.

In addition to redband trout, shortnose and Lost River sucker, the Upper Klamath Basin supports many other fish species. Resident fishes include several species of minnow, sucker, sculpin, and salmonids. At least 18 species have been introduced into the Upper Klamath Basin including several species of minnow, catfish, sunfish, largemouth bass, and spotted bass, as well as yellow perch.

3.3.3.2.2 Hydroelectric Reach: J.C. Boyle Reservoir Downstream to Iron Gate Dam

The hydroelectric reach, from the upstream extent of J.C. Boyle Reservoir to Iron Gate Dam, includes four reservoirs (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) and two riverine reaches. Several coolwater tributaries enter the Klamath River and reservoirs in this reach. The reservoirs are productive and nutrient rich. They tend to be warm during the summer months, with mean daily temperatures sometimes reaching 23ºC (FERC 2007). Water quality in the Copco 1 and Iron Gate Reservoirs during the summer ~~is~~ is generally quite poor due to warm surface waters and annual blooms of the *Aphanizomenon flow-aquae*, *Anabaena flos-aquae*, and *M. aeruginosa* (see Section 3.~~2). These algae~~4). *M. aeruginosa*, and to an unknown extent *Anabaena flos-aquae*, produce toxins that ~~are~~ could be harmful to fish and other animals and humans. ~~Tests for the *A. flos-aquae* toxin have not been routinely performed, because adequate testing protocols have not been available (Anderson, pers. comm., 2011). *M. aeruginosa* produces a compound known to cause liver failure. Samples taken~~Routine sampling from areas

frequented by recreational users of the reservoirs ~~contained~~has documented cell counts up to 4,~~000~~ 000 times greater than what the World Health Organization considers a moderate health risk (see Section 3.4). This has resulted in ~~the~~ Copco and Iron Gate reservoirs being posted by local health officials during each summer since 2005.

The 22 miles long riverine reach between J.C. Boyle and Copco 1 Reservoirs, is divided into two reaches: a 4-mile long ~~bypass reach,~~ Bypass Reach, which receives bypass flows from J.C~~.~~. Boyle Dam, and a 17-mile long "peaking reach," which receives variable flow from hydroelectric operations. The downstream 6.2 miles is designated by CDFG as a Wild Trout Area with the whole reach managed for wild trout (FERC 2007) and the reach from the J.C. Boyle Powerhouse to the California-Oregon border is designated as a National Wild and Scenic River. Approximately 100 cubic feet per second (cfs) is released from J.C. Boyle Dam through a minimum flow outlet and the ladder. This is augmented by inflows from Big Springs of about 220 to 250 cfs (FERC 2007~~, more recent estimates indicate this inflow is about 285 cfs~~). In the peaking reach, this flow is ~~provided by~~ added to flows from the powerhouse, which can range from 0 to over 3,~~000~~ 000 cfs, depending on water availability (FERC 2007). Depending on water availability, power demands and whitewater boating needs, peaking operations can occur daily, or cycles may extend over several days. The 1.~~5~~4 mile long Copco 2 Bypass Reach, has flows of about 5 cfs provided below Copco 2 Dam. ~~Both~~Disregarding flow requirements, both of these riverine reaches provide complex physical habitat suitable for salmonid spawning and rearing.

A number of tributary streams come into this reach, including Spencer, Shovel, Fall, Spring, and Camp Creeks. These streams provide suitable coldwater spawning and rearing habitat for riverine fish.

The reservoirs currently provide a recreational fishery for non-native fishes including largemouth bass, trout, catfish, crappie, and sunfish (Hamilton et al. 2011). Fishing is popular in Copco 1 and Iron Gate Reservoirs, especially for yellow perch~~,~~; this area is known locally as the best yellow perch fishery in California (Hamilton et al. 2011). These reservoirs also support ~~the~~ small numbers of native shortnose and Lost River suckers ~~in small numbers~~ that are believed to be individuals that have migrated down from the upstream reservoirs and that are not thought to be self-sustaining populations or to be contributing to populations in upstream areas (Hamilton et al. 2011). Fish collections by Oregon State University in Copco 1 Reservoir during 1998 and 1999 found about 13 percent of all adult fish caught were listed suckers, primarily shortnose sucker. One percent of the adult fish in Iron Gate Reservoir were listed sucker, and those were only shortnose sucker. Riverine sections between reservoirs support populations of speckled dace, marbled sculpin, tui chub, and rainbow and redband trout. This area historically supported anadromous fish populations, including Chinook and coho salmon, steelhead, and Pacific lamprey. These fish can no longer access this area because of the lack of adequate facilities for fish passage at the dams.

3.3.3.2.3 Klamath River from Iron Gate Dam Downstream to Estuary

The ~~lower~~Lower Klamath River flows unobstructed for 190 miles downstream ~~of~~ from Iron Gate Dam before entering the Pacific Ocean. Downstream ~~of~~ from Iron Gate Dam, the Klamath River has a gradient of approximately 0.0025 and four major tributaries enter this reach: the Shasta, Scott, Salmon, and Trinity Rivers.

The ~~river basin~~Klamath Basin downstream ~~of~~from Iron Gate Dam supports anadromous fish, including fall-run and spring-run Chinook salmon, coho salmon, steelhead, green sturgeon, American shad, and Pacific lamprey. Most of the anadromous salmonid species spawn primarily in the tributary streams, although fall-run Chinook salmon and coho salmon do spawn on the mainstem. The mainstem also serves as a migratory corridor and as rearing habitat for juveniles of many salmonid species (FERC 2007). The amount of time spent on the mainstem varies with species, run, temperature and hydrologic conditions in the mainstem and the tributaries. Pacific lamprey are also found throughout the mainstem Klamath River and its major tributaries downstream ~~of~~from Iron Gate Dam. Green sturgeon (belonging to the Northern Green Sturgeon DPS) spawn and rear in the Klamath River downstream ~~of~~from Ishi Pishi Falls, and in the Salmon and Trinity Rivers. Tributaries to the Klamath River provide hundreds of miles of suitable habitat for anadromous fish. ~~Stocks of anadromous~~Anadromous fish stocks have declined substantially from historical ~~levels~~abundance (NRC 2004, FERC 2007). The ability of the mainstem Klamath River to support the rearing and migration of anadromous species is reduced by periodic high water temperatures during summer, poor water quality (low ~~DO~~dissolved oxygen and high pH; see Sections 3.2.3.5 and 3.2.3.6), and disease outbreaks during spring. Habitat quality in the tributaries is also affected by high temperatures. The Shasta and Scott Rivers also are impaired by low flows, high water temperatures, stream diversions, non-native species, and degraded spawning habitat (Hardy and Addley 2001; FERC 2007; North Coast Regional Water Quality Control Board [NCRWQCB] 2010). In the Salmon River, past and present high severity fires and logging roads in the ~~basin~~Watershed contribute to high sediment yields, and continued placer mining has disturbed spawning and holding habitat (NRC 2004).

The Trinity River (RM 42.8) is not expected to be directly affected by conditions in the mainstem Klamath River, but the lower one-quarter to one-half mile of the river may be used by fish as refuge from water quality impacts during implementation of the ~~drawdown~~Proposed Action. Fish populations in the Trinity River are expected to be directly affected by the Proposed Action while migrating along the mainstem Klamath River, and indirectly affected by potential changes in salmonid escapement to the ~~basin.~~ Basin.

3.3.3.2.4 Klamath River Estuary and Pacific Ocean Nearshore

Wallace (1998) surveyed the Klamath River Estuary, and noted formation of a sand berm at the river mouth each year in the late summer or early fall, raising the water level in the estuary, reducing tidal fluctuation, and restricting saltwater inflow. The surveys found a brackish water layer along the bottom of the estuary may be extremely important ~~to~~ to rearing juvenile salmonids, as they appeared to be more abundant near the freshwater/saltwater interface. Juvenile Chinook salmon may also use the cooler brackish water layer as a thermal refuge~~.~~

The Klamath River Estuary supports a wide array of fish species and may also serve as breeding and foraging habitat for marine and estuarine species. These species include, but are not limited to all of the anadromous fish listed previously, federally threatened Southern DPS green sturgeon, Pacific herring, surf smelt, longfin smelt, eulachon, top smelt, starry flounder and other flatfish, Klamath speckled dace, Klamath smallscale sucker, prickly sculpin, and Pacific staghorn sculpin, northern anchovy, saddleback gunnel, and bay pipefish.

3.3.3.3 Habitat Attributes Expected to be Affected by the Project

The action alternatives would affect the physical, chemical, and biological components of habitat throughout the Klamath River watershed, from the tributaries to Upper Klamath Lake downstream to the Pacific Ocean. These effects would result from changes in suspended sediment, bedload sediment, water quality, water temperature, disease and parasites, and flow related habitat. As described in the following sections, these changes would act in both beneficial and harmful ways on species, critical habitat, and EFH. Appendices E and F provide more detailed technical descriptions of suspended sediment and bedload sediment. Changes in water quality are discussed in greater detail in ~~Section~~ Section 3.2, Water Quality and its associated appendices, and a description of the effects of the action alternatives on algae is found in Section 3.4, Algae. A description of these parameters, water temperature, and disease and parasites under existing conditions is provided in the following sections.

~~**Suspended Sediment**~~

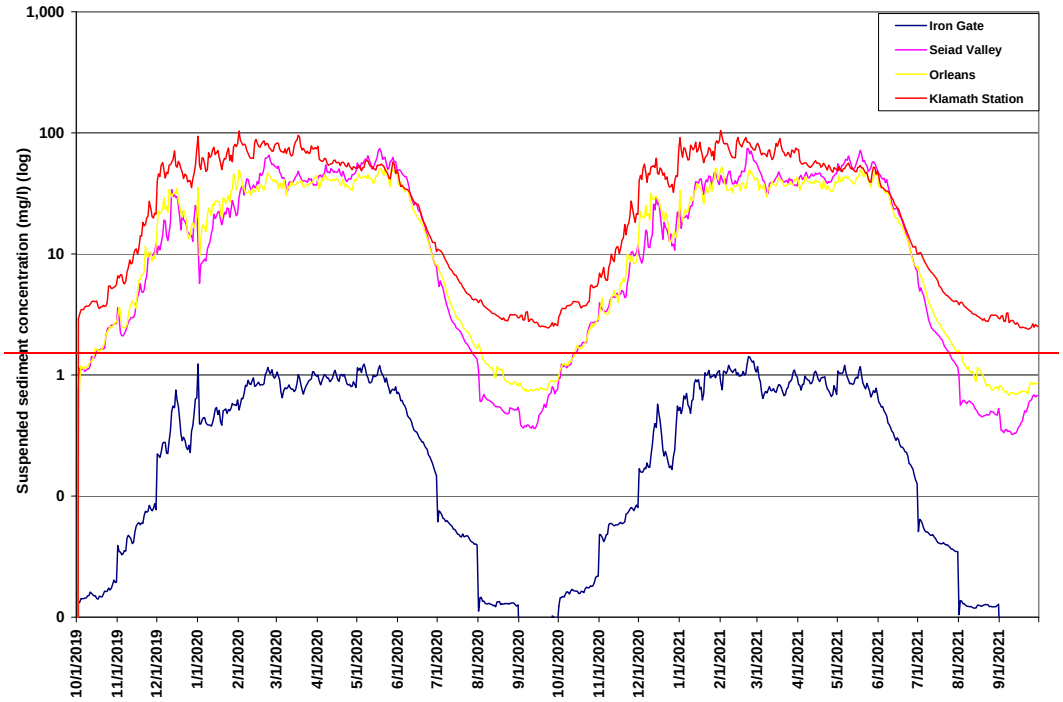
3.3.3.3.1 Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam

The downstream transport of suspended sediment can affect species through elevated suspended sediment concentrations (SSCs) that may clog or abrade the gills of fish, or reduce foraging efficiency and as the material settles on the stream bed during declining flows, it can reduce the survival of incubating eggs and developing alevins in salmonid redds by impeding intergravel flow as well as the emergence of fry. ~~SSCs~~ Everest et al. (1987) concluded all salmonids can cope with the natural variability in sediments, but salmonid populations can be reduced by persistent fine sedimentation that exceeds the natural levels under which salmonids evolved. Suspended sediments under existing conditions in the Klamath River upstream and downstream ~~of~~ from Iron Gate Dam are summarized in Section 3.2.3~~, Water Quality~~.3. In general, the data indicate that ~~suspended sediment~~ SSCs downstream ~~of~~ from Iron Gate Dam ~~ranges~~ range from less than 5 mg/L during summer low flows to greater than 5,000 mg/L during winter high flows ~~(see Section 3.2.3.3)~~. During large winter storms or following landslides in the Klamath Basin, extremely high SSCs have been observed in the Klamath River mainstem

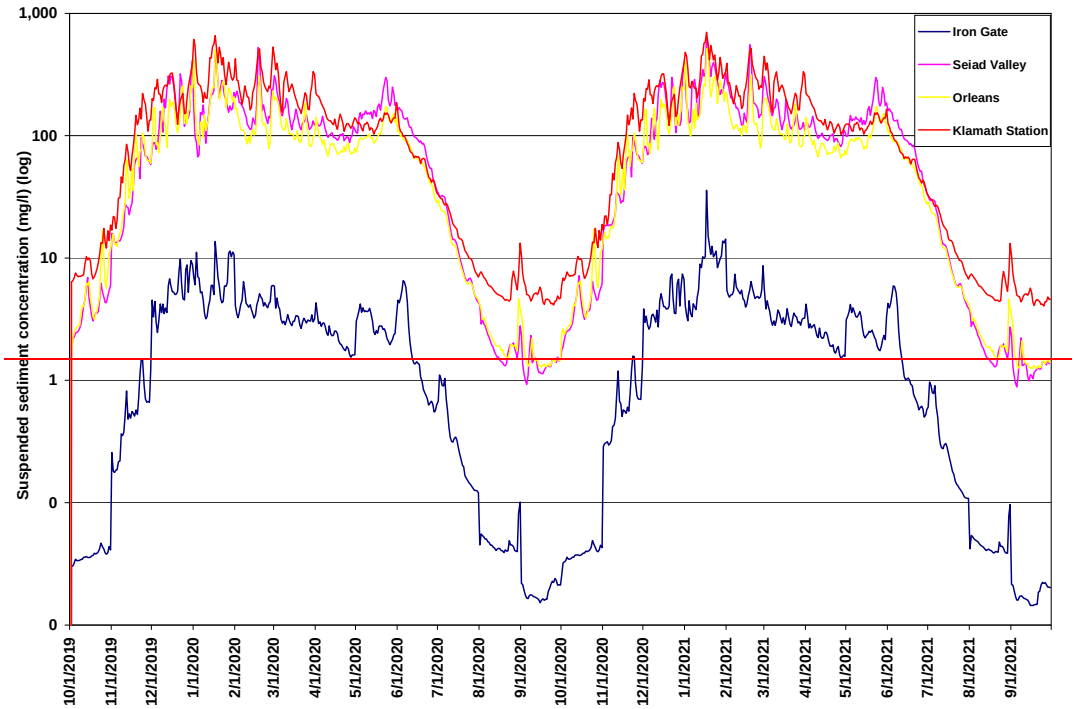
and tributaries. Appendix E provides a detailed analysis of the effects of suspended sediment on aquatic species downstream ~~of~~from Iron Gate Dam under existing conditions. To provide a reliable basis for a relative comparison of SSCs to the alternatives, SSCs under existing conditions were calculated using the SRH-1D model (Reclamation 2011) based on hydrology data from 1961 to present. SSCs were developed for two conditions meant to represent the existing range of variability under existing conditions, defined as follows:

- **Normal conditions:** ~~suspended sediment concentrations~~ SSCs and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream ~~of~~from Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded in any one year is 50 percent). Exceedance probabilities were based on modeling SSC for all water years subsequent to 1961 with facilities in place. To assess "normal conditions" the median (50 percent) ~~suspended sediment concentration~~ SSC and duration from these results was estimated (~~Figure 3.3-2).~~ Figure 3.3-2).

- **Extreme conditions:** ~~suspended sediment concentrations~~ SSCs and durations with a 10 percent exceedance probability (i.e., the probability of these concentrations and durations being equaled or exceeded in any 1 year is 10 percent). This represents an extreme condition ~~(Figure 3.3-3).~~



- ~~Figure~~ with high SSCs, such as a flood (Figure 3.3~~.~~-3~~-2. Normal conditions (50 Percent Exceedance Probability) SSCs for Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model~~).



~~Figure 3.3-3. Extreme conditions (10 Percent Exceedance Probability) SSCs for Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.~~

Under both normal and extreme conditions, SSCs of the magnitude and duration modeled are expected to cause major stress to migrating adult and juvenile salmonids primarily during winter (Newcombe and Jenson 1996, Appendix E). SSC generally increases in a downstream direction from the contribution of tributaries, and since Iron Gate Dam currently effectively traps most suspended sediment.

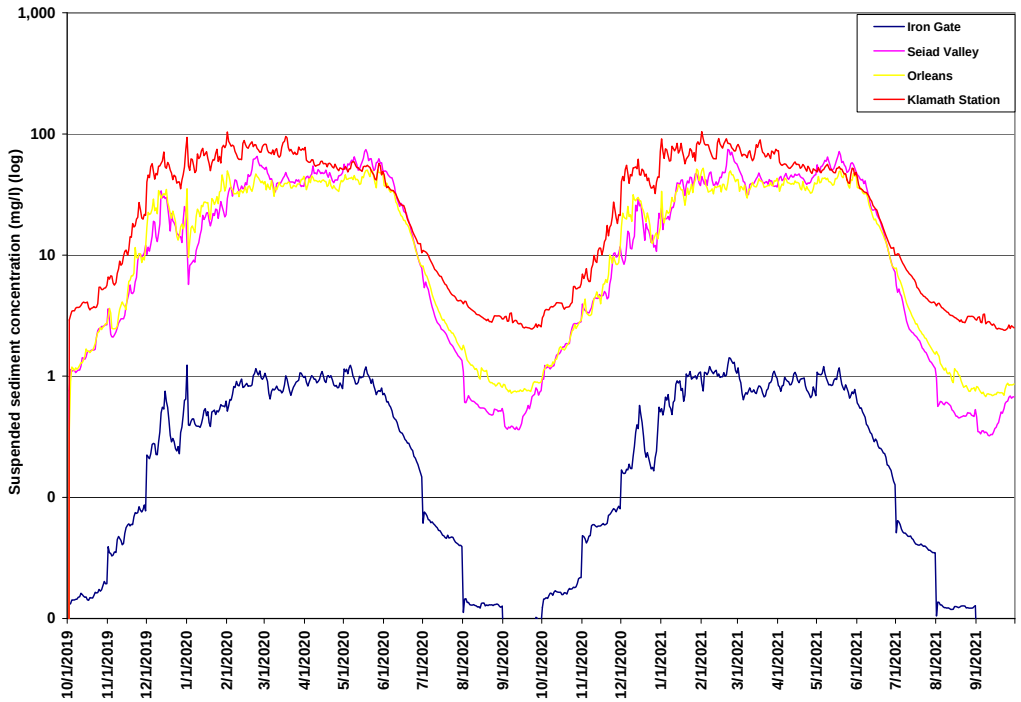


Figure 3.3-2. Normal conditions (50 Percent Exceedance Probability) SSCs for Three Locations Downstream from Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.

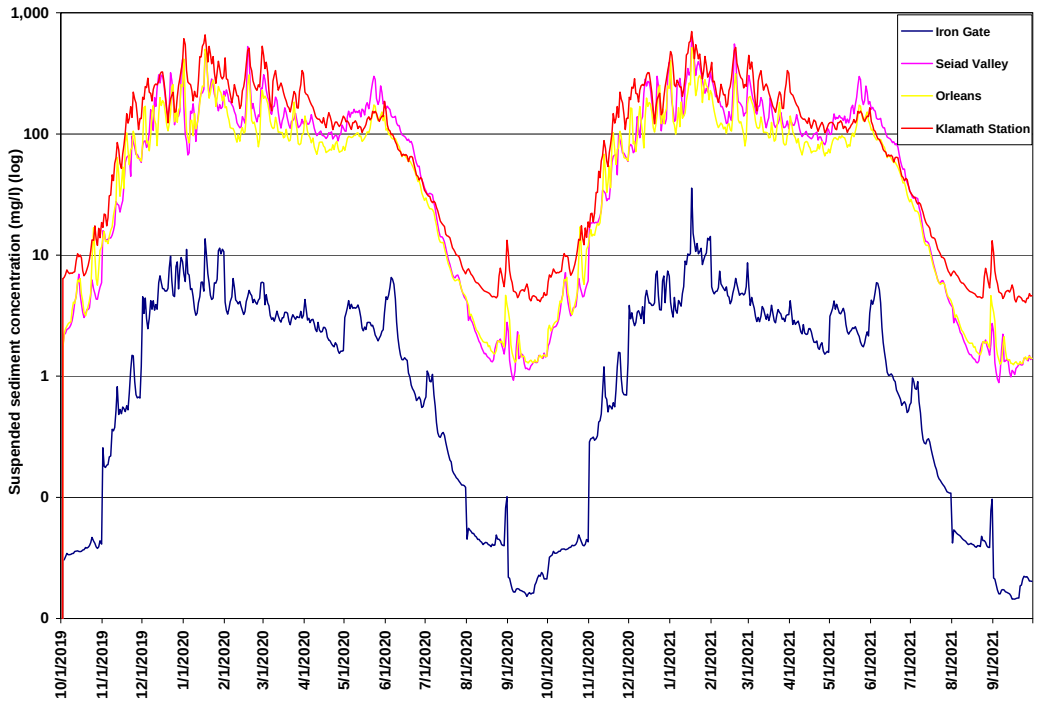


Figure 3.3-3. Extreme conditions (10 Percent Exceedance Probability) SSCs for Three Locations Downstream from Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.

Klamath River Estuary

Under existing conditions SSCs within the Klamath River Estuary ~~is~~ are relatively high compared to SSC observed further upstream (Figures 3.3-2 and Figure 3.3-3). As described in Section 3.2.4.3.1.2, the ~~lower~~ Lower Klamath River downstream ~~of~~ from the Trinity River confluence to the estuary mouth is currently listed as sediment impaired under Section 303(d) of the Clean Water Act, as related to protection of the cold freshwater habitat beneficial use associated with salmonids (NCRWQCB 2010). Modeling in the Klamath River (from Seiad Valley at approximately RM 128 downstream to the Klamath Station at RM 5) indicates that under normal conditions ~~indicates that~~ SSCs are ~~generally less than~~relatively high during winter (typically 50 to 100 mg/L ~~year-round (Figure 3.3-2), and under~~), and lower (< 10 mg/L) during summer. Under extreme conditions ~~are less than 100mg/L~~ the SSC is generally 10 to 100 mg/L in summer and fall ~~but can spike to well over 100 mg/L~~ , with peaks between 100 and 1,000 mg/L during winter and spring (~~Figure 3.3-3~~Figure 3.3-3).

Pacific Ocean Nearshore Environment

Under existing conditions a "plume" exists within the nearshore environment in the Klamath River vicinity that is subject to strong land runoff effects following winter rainfall events. ~~These effects include~~ The plume can create areas of low-salinity, high levels of suspended particles, high sedimentation, and low light (and potential exposure

to land-derived contaminants). The extent and shape of the plume is variable, and influenced by wind patterns, upwelling effects, shoreline topography (especially Point Saint George), and longshore currents. High SSCs events contribute to the plume, especially during floods. ~~In a recent study of the Eel River nearshore sediment plume, located approximately 80 miles to the south of the Klamath River,~~As described in ~~*situ* measurements of~~ detail in Section 3.2.4.3.2, in northern California, plume ~~characteristics indicated no relationship with SSCs, turbulent-kinetic-energy, time from~~ zones are primarily north of river mouth~~, wind speed, wave height, or discharge. A relationship apparently did exist between effective settling velocity (bulk mean settling velocity) of plume sediments~~ s because alongshore currents and ~~wind speed/direction, as well as with tides (Curran~~prevailing winds are northward during periods of strong runoff (Geyer et al. ~~2002).~~2000, Pullen and Allen 2000, Farnsworth and Warrick 2007). River plumes and the associated habitat conditions they create are considered to be areas of high productivity for marine organisms (Grimes and Finucane 1991, Morgan et al. 2005), and create abrupt changes in marine water quality conditions (e.g., water temperature, salinity, sediment) that support salmonids (Schabetsberger et al. 2003, DeRobertis et al. 2005).

3.3.3.3.2 Bedload

Appendix F describes current habitat conditions and assesses the changes to bedload sediment within the analysis area for existing conditions, and under each Klamath River EIS/EIR alternative. The sections below provide a brief summary of the analysis provided in Appendix F. Bedload sediment movement and transport are vital to create and maintain functional aquatic habitat. Bedload sediment, in the form of sand, gravels, cobbles and boulders is naturally delivered to and transported in streams and rivers. Natural sediment pulses that result from heavy rainfall and snowmelt events are incorporated by stream and river processes into spawning beds, gravel bars, side channels, pools, riffles and floodplains that provide habitat and support food chains of aquatic species. These periodic inputs of bedload sediments are necessary for the long-term maintenance of aquatic habitats. Salmonids evolved with bedload sediment transport and depend on continued sediment delivery to provide substrate suitable for spawning and early rearing in streams and rivers. As described in detail below, these processes have been disrupted in the Klamath River by the construction of dams.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

For all practical purposes, the amount of inorganic, fluvial sediment supplied to the Klamath River from the Klamath Basin upstream of Keno Dam is negligible (Reclamation ~~2011~~2012). Upper Klamath Lake, with its large surface area, traps nearly all inorganic sediment delivered from upstream tributaries, although some finer material may be transported through the lake during high runoff events.~~ All fluvial sediment supplied to reaches downstream of Iron Gate Dam is delivered to the Klamath River between Keno Dam and Iron Gate Dam. Sources within this reach supply 24,160 tons/year of coarse sediment (1.3 percent of the cumulative average annual basin wide coarse sediment delivery) (Stillwater Sciences 2010a).~~

Hydroelectric Reach: Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

The Project reservoirs are the dominant feature in this 38-mile reach, with a 22-mile riverine section between J.C. Boyle Dam and Copco 1 Reservoir and a 1.~~5~~4-mile riverine reach between Copco 2 Dam and Iron Gate Reservoir. Fluvial sediment (>0.063 mm) supply from the reach between Keno Dam and Iron Gate Dam is around 24,160 tons/year, which is 1.3 percent of the cumulative average annual basin wide sediment delivery to the Pacific Ocean (Stillwater Sciences 2010a). The four Project ~~dams~~reservoirs currently store 13.1~~5~~ million cubic yards (yd^3) of sediment (Reclamation ~~2011~~2012), with Copco 1 Reservoir storing the largest amount of sediment (~~Table 3.3~~ Table 3.3-2). The sediment stored behind the dams has high water content and 85 percent of its particles are silts and clays (particle size less than 0.063 mm) while 15 percent are sand or coarser (particle size higher than 0.063 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences 2008; Reclamation ~~2011). As such, most sediment released from behind the dams under the Proposed Action would be silt and clay (less than 0.063 mm) with smaller fractions of sand (0.063 to 2 mm), gravel (2 to 64 mm), and cobble (64 to 256 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences2010a; Reclamation 2011).~~ 2012).

~~**Table 3.3-2. Estimated Volume of Sediment Currently Stored within Hydroelectric Reach Reservoirs (Reclamation 2011).**~~

Table 3.3-2. Estimated Volume of Sediment Currently Stored within Hydroelectric Reach Reservoirs (Reclamation 2012)

Reservoir	Current Sediment Volume (yd^3)
J.C. Boyle	1,000,000
Copco 1	7,440,000
Copco 2	0
Iron Gate	4,710,000
Total	**13,150,000**

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam

Downstream ~~of~~ from Iron Gate Dam, channel conditions reflect the interruption of sediment flux from upstream by Klamath Hydroelectric Project dams and the eventual re-supply of sediment from tributaries entering the mainstem Klamath River (PacifiCorp 2004a; Reclamation ~~2011~~2012). The reach from Iron Gate Dam to Cottonwood Creek (RM 182.1) is characterized by coarse, cobble-boulder bars immediately downstream ~~of~~from the dam, transitioning to a cobble bed with pool-riffle morphology farther downstream near Cottonwood Creek (Montgomery and Buffington 1997; PacifiCorp 2004a; Stillwater Sciences 2010a). Cottonwood Creek to the Scott River is a confined channel with a cobble-gravel bed and pool-riffle morphology (PacifiCorp 2004a). The median bed material ranges from 45 to 50 mm, but bar substrates become finer in the downstream direction, with median sizes of 49 mm and 25 mm at the upstream and downstream ends, respectively. Downstream ~~of~~ from the Scott River, including through

the Seiad Valley, the Klamath River is cobble-gravel bedded with pool-riffle morphology (PacifiCorp 2004a). PacifiCorp (2004a) also noted increasing quantities of sand and fine gravel on the bed surface with distance downstream, likely reflecting the resupply of finer material from tributaries to the Klamath River.

~~The~~ Upper Klamath Lake, Keno Impoundment/Lake Ewauna, and the Klamath Hydroelectric Project dams trap most of the finer sediment produced in the low sediment yielding, young volcanic terrain upstream of the dams, which results in coarsening of the channel bed downstream ~~of~~from the dams until tributaries resupply the channel with finer sediment. ~~However, most of the supply from the portion of the watershed upstream of J.C. Boyle Reservoir is trapped in Upper Klamath Lake, which is a natural lake.~~ Most (≈98 percent) of the sediment supplied to the mainstem Klamath River (Stillwater Sciences 2010a) currently is delivered from tributaries downstream ~~of~~ from Cottonwood Creek, limiting the effects of interrupting upstream sediment supply ~~downstream of around~~ to the reach between JC Boyle Reservoir and approximately the Scott River.

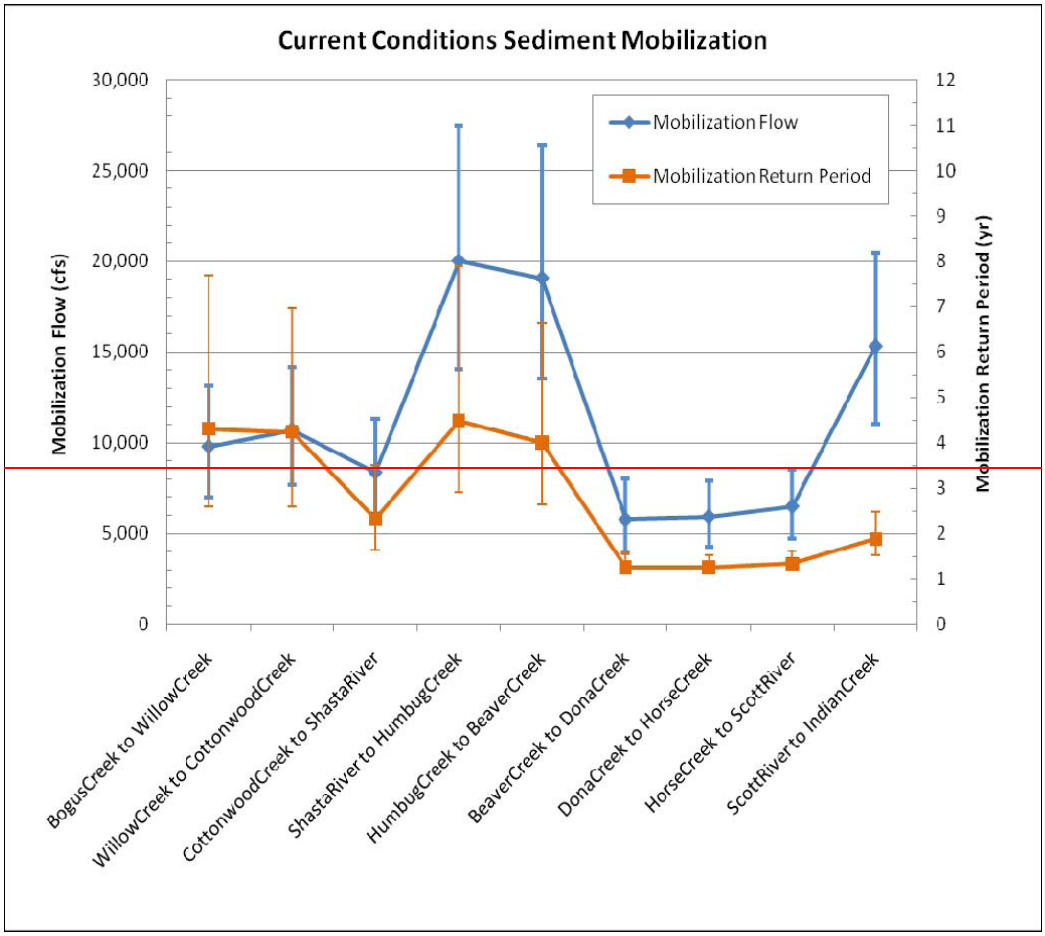
This sediment interception has disrupted geomorphic and vegetative processes that form channel habitats and create spawning gravels downstream from Iron Gate Dam (Buer 1981; PacifiCorp 2004a; Klamath River Basin Fisheries Task Force 1991). Since the construction of the Project, sediment and spawning gravel have been intercepted by Project reservoirs and cut off by the Iron Gate Dam. The resultant reduction in spawning gravels downstream from Iron Gate Dam has been identified as one of the causes of the decline in salmonid fry production in this reach of the Klamath River (Buer 1981). In

response to this recognized limiting factor, the California Department of Water Resources initiated gravel augmentation programs for spawning gravel downstream from Iron Gate Dam (Buer 1981).

Reclamation (2011a) used reach average hydraulic properties and previously collected grain size data to estimate the flow magnitude and return period at which sediment mobilization occurs downstream ~~of~~ from Iron Gate Dam. The estimates did not include the reach from Iron Gate Dam to Bogus Creek, for which there were no grain size data. Reclamation (2011a) assumed this reach to be fully armored because there has been no sediment supplied to this reach in the past 50 years because the dams capture sediment from upstream. From downstream ~~of~~ from Bogus Creek to Willow Creek, flows to mobilize median substrate sizes (D50) ranged from 6,800 to 12,700 cfs, and recur every 2.6 to 7.~~5~~ 5 years, on average (~~Figure 3.3-4).~~ Figure 3.3-4).

~~**Water Quality**~~

~~Section 3.2.3 provides information regarding water quality as it relates to aquatic resources in the area of analysis. As described, therein, many water bodies in the area of analysis are listed under Section 303 (d) of the Clean Water Act for a variety of parameters including temperature, sediment and turbidity, nutrients, dissolved oxygen, pH, ammonia, Chlorophyll *a*, and microcystin (Table 3.2-8 in Section 3.2., Water Quality). The SSCs, dissolved oxygen, and temperature are evaluated in greater detail in Section 3.3.3.3. Microcystins are also addressed in Section 3.4, Algae.~~


Current Conditions Sediment Mobilization
Mobilization Flow
Mobilization Return Period
Mobilization Flow (cfs)
Mobilization Return Period (yr)
30,000
25,000
20,000
15,000
10,000
5,000
0
12
11
10
9
8
7
6
5
4
3
2
1
0
BogusCreek to WillowCreek
WillowCreek to CottonwoodCreek
CottonwoodCreek to ShastaRiver
ShastaRiver to HumbugCreek
HumbugCreek to BeaverCreek
BeaverCreek to DonaCreek
DonaCreek to HorseCreek
HorseCreek to ScottRiver
ScottRiver to IndianCreek

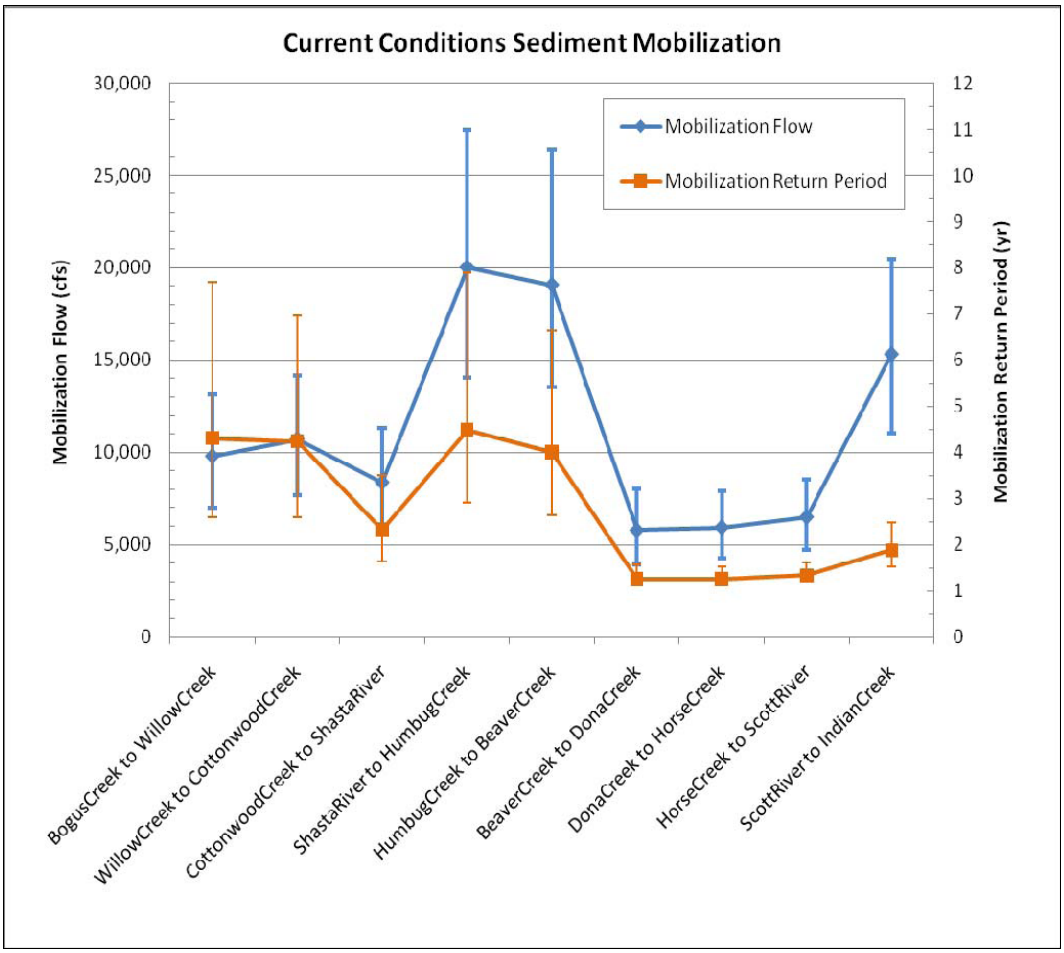


Figure 3.3-4. Mobilization Flow and Return Period at which Sediment Mobilization Occurs (Reclamation 2011) 2012).

3.3.3.3.3 Water Quality

Sections 3.2.2 and 3.2.3 provide information regarding regulatory considerations and existing conditions for water quality in the area of analysis, including those that can directly affect beneficial uses for aquatic species (i.e., water temperature, suspended sediments, dissolved oxygen, pH, and algal toxins such as microcystin). As described therein, multiple water bodies in the area of analysis, including the mainstem Klamath River, are listed under Section 303(d) of the Clean Water Act (CWA) for a variety of water quality parameters such as water temperature, sedimentation, nutrients, dissolved oxygen, pH, ammonia, chlorophyll-*a*, and microcystin (Table 3.2-8 in Section 3.2., Water Quality). Existing conditions for water temperature and algal toxins are evaluated in greater detail below with respect to implications on fish health and survival in the Klamath Basin. Microcystin concentrations are also addressed in Section 3.4, Algae.

3.3.3.3.4 Water Temperature

As described in Section 3.2, Water Quality, the entire Klamath River~~, including Upper Klamath Lake, Lost River, and the Klamath Straights Drain,~~ from the Klamath Estuary to Keno Dam has been listed as impaired for water temperature (~~Oregon Department of Environmental~~ Table 3.2-8 in Section 3.2, Water Quality ~~(ODEQ 2002). Temperatures in~~). Water temperatures in the Klamath River are of special concern as they are elevated with a greater frequency and they remain elevated for longer periods of time than temperatures in adjacent coastal anadromous streams, and ~~are currently~~ they are seasonally marginal in the lower mainstem for anadromous salmonids (Bartholow 2005). These elevated temperatures are especially detrimental to anadromous species during the warmer portions of the year (ODEQ 2002). Acute thermal effects for salmonids are expected to occur as mean daily water temperatures begin to exceed 20°C (Bartholow 2005). Bartholow (2005) expressed concern that if water temperature trends in the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam continue, some stocks may decline to levels insufficient to ensure survival. Klamath River salmonids are generally more tolerant of high water temperatures than salmonids from other basins (FERC 2007, Foott et al. 2012). Moreover, the Administrative Law Judge (2006) found that juvenile steelhead trout can withstand incrementally higher temperatures exceeding 22 °C provided food is abundant and by finding thermal refuge or by living in areas where nocturnal temperatures drop below the thermal threshold. Elevated temperatures can affect the timing of different life-history events, altering migration patterns, delaying and shortening the spawning season, impairing reproductive success, reducing growth, and result in an ongoing lack of temporal diversity (Hamilton et al. 2011). High water temperatures can contribute to low dissolved oxygen events by reducing dissolved oxygen solubility and accelerating oxygen-demanding processes, and can facilitate the spread of disease (Wood et al. 2006). Stress associated with high water temperatures can make cold water species more vulnerable to disease and parasites, and have been associated with fish kills in the Klamath River downstream ~~of~~ from Iron Gate Dam during low flow periods in late summer (Hardy and Addley 2001).

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

~~Summer water temperatures~~Both Upper Klamath Lake and the Keno Impoundment/Lake Ewauna are ~~naturally high~~relatively shallow; temperatures in Upper Klamath Lake, the Keno Impoundment/Lake Ewauna, and J.C. Boyle Reservoir are generally warm during the late spring through early fall (see Section 3.2.3.2). In the summer, instantaneous maximum water temperatures of 22 to 24 °C are common in the upper 3 to 6 feet of Upper Klamath Lake and temperatures can approach a maximum of 30 °C near the surface (PacifiCorp 2004a). Although prolonged exposure to these high temperatures could be lethal for some species, these temperatures remain within tolerance criteria for migrating adult anadromous salmonids ~~(~~during the period when migration would be expected (Dunsmoor and Huntington 2006, Hamilton ~~et~~ et al. 2011~~), and~~). In addition, anadromous salmonids successfully navigated through the lake to spawn in the Upper Klamath Basin prior to their access being blocked by the Project. ~~In the late summer and early fall, temperatures~~Temperatures in Upper Klamath Lake are actually cooler than those downstream ~~of~~from Iron Gate Dam in the late summer and early fall when fall-run Chinook salmon are migrating. In addition, thermal refugia are available in this reach where fish can moderate the temperatures they are exposed to. Upper Klamath Lake supports a population of redband trout that move into cooler tributary habitats in the summer, but which have high growth rates while in the lake. Those in the lake over the summer can find thermal refuge in Pelican Bay, which is fed by springs and remains cool (Dunsmoor and Huntington 2006). Wetlands surround this bay and would be expected to provide juvenile salmonids with excellent rearing habitat (Dunsmoor and Huntington 2006).

~~Both Upper Klamath Lake and the Keno Impoundment/Lake Ewauna are relatively shallow; temperatures in Upper Klamath Lake, the Keno Impoundment/Lake Ewauna, and J.C. Boyle Reservoir are generally warm during the late spring through early fall (see Section 3.2.3.2). Under existing conditions, water temperatures are suitable for migrating salmonids from mid-September to mid-June in Upper Klamath Lake and Keno Impoundment (Dunsmoor and Huntington 2006).~~

The Keno Impoundment/Lake Ewauna has generally poor water quality in the summer, with instantaneous maximum water temperatures exceeding 25 °C and low dissolved oxygen (Hamilton et al. 2011). These warm temperatures are also present downstream ~~of~~from Keno Dam. However, from November through mid-June, the reach from Link River Dam to Keno Dam is cooler (below 20 °C) and meets criteria for migrating adult anadromous salmonids (Hamilton et al. 2011). Temperatures in the Link River and the Keno Impoundment/Lake Ewauna tend to increase in the summer; maximum water temperatures (22 to 25 °C) are still within the preferred range for warm- and some cool-water species found in the Upper Klamath Basin (yellow perch, catfish, sunfish, largemouth bass, and spotted bass~~), but temperatures above 22 to 25°C are potentially lethal to anadromous salmonids.~~

).

Hydroelectric Reach: Klamath River from Upstream End of J.C~~.~~. Boyle Reservoir to Iron Gate Dam

Water temperatures through the Hydroelectric Reach are generally warm in the reservoirs from late spring through early fall, but tributaries in this reach are generally cool ~~(see Section 3.2.3.2)~~. In addition, numerous cold-water springs contribute flows to both Copco 1 and Iron Gate Reservoirs. Average monthly water temperatures within reservoirs from 2001 to 2004 ranged from just over 5 °C in November to more than 22 °C in June through August (FERC 2007), with thermal stratification in Copco 1 and Iron Gate reservoirs resulting in relatively warm discharge waters during summer months. Water temperatures at the downstream end of the J.C. Boyle Bypass Reach and in the Klamath River upstream of Shovel Creek are consistently cooler than other sites sampled between Link Dam and the Shasta River (PacifiCorp 2004b) (see Section 3.2.3.2). Temperatures in the J.C. Boyle Bypass Reach are cooled by the contribution of 200 to 250 cfs of groundwater within the reach. The cool water input from the bypass reach during the summer results in a relatively lower daily water temperature range in the Klamath River in the J.C. Boyle Peaking Reach (FERC 2007).

Temperature data for tributary reaches are based on a limited study period as described in PacifiCorp (2004a). Fall Creek, which flows into Iron Gate Reservoir, is generally cold year-round and does not exceed 14 °C degrees during the summer (Pacificorp 2004a). Temperatures in Jenny Creek, which also flows into Iron Gate Reservoir, vary seasonally, ranging from less than 10°C in the spring to more than 22 °C in July and August (PacifiCorp 2004a). Temperatures in Shovel Creek are generally low year-round and do not exceed 15 °C in the summer (PacifiCorp 2004a). Spencer Creek temperatures are low during spring (<15 °C) and are generally below 18°C, but can exceed 20 °C for short durations (Pacificorp 2004a).

Copco 1 and Iron Gate Reservoirs reach maximum temperatures exceeding 20 °C near their surfaces during the summer while maintaining average temperatures near 8 °C or 10 °C when stratified (PacifiCorp 2004a). These cooler water temperatures at a depth >6–8 m below the surface (see Appendix C, Section C.1.1.4) are a result of ~~4°C~~the retention of cold water ~~entering~~ in Copco 1 and Iron Gate ~~Reservoirs from upstream areas~~ reservoirs during the winter, and the relatively shallow outlets of both reservoirs (PacifiCorp 2004a). ~~During reservoir~~Summertime thermal stratification~~, dissolved oxygen in Iron Gate and Copco 1 in deeper waters decreases and can reach minimum values close to 0 mg/L by July near the reservoir bottoms (see~~ in Copco1 and Iron Gate reservoirs is typically accompanied by hypoxia (Appendix C, Section C.4.1.4). Although water temperatures ~~are increasing~~increase in the summer months (see Section 3.2.3.2), temperatures documented in ~~these reaches are all~~ the Hydroelectric Reach are within the tolerance ranges of the species observed there ~~(see Section 3.2.3.2)~~, but would be considered seasonally stressful for cold water species.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

Water temperatures in spring in the Lower Klamath Basin downstream ~~of~~from Iron Gate Dam can be slightly cooler from reservoir releases than those upstream of Iron Gate Dam (see Section 3.2.3.2), with this difference diminishing downstream ~~of~~from Iron Gate Dam

with no noticeable difference just upstream of the Salmon River confluence. Summer weather conditions, however, can be severe from June through September, and rising ambient ~~air~~ air temperatures can lead to increased water temperatures (Hamilton et al. 2011). Downstream ~~of~~from Iron Gate Dam, mean monthly temperatures in the river are 3 to 6 °C in January and 20 to 22.5 °C in July and August (Bartholow 2005). Substantial losses of juvenile salmonids have occurred during their migration through the ~~lower~~Lower Klamath River, and were especially severe during low-water years with periods of sustained high water temperatures, which may cause them to crowd into thermal refugia and may reduce the resistance of these fish to disease and other stressors (Scheiff et al. 2001). Summary statistics compiled by the United States Environmental Protection Agency (EPA) indicate that water temperatures at locations between Iron Gate Dam and the Klamath River's confluence with the Scott River range from about 16 to 22 °C in June, and from 16 to 26 °C in July (FERC 2007). The Klamath Basin downstream ~~of~~from Iron Gate Dam (i.e., the Lower Klamath Basin) supports a variety of species of anadromous fish including fall and spring Chinook salmon, coho salmon, steelhead, green sturgeon, and Pacific lamprey. From May through September (peaking in June–August) summer temperatures begin to warm to stressful levels for cold water species such as salmon, steelhead, and Pacific lamprey.

Klamath River Estuary and Pacific Ocean Nearshore Environment

Water temperatures in the estuary range from 5 to 12 °C from December through April (Hiner 2006). Warmer air temperatures and lower flows in summer and fall months result in increased water temperatures ranging from 20 to 24°C (Hiner 2006). Under summer low-flow conditions, water temperatures in the Klamath Estuary exceed those for optimal growth as well as critical thermal maxima for Chinook salmon, coho salmon, and steelhead (Stillwater Sciences 2009a). ~~Input~~However, this effect is reduced by input of cool ocean water ~~provides cooler areas for fish~~ and a high prevalence of coastal fog ~~along the coast minimizes this effect much of the time~~.

3.3.3.3.5 Disease and Parasites

Fish diseases, specifically the myxozoan parasites *Ceratomyxa shasta* (*C. shasta*) and *Parvicapsula minibicornis,* periodically result in substantial mortality for Klamath River salmonids, (though steelhead are generally resistant to *C. shasta*). Additional diseases that may affect fish in the Klamath Basin include *Ichthyophthirius multifis* (Ich) and *Flavobacterium columnare* ("columnaris disease"). These parasites and diseases occur throughout the watershed, but appear to cause the most severe mortality in the Lower Klamath Basin where *C. shasta* has been observed to result in high rates of mortality in salmon. Ich and columnaris ~~occur episodically,~~ occasionally result~~ing~~ in substantial mortality (e.g., the 2002 fish kill of ~~juvenile and~~primarily adult Chinook salmon). ~~-~~The effects of Ich and columnaris are generally not as harmful on a population level as the myxozoan parasites, although impacts on juvenile salmonids and other species have not been well studied.

Both *P. minibicornis* and *C. shasta* spend part of their life cycle in an invertebrate host and another part in a fish host. Transmission of these parasites is limited to areas where the invertebrate host is present. In the Klamath River, their invertebrate host is the annelid polychaete worm *Manayunkia speciosa* (Bartholomew et al. 1997, 2007). Once the polychaetes are infected, they release *C. shasta* actinospores into the water column. Actinospores are generally released when temperatures rise above 10°C and remain viable ~~-~~from 3 to 7 days at temperatures from 11 to 18ºC, with temperatures outside that range resulting in a shorter period of viability (Foott et al. 2007). The longer the period of viability, the wider the distribution of the actinospores~~, raises~~ within the river, and thus the higher the risk of exposure ~~rate of~~ for salmon ~~over a larger area of the river~~ (Bjork and Bartholomew 2010). Actinospore abundance, a primary determinant of infectious dose, is controlled by the number of ~~infected~~ polychaetes and the prevalence and severity of infection within their population.

Salmon become infected when the actinospores enter the gills, eventually reaching the intestines where the parasite replicates and matures to the myxospore stage. Myxospores are shed by the dying and dead salmon, and the cycle continues with infection of polychaete worms by the myxospores (Bartholomew and Foott 2010). The polychaete host for the parasite is present in a variety of habitat types, including runs, pools, riffles, edge-water, and reservoir inflow zones, as well as sand, gravel, boulders, bedrock, aquatic vegetation, and is frequently ~~present with a periphyton~~found among mats of

filamentous periphytic algal species: (e.g. Cladophora-) that traps fine sediment and organic detrital matter.

(Bartholomew and Foott 2010). Slow-flowing and more stable, depositional habitats (e.g., pools with sand) may support higher densities of polychaetes, (Bartholomew and Foott 2010), especially if instream flows remain constant. The mobilization of particles on the bed of the channel downstream from Iron Gate Dam depends directly upon the size of the substrate and magnitude of peak flows. The greater the flows, the larger the particles likely to be moved, and the smaller the particle, the lower the flow required for mobilization. Polychaetes are more persistent if the substrate remains immobile for long periods (on the order of years). Under historical conditions frequent flood events and natural sediment supply, combined with considerable intra-annual flow variability, ensured that the substrate was frequently mobilized. Under existing conditions with dams in place, sediment supply is reduced, flow variability is decreased, and conditions supporting the persistence of polychaetes are more prevalent.

~~Bartholomew (1998) noted that native~~Native populations of salmonids in waters where *C. shasta* is endemic generally develop a high degree of resistance to the disease. Stocking et al. (2006) conducted studies of the seasonal and spatial distribution of *C. shasta* in the Klamath River. The study included the exposure of fall Chinook salmon (*Oncorhynchus tshawytscha*; Iron Gate Hatchery strain). The study found the polychaete host, *M. speciosa*, from Upper Klamath Lake to the mouth of the river. Although infection rates were high in non-native, non-resistant, rainbow trout, used as sentinel fish in the upper Klamath River upstream of Iron Gate Dam and ~~below~~downstream from the Williamson River, mortality rates were very low (Stocking et al. 2006). Chinook salmon at this location did not become infected. Minimal mortality in both was likely due to low levels of parasites in this area and a predominance of Type 0 genotype of *C. shasta* (see below). Because the parasites are endemic to the watershed, the native salmonid populations have some level of resistance to the disease. However, an altered river channel ~~below~~downstream from Iron Gate Dam, where the bed has been atypically stable, has provided favorable habitat for the polychaete worm host, likely increasing the parasite load to which the fish are exposed. High parasite loads are believed to lead to higher rates of mortality.

Susceptibility to *C. shasta* is also influenced by the genetic type of *C. shasta* fish encounter~~s~~. Atkinson and Bartholomew (2010) conducted an analysis of the genotypes of *C. shasta* and the association of these genotypes with different salmonid species, including Chinook and coho salmon, steelhead, rainbow trout, and redband trout. In the Williamson River, although parasite densities had been found to be high, Chinook salmon were resistant to infection because the genotype specific to Chinook salmon was absent. In a genetic analysis, the *C. shasta* genotypes were characterized as Type 0, Type I, ~~Type~~ Type II and Type III (Table 3.3-3):

Table 3.3-3. C~~.~~eratomyxa shasta ~~Genotypes~~genotypes in the Klamath Basin.

C. shasta Genotype	Distribution	Affected Species	Notes
Type 0	Upper and Lower Klamath Basin	native steelhead, rainbow, and redband trout	Usually occurs in low densities, is not very virulent, and causes little or no mortality
Type I	Lower Klamath Basin	Chinook salmon	If the Type I genotype were carried into the Upper Klamath Basin, only Chinook salmon would be affected
Type II	Klamath Lake, Upper and Lower Klamath Basin	coho salmon and non-native rainbow trout	The "biotype" found in the Upper Klamath Basin does not appear to affect coho salmon, and risks to native rainbow/redband trout are low[1]
Type III	Assumed widespread in Klamath Basin based on presence in fish	all salmonid species	Prevalence of this genotype is low and it infects fish but does not appear to cause mortality

[1] (J. Bartholomew, pers. comm.~~,~~). 2010)

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

Fish in the upper Klamath River are exposed to disease and parasites. ~~All~~Many of the diseases and parasites described above can occur here. *C. shasta* and *P. minibicornis* are both known to occur in the Upper Klamath Basin (Administrative Law Judge 2006), and *C. shasta* ~~density is~~ densities have been reported to be as high in the Williamson River (Hurst et al. 2012) as ~~it is~~ in the area downstream ~~of~~ from Iron Gate Dam (Hallett and Bartholomew 2006). In ~~this~~ the section of the river upstream of J.C. Boyle Reservoir, however, *C. shasta* does not have the same serious effects as it does downstream ~~of~~ from Iron Gate Dam, because of the genotype of the parasite and the higher resistance of the redband trout to the disease. Historically *C. shasta* and *P. minibicornis* occurred in the Upper Klamath Basin and resident fish above the dams evolved with these parasites.

~~Despite the fact that Klamath River fish disease science has advanced greatly in~~ The current infectious zone and high parasite loads below Iron Gate Dam are the ~~past five years, no recent information indicates~~ result of a ~~conflict~~synergistic effect of numerous factors (FERC 2007; Hamilton et al. 2011). Factors associated with the current infectious zone and high parasite loads include: 1) close proximity of myxospores- shedding carcasses (concentration of carcasses), 2) abundant polychaete populations that are found in atypically stable habitats, 3) permissible temperatures (>15 C) during periods when juvenile salmonids are present, and 4) low flow variability. This synergy would be unlikely in the Upper Klamath River. Results from the large amount of recent research on Klamath River fish diseases remain consistent with the previous finding that the movement of anadromous fish above Iron Gate Dam presents a relatively low risk of introducing pathogens to resident fish (Administrative Law Judge 2006, USFWS/NOAA Fisheries Service Issue 2(B)).

Hydroelectric Reach: Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

As described above, Stocking et al. (2006) found the polychaete host for *C. shasta* and *P.~~.~~ minibicornis* throughout the mainstem Klamath River, including the reach from J.C.~~-~~ Boyle Reservoir to Iron Gate Dam (the Hydroelectric Reach~~). In J.C. Boyle Reservoir, densities of polychaetes increased~~), and within all four Project reservoirs. However, these polychaete populations are most abundant at reservoir inflow areas with densities decreasing with distance from ~~the~~ reservoir~~ inflow~~/river interface, but not disappearing entirely (Stocking and Bartholomew 2007). Stocking and Bartholomew (2007) noted that the ability of some polychaete populations to persist through disturbances (e.g., large flow events) indicates that the lotic populations are influenced ~~by~~ by the stability of the microhabitat they occupy. In order for an area to develop as an infectious zone, several factors need to coincide, including microhabitats with low velocity, and stable flows (Bartholomew and Foott 2010).

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

In the ~~lower~~ Lower Klamath River, the polychaete host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations~~ mostly concentrated between the Interstate 5 bridge and the Trinity River confluence, and especially above the Scott River (Stocking and Bartholomew 2007)~~. The reach of the Klamath River from the Shasta River to Seiad/Indian Creek is known to be a highly infectious zone with high actinospores exposure, particularly from May through August (Beeman et al. 2008, Bartholomew and Foott 2010). This portion of the river contains areas of dense populations of polychaetes within low-velocity habitats with *Cladophora* (a ~~type of~~filamentous green periphytic algae), sand-silt, and fine benthic organic material in the substrate (Stocking ~~et al.~~ and Bartholomew 2007~~)~~). As described above, the reduced bedload mobility has increased the persistence of polychaetes under existing conditions. High parasite prevalence in the ~~lower~~Lower Klamath River is considered to be a combined effect of high spore input from heavily infected, spawned adult salmon that congregate downstream ~~of~~from Iron Gate Dam and Iron Gate Hatchery and the proximity to dense populations of polychaetes (Bartholomew et al. 2007). The highest rates of infection occur in the ~~lower~~Lower Klamath River downstream ~~of~~from Iron Gate Dam, generally the reach from Shasta River to Seiad (Stocking and Bartholomew 2007; Bartholomew and Foott 2010).

Despite potential resistance to the disease in native populations, fish (particularly juvenile fish, and more so at higher water temperatures) exposed to high levels of the parasite may be more susceptible to disease. Chinook and coho salmon migrating downstream have been found to have infection rates as high as 90 percent and 50 percent, respectively (Bartholomew and Foott 2010). The number of juvenile salmonids that become infected is estimated to be 10 to 70 percent annually based on surveys of fish captured in the river (True et al. 2010). High disease infection rates are apparently resulting in high mortality of outmigrating smolts. Studies of outmigrating coho salmon smolts by Beeman et al. (2008) estimated that disease-related mortality rates were between 35 and 70 percent in the Klamath River near Iron Gate Dam. Their studies suggested that higher spring discharge increased smolt survival (Beeman et al. 2008). In 2008, mortality rates were as high as 85 percent in May (7-day exposure for age 1+ coho smolts), and 96 percent (age 0+ coho smolts) and 84 percent (0+ Chinook smolts) in June (3-day exposure). In ~~May~~ May 2004, the USFWS, the Yurok Tribe and the Karuk Tribe, reported high levels of

mortality and disease infections among naturally produced juvenile Chinook salmon captured in downstream migrant traps fished in the Klamath River (~~Klamath Fish Health Assessment Team [KFHAT]~~Nichols and Foott 2005). The symptoms observed included bloated abdominal cavities, pale gills, bloody vents, and pop-eye. Infected fish also exhibited lethargic behavior, poor swimming ability and increased vulnerability to handling stress. The primary cause of the disease was found to be *C. ~~Shasta~~shasta*, with *P. minibicornis* observed as well. The 2004 mortality event was not quantified, because of limited resources and other problems associated with sampling small fish in a large river system. Other recent fish kills include the June 2000 and June 1998 fish kills. CDFG (2000) estimated 10,000 to 300,000 individuals, mostly young-of-year killed in the June 2000 event, believed to be infected with *C. shasta* and columnaris. However in 2010 and 2011, years with lower river temperatures, prevalence of *C. shasta* in juvenile Chinook salmon during the peak migration period was less than 30 percent.

For adult salmon disease risk have been less frequent and of a different nature. Ich and columnaris have occasionally had a substantial impact~~ on adult salmon downstream of Iron Gate Dam as well~~, particularly when habitat conditions include exceptionally low flows, high water temperatures, and high densities of fish (such as adult Chinook salmon migrating upstream in the fall and holding at high densities in pools). ~~In 2002, these habitat factors were present, and an outbreak of disease occurred,~~ The effects of Ich and columnaris are generally not as harmful as the myxozoan parasites, although the 2002 fish kill in the lower Klamath provided dramatic evidence of the ability of Ich and columnaris to cause significant salmon mortality, .with more than 33,000 adult salmon and steelhead ~~losses~~were lost during a disease outbreak. Most of the fish affected by the 2002 fish die-off were fall-run Chinook salmon in the lower ~~36~~ 36 miles of the Klamath River (CDFG 2004). Based on a review of available literature and historical records, this was the largest known pre-spawning adult salmonid die-off recorded on the Klamath River and possibly the Pacific Coast (USFWS 2003). Subsequent reviews of the 2002 fish kill by CDFG (2004), NRC (2004), and USFWS (2003) determined several factors contributed to the epizootic of Ich and columnaris. An above average number of Chinook salmon entered the Klamath River during this period. Flows in September 2002 were among the lowest recorded in the last 50 years (CDFG 2004), which may have caused crowding in holding areas that increased transmission of disease. Low flows can also be associated with high water temperature and lower than normal dissolved oxygen concentrations (NRC 2004). Low river discharges were apparently unsuitable for migrating adult salmon, resulting in a large number congregating in the warm water of the Lower Klamath River (USFWS 2003). Fish passage may also have been impeded by low flows, contributing to crowding (CDFG 2004). The NRC did not rule out low flows as a contributing factor but hypothesized that high water temperatures may have also inhibited the fish from moving upstream (NRC 2004). Whether inhibited by low flows, high temperatures, or both, fish in the Lower Klamath River stopped migrating upstream, resulting in crowded, stressful conditions and possibly longer residence times in a confined reach of the river.

Although losses of adult salmonids can be substantial when events such as the 2002 fish die-off occur, the combination of factors that leads to adult infection by Ich and

columnaris disease ~~may~~ are not be as frequent as the annual exposure of juvenile salmonids to *C. shasta* and *P. minibicornis*, as many juveniles must migrate each spring downstream past established populations of the invertebrate polychaete worm host.

FERC (FERC 2007) concluded that Klamath Hydroelectric Project has likely contributed to conditions that foster disease losses in the Lower Klamath River by (1) increasing the density of spawning adult fall Chinook salmon downstream from Iron Gate Dam; (2) promoting the development of attached algae beds that provide favorable habitat for the polychaete alternate host for *C. shasta*, with *P. minibicornis*; and (3) contributing to water quality conditions that increase the stress level of juvenile and adult migrants and increase their susceptibility to disease. The water quality conditions that may increase stress levels include: (1) increased water temperatures in the late summer and fall; (2) elevated ammonia concentrations and swings in DO and pH associated with algal blooms in project reservoirs; and (3) effects of exposure to elevated levels of microcystin produced from microcystis blooms in Project reservoirs, which may also result in direct mortality.

Klamath River Estuary and Pacific Ocean Nearshore

While disease and parasites occur in the Klamath Estuary and Pacific Ocean, these areas are not known to be important source areas for these stressors. Juvenile salmonids that are weakened by disease or parasites upstream may succumb to those diseases once they enter the estuary or ocean as a result of the additional stress created by adapting to the saline environment.

3.3.3.3.6 Algal Toxins

Algae produced in Upper Klamath Lake and the reservoirs in the Klamath Hydropower Reach (Copco 1 and Iron Gate Reservoirs) may be deleterious to the health of aquatic organisms in Upper Klamath Lake and the Klamath River. Some cyanobacteria species, such as *M. aeruginosa*, produce toxins that can cause irritation, sickness, or in extreme cases, death to exposed organisms (see Section 3.2.3.7 and Appendix C, Section C.6). While direct links to fish health are still somewhat unclear, recently collected data from the Klamath Basin indicates that algal toxins ~~are bioaccumulating~~bioaccumulate in ~~fish~~ tissue from fish and mussels at concentrations that may be detrimental to the affected species~~.~~

(Fetcho 2011), as discussed below.

In Upper Klamath Lake, a ~~preliminary~~reconnaissance study ~~of~~ was conducted to evaluate the presence, concentration, and dynamics of microcystin ~~as related to~~ exposure by Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*~~) exposure is currently ongoing. United States~~). The U.S. Geological Survey (USGS) collected water samples at multiple lake sites from July to October 2007 and June through September 2008 and found evidence of gastro-intestinal lesions in juvenile suckers sampled from around the lake, although organ damage was also absent from many fish, and most of the affected fish were collected in the northern portion of the lake. The pathology of the lesions was consistent with exposure to microcystin, and evidence of a route of exposure

was suggested by gut analysis showing that juvenile suckers had ingested chironomid larvae, which had in turn ingested *A. flos-aquae* and colonies of *M*~~.~~. *aeruginosa*. The lesions were observed when liver necrosis was either present or absent suggesting that the gastro-intestinal tract was the first point of toxin contact. The authors ~~indicated~~hypothesized that the ~~totality of the evidence suggests that the fish were exposed to~~lesions were caused by algal toxins, and that the route of exposure to toxins was an oral route through the food chain, rather than exposure to dissolved toxins at the gills (VanderKooi et al. 2010). However, there were other possible explanations for the lesions, including the potential for an undetected viral infection. Conclusive pathology experiments demonstrating that exposure of juvenile suckers to algal toxins via the described oral routes can cause the types of lesions observed have not yet been done. The pathologies and evidence therefore are consistent with the hypothesis of exposure to algal toxins but do not constitute proof of a causal mechanism. Additional work to describe the observed pathologies is ongoing.

In the Hydroelectric Reach and the Klamath River downstream ~~of~~ from Iron Gate Dam, ~~preliminary results from salmonid tissue samples collected by the Karuk Tribe in 2010 show that three of seven Chinook salmon livers collected near Happy Camp had~~the occurrence of microcystin toxin in fish and mussel tissue has been studied since 2005 (Fetcho 2006; Kann 2008; CH2M Hill 2009a, 2009b; Prendergast and Foster 2010; Kann et al. 2010 a, b; Fetcho 2011). Samples of muscle and liver tissues from resident fish (i.e., yellow perch [*Perca flavescens*] and crappie [*Pomoxis nigromaculatus*]) in Copco 1 and Iron Gate Reservoirs in 2007 and 2008 indicate that two of eight microcystin congeners (i.e., chemically different forms of microcystin) were detected in muscle and liver tissues of yellow perch (total samples = 36) during September 2007 (Kann 2008) but unbound or "free" microcystin was not detected in muscle tissues of yellow perch and crappie during May-June, July, September, and November 2008 (total samples = 196) (CH2M Hill 2009a). Yellow perch muscle tissue samples collected from Copco 1 and Iron Gate Reservoirs in August and September 2009 (total samples = 43) did not exhibit microcystin (Prendergast and Foster 2010).

Rainbow trout muscle tissue samples collected upstream of Copco 1 Reservoir and immediately downstream from Iron Gate Reservoir during May-June, July, September, and November 2008 (total samples = 76) indicated that no un-bound or "free" microcystin was detected before, during, or after the 2008 bloom period in the reservoirs (CH2M Hill 2009a). Chinook salmon tissue samples from Iron Gate Hatchery in September and October 2005 did not contain detectable levels of microcystin (~~Kann et al. 2011). During the period the~~ Fetcho 2006) and Chinook salmon and steelhead liver and muscle samples from the hatchery in October 2007 (total samples = 6) did not contain detectable levels of un-bound or "free" microcystin (CH2M Hill 2009b). However, Kann (2008) reported that one of eight microcystin congeners was detectable in three composite samples of liver, stomach, and muscle tissue from six juvenile Chinook salmon obtained at Iron Gate Hatchery in August 2007.

Further downstream in the Lower Klamath River, Fetcho (2006) reported that liver and muscle tissue samples from five Chinook salmon and two steelhead specimens taken

from the Klamath River at or near Weitchpec (near RM 43) in 2005 did not contain detectable levels of microcystin. PacifiCorp collected liver and muscle tissue samples from five Chinook salmon and three steelhead in the middle Klamath River and the Lower Klamath River downstream from the Trinity River in October 2007 and reported that no detectable levels of un-bound or "free" microcystin were found (CH2M Hill 2009b). However, preliminary results from salmonid tissue samples collected in September and October 2010 near Happy Camp show that microcystin was detected in multiple Chinook salmon livers and one steelhead liver at levels which exceeded public health guidelines (Kann et al. 2011). Since livers are not typically consumed, the tested fish did not likely pose a public health concern with respect to consumption. However, results indicate that direct effects to fish health due to microcystin exposure such as stress and/or disease are a possibility (Kann et al. 2011). During the October period that Chinook salmon samples were collected, the 2010 longitudinal microcystin sampling in river-water showed very high microcystin levels being exported ~~directly~~ from Iron Gate Reservoir and ~~then~~ transported downstream to areas where Chinook salmon were migrating upstream ~~(Kann and Johnson 2010). In addition, data from 2007 indicate~~ .

Overall, the variation in fish tissue results in Copco 1 and Iron Gate Reservoirs and the Klamath River downstream from Iron Gate Dam indicates that the presence of *M. aeruginosa* and microcystin does not necessarily correlate to microcystin concentrations in fish tissue. Reasons for this lack of correlation may include, but are not limited to, the patchy distribution of algal blooms within the reservoirs, the ability of fish to move in and out of algal bloom areas where microcystin is likely most prevalent, and the fact that uptake of toxins into fish tissue occurs through the food chain and not directly from the water (Prendergast and Foster 2010). Microcystin can also bioaccumulate in mussel tissue in the Lower Klamath River.

Kann (2008) reported on the concentrations of eight individual microcystin congeners in freshwater mussel tissue samples obtained from the Klamath River in July and November 2007. Microcystin congeners were detected in July in composite and individual tissue samples from the Klamath River near the Klamath Highway Rest Area (at RM 178), near Seiad Valley (at RM 129) and at Big Bar (near RM 51). Individual mussel samples taken later in the year in November from the Klamath River near Orleans (at RM 59), near Happy Camp (at RM 108), near Seiad Valley (at RM 129), at the Brown Bear River Access (at RM 157.5), and near the Klamath Highway Rest Area (at RM 178) did not contain detectable levels of microcystin congeners. Overall, for the 2007 *M. aeruginosa* bloom, 85 percent of fish and mussel tissue samples collected during July through September 2007 in the Klamath River, including Iron Gate and Copco 1 Reservoirs, exhibited microcystin bioaccumulation ~~in juvenile salmonids reared in Iron Gate Hatchery (Kann 2008). Trace concentrations of microcystin were also found in Klamath River steelhead livers in 2005 (Fetcho 2006~~(Kann 2008). Results indicated that all of the World Health Organization (WHO) total daily intake guideline values were exceeded, including several observations of values exceeding acute total daily intake thresholds (Kann 2008). In a retrospective letter to PacifiCorp (August 6, 2008), the California Office of Environmental Health Hazard Assessment (OEHHA) stated that they "would have recommended against consuming mussels from the affected section of the Klamath River,

and yellow perch from Iron Gate and Copco Reservoirs, because their average concentrations exceeded 26 nanograms per gram (ng/g)," which is the OEHHA upper bound of advisory tissue levels fish or shellfish consumption (for a single serving per week based on 8 ounces uncooked fish). Additional public health advisories were issued in 2009 and 2010 in Copco 1 and Iron Gate Reservoirs, as well as downstream locations in the Klamath River (including locations on the Yurok Reservation), for microcystin levels in ambient and/or freshwater mussel tissue (Kann et al. 2010a,b, Fetcho 2011).

3.3.3.3.7 Aquatic Habitat

One of factors that influence habitat availability for aquatic species is instream flow. Reclamation manages Upper Klamath Lake to meet the requirements of biological opinions (BOs) from the USFWS (2008) and NOAA Fisheries Service (2010a) and its contract requirements for the Reclamation's Klamath Project (Reclamation 2010). If implemented, the Proposed Action would result in changes in the operations of Upper Klamath Lake (see Section 2.4.3.9). These changes would affect reservoir elevations in Upper Klamath Lake, and river flows in downstream reaches. These hydrologic changes would result in changes to instream habitat. Studies to determine how fish habitat changes with flow have been conducted in areas of the Klamath River, including two reaches between J.C. Boyle Reservoir and Iron Gate Dam, for selected life stages of rainbow trout (Bureau of Land Management 2002) and seven locations between Iron Gate Dam and the estuary for selected life stages of Chinook salmon, coho salmon, and steelhead (Hardy et al. 2006).

The following sections describe the amount of flow-related habitat in various portions of the ~~basin~~Basin for the species for which information exists. Where specific information is not available for a species or area, the Lead Agencies used hydrologic changes, species habitat requirements, and comparisons with those species for which the Lead Agencies does have specific information to qualitatively assess changes in flow-related habitat. This information was used to evaluate how the Proposed Action and alternatives might result in changes to the amount of flow-related habitat. The Lead Agencies determined that the hydrologic record of the past decade was insufficient for describing the amount of habitat available under existing conditions because of management actions made over the past eight years to protect listed fish species (minimum lake elevations; minimum flows downstream ~~of~~ from Iron Gate Dam). These changes are described in ~~biological opinions~~BOs from USFWS (2008) and NOAA Fisheries Service (2002, 2010a). The flows under existing conditions and with the various alternatives are described in Section 3.6, Flood Hydrology.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

This area was not evaluated for flow-related habitat, as no known flow-related habitat relationships exist for the Klamath or Link Rivers in this area. Some changes in flow-related habitat in tributaries to Upper Klamath Lake may occur; however, the location and magnitude of these changes are unknown at this time.

Water surface elevations in Upper Klamath Lake are expected to vary as a result of implementation of the Proposed Action and alternatives. The USFWS ~~biological opinion~~

BO (2008) provides information on the amount of habitat provided for Lost River and shortnose suckers at different lake elevations, with higher elevations providing increased habitat for all life stages of sucker. It requires that Reclamation maintain the lake at minimum elevations from February through October each year to protect shortnose and Lost River suckers.

Under existing conditions (as indicated by the hydrologic modeling for the No Action/No Project Alternative), lake elevations are maintained at elevations ranging from about 4,138 to 4,142.2 feet in drier conditions (90 percent exceedance) and 4,139.8 to 4,143.3 feet under wetter conditions (20 percent exceedance). Lake elevations increase during the fall and winter, peak in April or May, and then decline until October.

Hydroelectric Reach: Klamath River from Upstream End of J.C~~.~~. Boyle Reservoir to Iron Gate Dam

Under its existing license, PacifiCorp operates the J.C. Boyle Powerhouse in peaking mode, meaning that water is run through the powerhouse to generate electricity ~~cyclically~~ cyclically depending on water availability and power demand. Flows through the reach downstream ~~of~~ from Copco 2 Dam are only about 5 cfs unless spill is occurring as a result of high runoff or project maintenance (PacifiCorp 2004a). Based on an Indicators of Hydrologic Alteration (IHA) Analyses (Richter et al. 1996) of flows within the reach downstream ~~of~~ from J.C. Boyle Powerhouse, Huntington (2004) found a high rate of deviation from conditions that would be expected without the project influencing conditions. Substantial changes in flow (350 to 3,000 cfs) can occur within the course of a single day in the 17-mile long J.C. Boyle Peaking Reach (the reach of the Klamath River between J.C. Boyle Powerhouse and Copco 1 Reservoir). These flow fluctuations can result in temperature fluctuations in this reach ranging 5–15°C during the summer months (ODEQ 2010). These extreme flow fluctuations may also result in stranding of fish and invertebrates (Dunsmoor 2006~~, as cited in FERC 2007~~), reductions in aquatic invertebrate production (City of Klamath Falls 1986, as cited in Hamilton et al. 2011), displacement of fish, and higher energetic costs to fish to maintain their position (FERC 2007). In the Trial-type Hearing for the relicensing of the Klamath Hydroelectric Project (Administrative Law Judge 2006), it was found that this reach had lower macroinvertebrate drift rates, indicating a reduced food base for fish.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam

A universal feature of the historical hydrographs of the Klamath River and its tributaries is a high spring flows, triggered by melting snow, followed by recession to a base flow condition by late summer (NRC 2004). This main feature of the hydrographs has undoubtedly influenced the adaptations of native organisms, as reflected in the timing of their key life-history features (NRC 2004). The natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change of hydrologic conditions, and variability across time scales (hours to multiple years), all without the influence of human activities (Poff *et al.* 1997). It is this diverse hydrology, with the range of hydraulic conditions and habitats supported, that allowed the various anadromous fish species and life history strategies to evolve and flourish in the Klamath River over time. Therefore, to fully understand the habitat requirements for anadromous fish species, the historical flow patterns under which these species developed must also be understood. There is a long history of water development in the Klamath Basin dating back to the late 1800's and early 1900's (See Chapter 1). Farmers introduced irrigation to the Upper Basin as early as 1882. Irrigation was necessary to the farmers because lack of timely and sufficient rain made watering crops a challenge. The earliest irrigation project in the Upper Klamath Basin occurred when residents of the town of Linkville dug a low capacity ditch connecting the town to the Link River, two miles above the present-day town of Klamath Falls. The ditch was later extended and enlarged, turning it into a high capacity canal, known as the Ankeny-Henley Canal. The first hydroelectric facility was constructed 1895 along the east side of Link River, below Upper Klamath Lake, to provide electricity to the town of Klamath Falls. The first major changes to the natural

hydrology of the Klamath River began after Congress authorized Reclamation's Klamath Project in 1905. The A canal was first completed in 1907, however, major diversions of flow from the Klamath River did not begin until after the construction of Link River Dam at the outlet of Upper Klamath Lake in 1921. Further downstream, the first major power peaking hydroelectric facility, Copco No. 1, was constructed in 1918, followed closely by construction of Copco No. 2 just downstream in 1925. JC Boyle Dam, which is the most upstream of the four mainstem dams, was completed in 1958 and also operates as a power peaking facility. Finally, Iron Gate Dam was constructed in 1962 to re-regulate power peaking flow releases from Copco No. 1 and 2 hydroelectric facilities just upstream. For more detail on the physical characteristics of each hydroelectric facility please refer to Chapters 1 and 2, and Section 3.6.3.2, Basin Hydrology.

The following provides a brief description of changes to Klamath River hydrology that have occurred through development of water management features related to irrigation, power generation, and environmental requirements over the years. The major hydrologic time periods discussed include a description of natural hydrology prior to development of major reclamation or hydroelectric facilities (pre 1913); a description of major hydrologic alterations caused by development of power peaking facilities (1913 to 1960); a description of hydrology following construction to Iron Game Dam through 2000, when ESA flow requirements began to influence water releases downstream from Iron Gate; and finally, a description of more recent events that led up to the development of KBRA flow recommendations (Proposed Action) and the 2010 NOAA Fisheries Service Biological Opinion's, Reasonable and Prudent Alternative (RPA) for flow releases downstream from Iron Gate Dam (No Action Alternative).

Owing to the long history and early development of water resources within the basin, little hydrologic data exist to describe the natural flow patterns that existed prior to construction of Reclamation's Klamath Project. The first streamflow records on the Klamath River began on June 1, 1904, when the United States Geological Survey (USGS) began operating an instream flow gage on the Klamath River at Keno (USGS Gage #11509500). River flow data for the USGS Gage at Keno are available for water years 1905 through 1912, after which the gage was discontinued until 1930. The Lost River Diversion Dam was completed in 1912, which can affect Klamath River hydrology (Hecht and Kamman 1996). Therefore, flow data collected at Keno from 1905 through 1912 provide the best source of information to best describe those unaltered hydrologic characteristics that supported the rivers natural ecological processes prior to construction of major irrigation facilities in the upper basin. Although this period is known to be slightly wetter than normal, the general shape of the hydrograph is still useful for illustrating the general timing, magnitude, and duration of flow throughout the year under near natural conditions. Over this eight year period the total annual discharge at Keno ranged from a low of 1,345,000 acre Feet to a high of 1,952,000 acre feet and averaged about 1,558,000 acre Feet. Examination of three different water years, representing conditions that range from dry to wet, provide a sense of the natural flow variation that existed under natural conditions (Figure 3.3-5). Average daily flows for the 1905-1912 water years therefore provide the most reasonable set of data to assess hydrologic

changes in the Klamath Basin through time as various irrigation and hydropower generation facilities were constructed. For the purposes of the following discussion, the

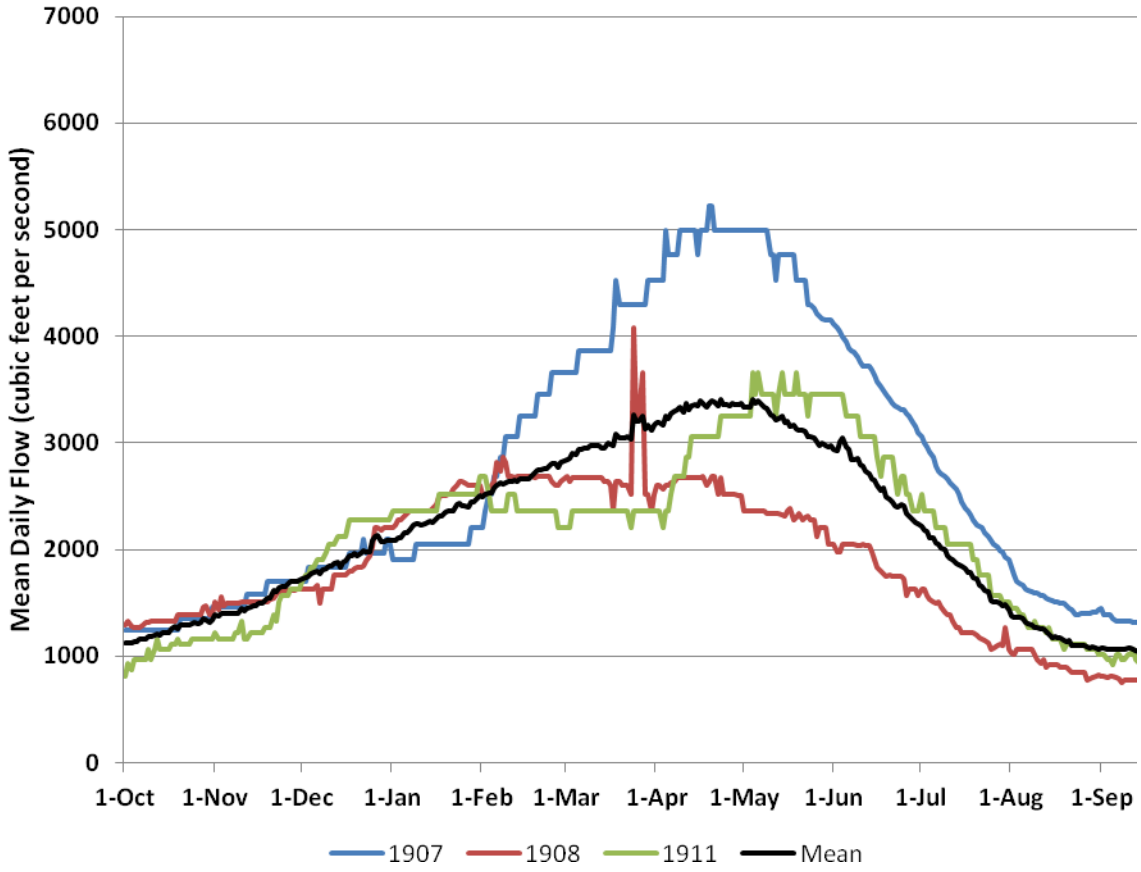


Figure 3.3-5. Mean daily flows (cubic feet per second) for the Klamath River at the USGS Gage at Keno for three different water years, generally representing drier (1908), more normal (1911) and wetter (1907) conditions. Mean daily flows for water years 1905 through 1912 are also displayed to illustrate the natural flow regime that existed prior to development of major Reclamation or hydroelectric projects.

term "natural" applies to the period prior to construction of either the hydroelectric or irrigation systems in the Klamath Basin, with river flows best represented by the 1905-1912 data.

Although there are no empirical river discharge data downstream from Keno prior to implementation of Reclamation's Klamath Project, modeling results of flows near Iron Gate Dam without Reclamation's Klamath Project show similar patterns to the natural discharge at Keno (Reclamation 2005). Spring peaks from snowmelt in tributary basins reliably provided an increase in discharge, typically near the end of April (NRC 2004), with base flows subsequently declining to a minimum in the beginning of September.

Under these conditions flows gradually increased during fall and winter months when Chinook salmon, followed closely by coho salmon, migrate upriver and spawn. Their eggs incubate over the winter when sporadic short duration high flows related to storm events typically occur. Fry emerge in late winter and early spring when flows are typically be near their highest level. These spring flows inundate side channel, off channel and backwater habitats along the flood plain creating abundant rearing habitat for salmonids. Fry grow during the spring and many smolt during that first spring and migrate downriver in late spring and early summer. Others seek out suitable rearing areas in colder tributary streams or in spring fed habitats to rear over the summer and smolt the following fall as water temperatures began to cool and flows began to increase once again.

As described in Section 3.6.3.1, a rock reef originally controlled the elevation of Upper Klamath Lake and river flows downstream to Link River. Link River is only 1.3 miles long and ends at the upper extent of Lake Ewauna and the Keno Impoundment. Historical accounts describe the occurrence of extremely low flows in Link River during prolonged dry spells (Dickens & Dickens, 1985). These extremely low flow conditions were most likely caused by strong south winds forming seiches within Upper Klamath Lake which greatly diminished flows to Link River for brief periods of time. The Klamath Indians referred to Link River as "Yulalona" which translates to "back and forth" (Donnelly 2002) and this is probably related to these natural seiches. Inputs from tributary streams and natural springs downstream from Keno would have maintained flow in the Klamath River and prevented it from drying completely further downstream near the current location of Iron Gate Dam. A second rock reef formed a natural hydraulic control for Lake Ewauna and provided an ideal location for the construction of Keno Dam.

Farther downstream in the coastal zone of the Lower Klamath Basin, the hydrologic pattern of the Klamath River is primarily dominated by rainfall events in the fall and winter. In the middle and lower portions of the Klamath River, discharge responds rapidly to rainfall events due to the relatively short length of lower tributary sub-basins (*e.g.*, Salmon River). The natural Klamath River hydrology was therefore diverse, with a range of hydraulic conditions affected by both the Upper Klamath Basin patterns previously described (e.g. Figure 3.3-5) and lower basin tributary inputs (see Section 3.6.3.3 Historic Stream Flows). As a result, habitats were also diverse, supporting a variety of different anadromous salmonid life history strategies throughout the year (Figure 3.3-6).

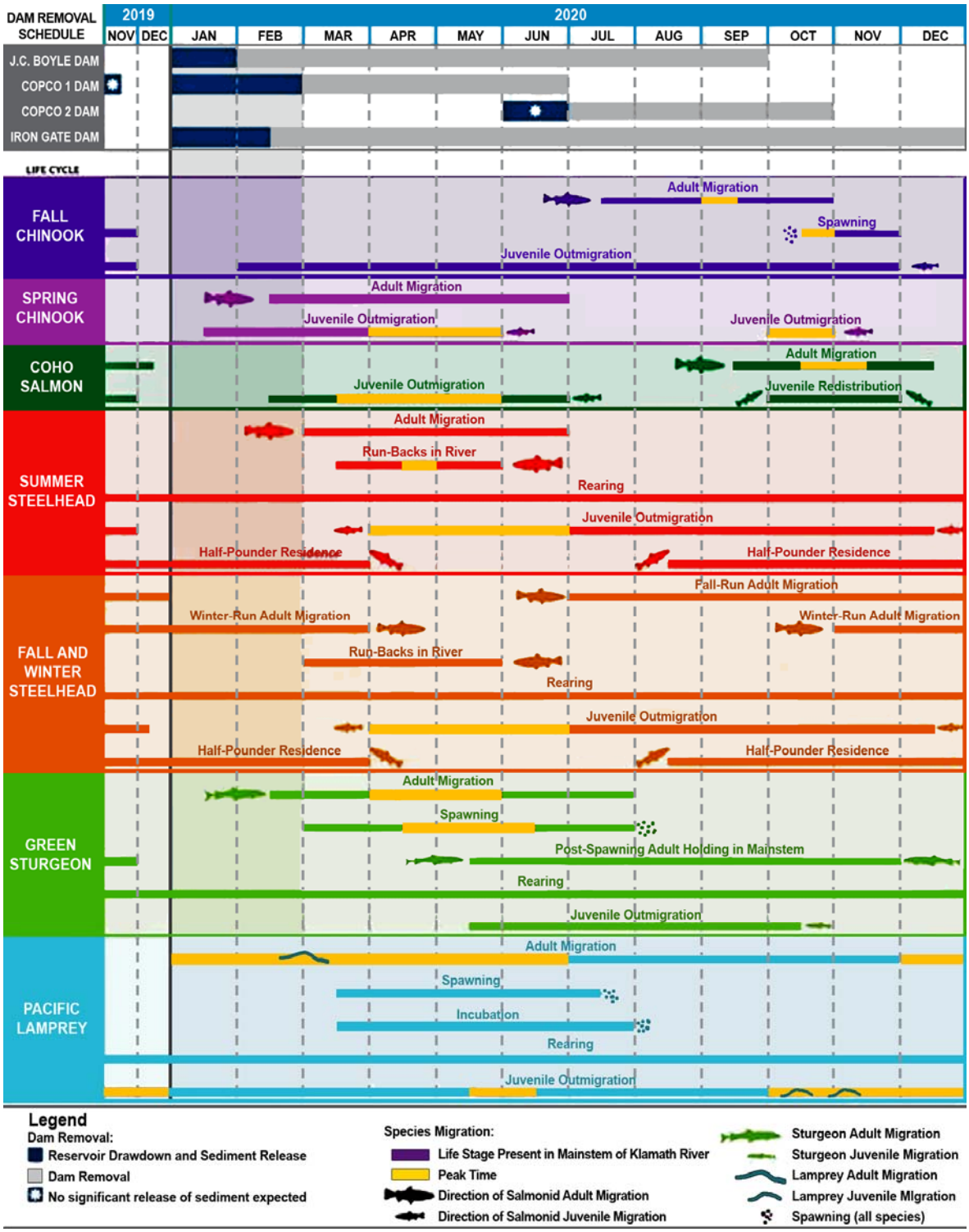


Figure 3.3-6. Timeline Depicting the Timing of Salmon Lifecycles in the Mainstem of the Klamath River Coinciding with Dam Removal Plans.

Copco No. 1 and Copco No. 2 facilities were constructed to generate hydroelectric power and their operation greatly altered flow patterns downstream. The USGS installed a gage on the Klamath River near Fall Creek downstream from Copco No. 1 and 2 and began recording flows at this location in October 1923 (USGS Gage #11512500). Flow data is available at this location until 1962 when construction of Iron Gate Dam inundated the river at this location. Hydroelectric power peaking operations at Copco No. 1 and 2 cause major changes to the hydrograph downstream from the powerhouse (Figure 3.3-7). Rapid changes in flow associated with hydropower generation during daily periods of high power demand, commonly referred to as power peaking, created both hazardous conditions for recreational fishermen and also created inhospitable conditions for aquatic species downstream. Rapid changes in flow associated with daily hydropower generation, commonly referred to as power peaking, created both hazardous conditions for recreational fishermen and also created difficult conditions for aquatic species downstream. Fish studies have shown considerable biological impacts due to Project peaking (City of Klamath Falls 1986; FERC 2007; BLM 2002; Wales and Coots 1950). From June 1948 to May 1949, Wales and Coots (1950) estimated that Project peaking operations resulted in the loss of over 1.8 million salmonid fingerlings downstream from below Copco No. 1 and 2 facilities. Mean daily flows fell below 100 cubic feet per second in the Klamath River near Fall Creek (USGS Gage #11512500), downstream from Copco No. 2 Dam, on fifty occasions between water years 1931 and 1937. Instantaneous flow levels may have been lower. Thus, hydropower peaking between 1918 and the construction of Iron Gate Dam to re-regulate flows in 1962 may explain some anecdotal accounts of the occurrence of low flows in the Klamath River in the past that were submitted by several citizens during public scoping.

Iron Gate Dam was completed in 1962 to re-regulate peaking flow releases from the Copco facilities upstream. At that time minimum flow releases downstream were stipulated by the Federal Energy Regulatory Commission (FERC) under Article 52 of the FERC License for operation of Project No. 2082. Article 52 required the following minimum flows downstream from Iron Gate Dam: September 1 through April 30, 1,300 cfs; May 1 through May 31, 1,000 cfs; June 1 through July 31, 710 cfs; and August 1 through August 31, 1,000 cfs. These requirements provided more stable flow conditions downstream, however, they also altered the timing of base flows and did not attempt restore or simulate the natural "pre-project" hydrograph. Fall flows were slightly increased while spring and summer flows were substantially reduced compared to natural flows.

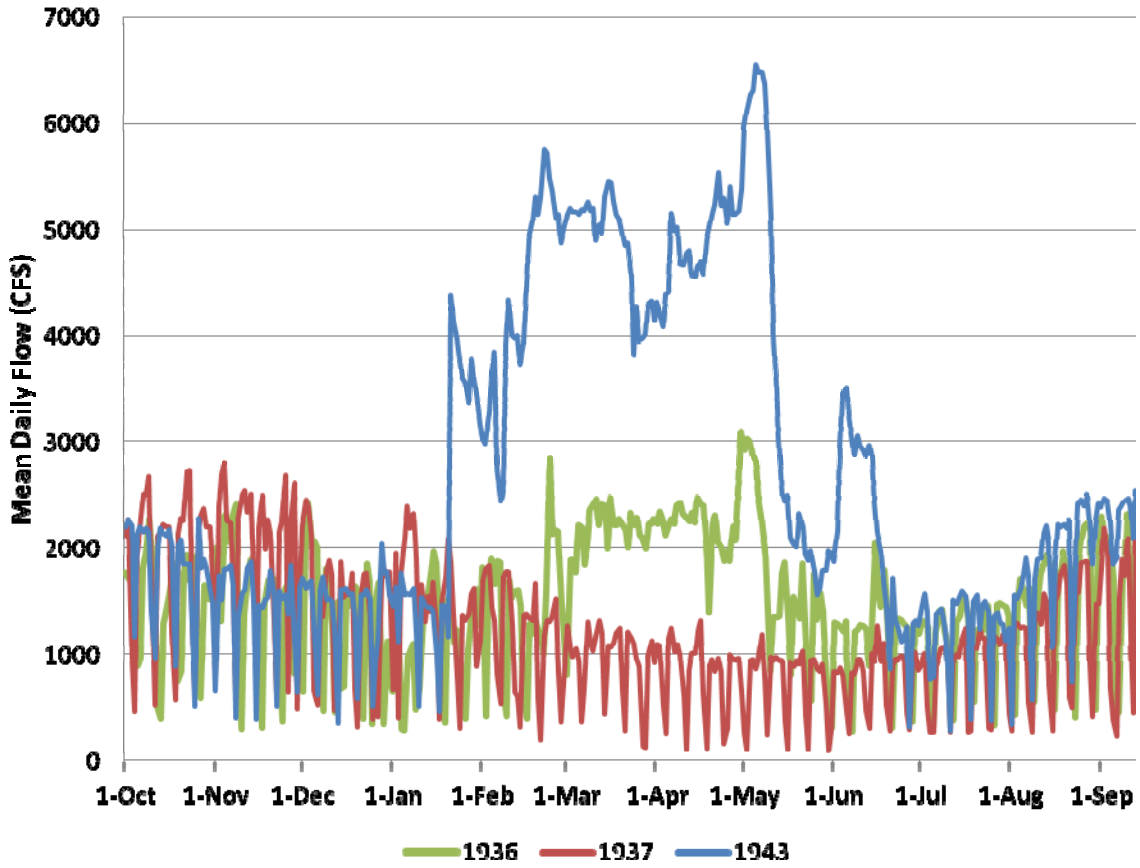


Figure 3.3-7. Mean daily flows (cubic feet per second) for the Klamath River at the USGS Gage near Fall Creek (Gage #11512500) for three different water years, generally representing drier (1937), normal (1936) and wetter (1943) conditions.

Hecht and Kamman (1996) analyzed the hydrologic records for similar water years (pre- and post-Project) at several locations along the Klamath River. The authors concluded that the timing of peak and base flows changed significantly after construction of Reclamation's Klamath Project, and that the operation of Reclamation's Klamath Project increases flows in October and November and decreases flows in the late spring and summer as measured at Keno, Seiad, and Klamath USGS gage sites. Comparison of mean daily flows recorded at Keno (USGS Gage #11509500) from 1905 to 1912 with mean daily flows recorded at Keno and Iron Gate (USGS Gage #11516430) in more recent years (1961-2000) provide visual confirmation of these findings (Figure 3.3-8).

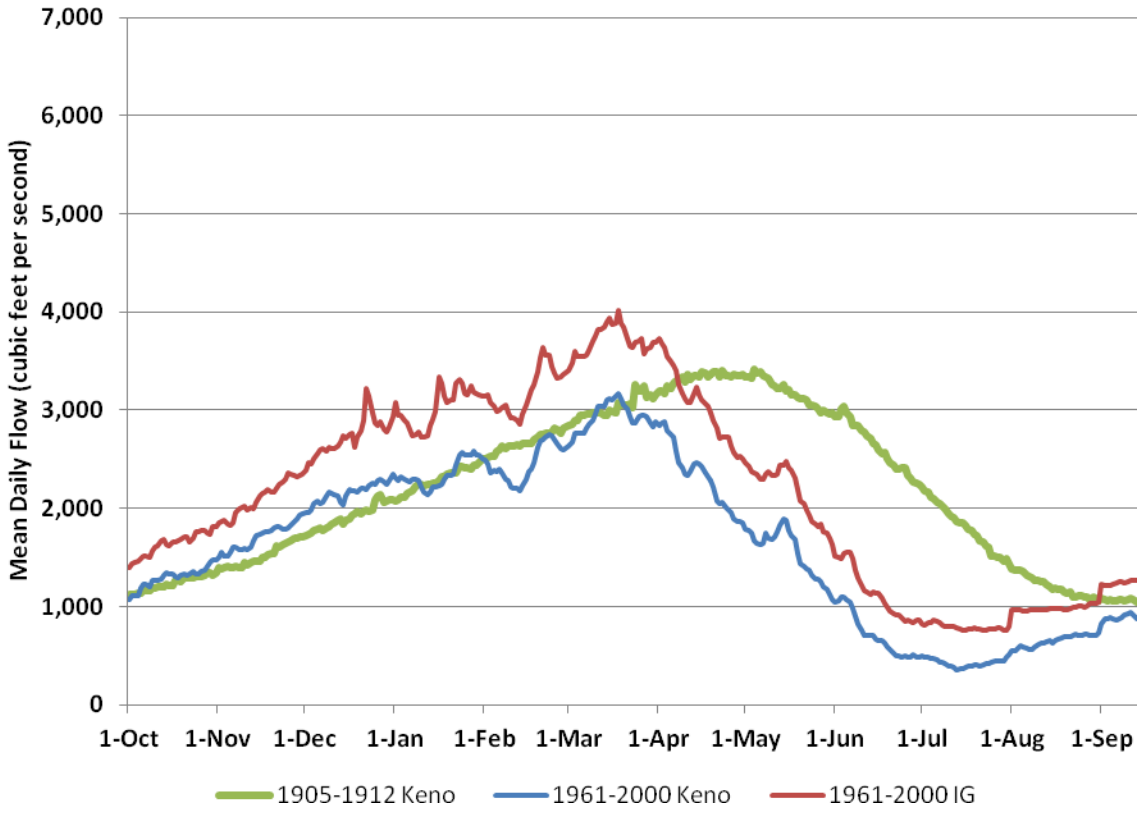


Figure 3.3-8. Comparison of mean daily flows recorded at Keno (USGS Gage # 11509500) historically (1905-1912) with more recent conditions (1961-2000). Mean daily flows recorded at Iron Gate (USGS Gage #11516530) are shown to depict both the mean daily accretions and similarities that exist in the hydrograph between Keno and Iron Gate.

As shown in Figure 3.3-8, for the period from 1961 through 2000, the timing and magnitude of average flows in the Klamath River at Keno have changed relative to the natural flow regime. Reclamation's Klamath Project diverts water from the Klamath River beginning in the spring and significantly reduces flow volumes in the Klamath River from April until September. The extraction of water significantly accelerates the decline of flow rates during the spring runoff and has the effect of moving the spring runoff peak from the end of April and beginning of May to the middle of March, a shift of more than one month. Although most of the diverted water remains within the basin, about 30,000 acre feet of water is diverted from Jenny Creek (tributary to the Klamath River at Iron Gate Reservoir) to the Rogue River Valley annually. Under natural conditions, river discharge did not reach base (minimum) flow, until September. Operation of Reclamation's Klamath Project has caused a shift in the onset of minimum base flow levels by about two months earlier in the summer from September to July.

Tributary inflows and spring flow accretions, the most prominent being Big Springs (about 250 cfs) in the JC Boyle bypass reach, account for difference in mean daily flow between Keno and Iron Gate were it not for the operation Reclamation's Klamath Project.

The Southern Oregon Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU) was listed as threatened under the Federal Endangered Species Act (ESA) on May 6, 1997 (62 FR 24588). In 2001, NOAA Fisheries Service determined that the operation of Reclamation's Klamath Project jeopardized the continued existence of SONCC coho salmon. To reduce impacts to levels that avoid jeopardy to SONCC coho salmon, NOAA Fisheries Service proposed Reasonable and Prudent Alternative (RPA) flows for the Klamath River downstream from Iron Gate Dam (NOAA Fisheries Service 2001). Because of the expectation that additional information and analyses relevant to the relationship between Iron Gate Dam flows and suitable salmonid habitat (e.g., the Hardy Phase II Report) would become available within a few months following the issuance of the NOAA Fisheries Service 2001 Biological Opinion, the RPA only included minimum Iron Gate Dam flows for the April through September 2001 period. In the 2001 Opinion (NOAA Fisheries Service 2001), NOAA Fisheries Service stated their intention to prepare a supplemental biological opinion and RPA, addressing all water year types. In addition, NOAA Fisheries Service stated that the supplemental biological opinion could include a more refined minimum Iron Gate Dam flow regime for future "critically dry" water years, based on any new information or analyses that may become available in the near future. NOAA Fisheries Service's reasonable and prudent alternative for 2001 included the following instantaneous minimum flow releases to the Klamath River downstream from Iron Gate Dam, by time step, for the April through September period:

Time Step	Iron Gate Dam Discharge (CFS)
April	1,700
May	1,700
June 1-15	2,100
June 16-30	1,700
July	1,000
August	1,000
September	1,000

In 2002, Reclamation requested formal consultation under ESA for ongoing operation of the Klamath Reclamation Project from 2002 through 2012. In the Biological Opinion, NOAA Fisheries Service found that the operation of Reclamation's Klamath Project as proposed in Reclamation's Biological Assessment would likely jeopardize the continued existence of SONCC coho salmon and would also adversely modify their critical habitat. To avoid the likelihood of jeopardizing the continued existence of SONCC coho salmon or cause adverse modification to their critical habitat, NOAA Fisheries Service developed a reasonable and prudent alternative which included development of a water bank and

water supply enhancement program to improve flows to benefit coho salmon habitat and long-term flow targets (Table 3.3-A).
The BO issued in 2010 by NOAA Fisheries Service (NOAA Fisheries Service 2010a) for the protection of coho salmon changed the flow requirements immediately downstream ~~of~~ from Iron Gate Dam from those contained in the annual license. These changes to operations increased minimum flows downstream ~~of~~from Iron Gate Dam, and set ramping rates to match those of Upper Klamath Lake inflows~~, and set target water surface elevations for Upper Klamath Lake.~~. The revised ramp-down rates are defined as follows~~.~~

:

- When flows at Iron Gate Dam are 3,000 cfs or above, Iron Gate Dam ramp-down rates will follow the rate of decline to inflows to Upper Klamath Lake combined with accretions between Keno Dam and Iron Gate Dam.
- When flows at Iron Gate Dam are between 1,750 cfs and 3,000 cfs, Iron Gate Dam ramp down rates will be 300 cfs or less per 24-hour period and no more than 125 cfs per 4 hour period.
- When flows at Iron Gate Dam are 1,750 cfs or less, Iron Gate Dam ramp down rates will be 150 cfs or less per 24 hour period and no more than 50 cfs per two hour period.

In addition, the BO issued in 2008 by USFWS set target water surface elevations for Upper Klamath Lake (USFWS 2008). Because Upper Klamath Lake has limited storage capacity, Reclamation operates the lake on an annual refill basis. The proposed minimum lake levels specified in USFWS (2008) (measured as feet above mean sea level at Iron Gate Dam) limit the drawdown of Upper Klamath Lake over the course of the summer. The minimum flows downstream ~~of~~from Iron Gate Dam required by the Reasonable and Prudent Alternatives outlined in NOAA Fisheries Service (2010a) during a 95 percent exceedence water year, and the proposed minimum lake elevations and refill targets for Upper Klamath Lake are provided below (Table 3.3-4):

~~**Table 3.3-4. 2010 Biological Opinion Proposed Flows and Lake Elevations.**~~

~~Month~~	~~Klamath River~~	~~Upper Klamath Lake~~	
	~~Proposed Minimum Flows below Iron Gate Dam (cfs)~~	~~Proposed Minimum Lake Elevations (msl)[1]~~	~~Proposed Lake Refill Target Elevations (msl)[1]~~

Table 3.3-4. Biological Opinion Flows and Lake Elevations.

Month	Klamath River[1]	Upper Klamath Lake[2]	
	Minimum Flows downstream from Iron Gate Dam (cfs)	Minimum Lake Elevations (msl)[1]	Lake Refill Target Elevations (msl)[3]
October	1,000	--	4139.1
November	1,300	--	4139.9
December	1,260	--	4140.8
January	1,130	--	4141.7
February	1,~~275~~300	4141.5	4142.5
March	1,~~325~~275	4142.2	4143.0
April	1,~~175~~325	4142.2	--
May	1,~~025~~175	4141.6	--
June	~~805~~1,025	4140.5	--
July	~~880~~805	4139.3	--
August 1–15	~~1,000~~880	4138.1	--
August 16–31	1,000	4138.1	--
September	1,000	4137.5	--

[1] NOAA Fisheries Service 2010a[2] USFWS 2008[3] "msl" defined as feet above mean sea level

Table 3.3-A. Summary of the Iron Gate Dam long-term flow targets expected to be achieved by water year 2010 unless modified by study results. These flow targets are instantaneous minimum flows (Table 9, NOAA Fisheries Service 2002).

* Convene "Between Year Transition Group"

Recommended Long Term Iron Gate Dam Discharge By Water year Type					
Month	Dry	Below Average	Average	Above Average	Wet
October	1,300*	1,300*	1,300	1,300	1,300
November	1,300*	1,300*	1,300	1,300	1,300
December	1,300*	1,300*	1,300	1,300	1,300
January	1,300*	1,300*	1,300	1,300	1,300
February	1,300*	1,300*	1,300	1,300	1,300
March	1,450	1,725	2,750	2,525	2,300
April	1,500	1,575	2,850	2,700	2,050
May	1,500	1,400	3,025	3,025	2,600
June	1,400	1,525	1,500	3,000	2,900
July	1,000	1,000	1,000	1,000	1,000
August	1,000	1,000	1,000	1,000	1,000
September	1,000	1,000	1,000	1,000	1,000

There are no provisions for flow through or minimum stream flow for the Hydroelectric Reach in the ~~Biological Opinion~~ NOAA Fisheries Service (2010a) BO with the exception of the minimum flow requirements ~~below~~downstream from Iron Gate Dam described above.

Concerns over the health of anadromous fish populations and their habitat in the Klamath River downstream from Iron Gate Dam lead the Department of the Interior (DOI) to fund development of a study to determine instream flows required to support the ecological needs of aquatic resources, with particular attention given to anadromous fish species. After several years of data collection, development of various draft reports, and extensive review of the biological findings by agency and public scientists, the final report "Evaluation of Instream Flow Needs in the Lower Klamath River, Phase II" was completed by Hardy et al. in July, 2006. Subsequent to its release, the National Research Council's Committee on Hydrology, Ecology, and Fishes of the Klamath River Basin also conducted a thorough review of the report (NRC 2008). The report, commonly referred to as the Hardy Phase II Report, provides recommendations for flow releases downstream from Iron Gate Dam to provide for the long-term protection, enhancement and recovery of the aquatic resources. The recommendations are intended to benefit all anadromous species and life stages on a seasonal basis and are not focused on a single species or life stage (Hardy et al. 2006). The recommendations were intended to provide guidance to the Department of the Interior in meeting their Public and Tribal Trust responsibilities, as well as meeting responsibilities described under the Endangered Species Act. A summary of the Hardy Phase II flow recommendations are presented in Table 3.3-B. It is important to note that these recommendations are for base flows only. Hardy recommendations include higher flows levels to satisfy important physical and ecological requirement to provide diverse habitat and floodplain maintenance. These

components were broadly defined by NRC (2004) as: Over Bank Flows (infrequent high flow event that overtops the riverbanks); High Pulse Flows (short duration high flow within the stream channel during or immediately after storm events); Base Average Flows (base flows in the absence of significant precipitation or runoff event); and, Subsistence Minimum Flows (stream flows needed to maintain tolerable water quality conditions and provide minimal aquatic habitat).

Table 3.3-B. Instream flow recommendations by annual exceedence* levels for net inflows to Upper Klamath Lake on a monthly basis below Iron Gate Dam (Table 27, Hardy et al. 2006)

% Exceed	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5	1,735	2,460	3,385	3,990	4,475	4,460	4,790	3,845	3,185	2,215	1,560	1,565
10	1,715	2,415	3,280	3,835	4,285	4,355	4,585	3,710	3,055	2,140	1,540	1,545
15	1,700	2,365	3,205	3,795	4,210	4,285	4,425	3,615	2,975	2,075	1,495	1,515
20	1,680	2,315	3,120	3,705	4,215	4,160	4,230	3,480	2,850	2,000	1,405	1,490
25	1,660	2,260	3,015	3,645	4,080	3,990	4,065	3,390	2,755	1,925	1,375	1,465
30	1,645	2,220	2,945	3,510	3,925	3,940	3,930	3,225	2,660	1,830	1,335	1,430
35	1,635	2,160	2,870	3,405	3,660	3,860	3,705	3,115	2,540	1,740	1,305	1,405
40	1,625	2,110	2,800	3,215	3,435	3,685	3,485	2,960	2,455	1,635	1,255	1,370
45	1,575	2,060	2,690	3,015	3,220	3,585	3,245	2,815	2,340	1,515	1,215	1,335
50	1,565	2,000	2,545	2,820	3,015	3,380	3,030	2,675	2,225	1,330	1,170	1,305
55	1,545	1,935	2,385	2,630	2,810	3,150	2,815	2,510	2,070	1,265	1,105	1,275
60	1,525	1,875	2,235	2,420	2,565	2,910	2,590	2,385	1,980	1,205	1,055	1,235
65	1,510	1,830	2,090	2,210	2,335	2,630	2,405	2,165	1,840	1,135	1,020	1,195
70	1,490	1,775	1,950	2,015	2,135	2,350	2,260	2,050	1,635	1,070	1,005	1,160
75	1,470	1,710	1,815	1,825	1,950	2,050	2,045	1,905	1,465	1,015	975	1,120
80	1,450	1,670	1,650	1,620	1,770	1,835	1,940	1,690	1,320	945	935	1,080
85	1,430	1,600	1,520	1,460	1,615	1,585	1,740	1,415	1,160	905	910	1,045
90	1,415	1,545	1,380	1,245	1,485	1,410	1,530	1,220	1,080	840	895	1,010
95	1,395	1,500	1,260	1,130	1,415	1,275	1,325	1,175	1,025	805	880	970

* For example, a 10 percent exceedence would be equivalent to the inflow value to Upper Klamath Lake that is exceeded 10 percent of the time for the existing hydrologic record, a more wet condition.

The Hardy Phase II flow exceedence recommendations incorporate the principles of "Ecological Base Flow" requirements. Ecological Base Flows are intended to provide adequate protection for aquatic resources. Human induced reductions in flow below this level are believed to result in unacceptable levels of risk to the health of aquatic resources (Hardy et al. 2006). Flow volumes equal to those identified for the 95 percent exceedence flows listed in Table 3.3-A (Table 27, Hardy et al. 2006) are intended to be

representative of Ecological Base Flows for the Klamath River downstream from Iron Gate Dam under conditions with dams in place. It is important to recognize that the monthly column headings in Table 27 in the Hardy Phase II Report are not intended to be interpreted as monthly time steps for implementation of instream flows. Under real time management, the exceedance flow recommendations would ideally be implemented using daily time steps as recommended in Hetrick et al (2009) and discussed by Hardy (2008). The findings of Hardy et al. (2006) provide the best available science on the relationship between anadromous fish habitat and instream flow in the Klamath River at this time.

During the negotiation of the Klamath Basin Restoration Agreement (KBRA) a Technical Team consisting of staff from the U.S. Fish and Wildlife Service, National Marine Fisheries Service, the California Department of the Fish and Game as well as technical experts from the other participants in the negotiation, was formed to evaluate potential impacts that may occur to either anadromous fish or listed suckers during the Interim period (between the dates of a positive Secretarial Determination, should one occur, and dam removal) for various management alternatives that were under consideration by the negotiating parties. This Technical Team should not be confused with the Technical Advisory Team (TAT) described in Section 20.4.3 of the KBRA or the Federal Team for the Secretarial Determination that was assembled to conduct technical studies requested in the KHSA or to conduct the environmental analysis required under the National Environmental Policy Act (NEPA) or the California Environmental Quality Act (CEQA). A full description of the analytical methods used by the Technical Team is described in detail in Hetrick et al. (2009). The Technical Team's approach to development of instream flow recommendations for the Klamath River considered both the Hardy Phase II instream flow recommendations in conjunction with instream flows that provide a minimum of 80 percent of the maximum habitat values for priority species and life stages for five different water year types ranging from dry to wet (Hetrick et al. 2009). The resulting flow recommendations were labeled Alt X by the Technical Team.

An alternative to the Alt X flow recommendations was proposed for KBRA by biologists from the Yurok Tribe, labeled the ALT-X Yurok flow schedule. The ALT-X Yurok schedule was designed to increase water storage in the fall and winter to increase the likelihood of filling Upper Klamath Lake. Filling the lake early in the water year increases the probability of spill and the availability of water to maximize, to the extent possible, river flows in the spring and early summer to provide better habitat conditions for Chinook salmon emergence and Chinook and coho salmon fry and juvenile rearing during the critical spring months of March through June. To accomplish this objective within the management regime described under the KBRA, the ALT-X Yurok flow schedule would maintain steady flows from October through February at 1,000 cfs for 90% exceedence years and 1,100 cfs for 70% exceedence years, and at levels reduced from the ALT-X schedule for the October to December period during higher inflow conditions (see Figure I-3 in Hetrick et al. 2009). The ALT-X Yurok flow schedule adopts the ALT-X flow schedule throughout the remainder of the water year. While the conservative fall/winter flow period of the ALT-X Yurok flow schedule increases the likelihood of spill occurring later in the year, it does not provide flow variability through

a substantial portion of the fall/winter period, nor does it mimic the natural flow regime as recommended throughout the current literature regarding instream flow management (Poff et. al. 1997). Differences in total flow volume between the ALT-X and ALT-X Yurok flow schedules during this period were, however, not considered to be of a magnitude that would preclude a real-time approach to water management that would provide desired variability in fall/winter flows.

The Technical Team used the Water Resources Integrated Modeling System (WRIMS) to provide the hydrologic data (river flow and lake levels) necessary to analyze potential impacts to anadromous fish habitat in the river and sucker habitat in Upper Klamath Lake under numerous water management scenarios (Hetrick et al. 2009). The WRIMS model is capable of simulating river flows at Iron Gate Dam as they would have happened under various management scenarios and allows for comparisons to be made between alternatives and historical conditions. The analysis was limited to hydrologic conditions present during water years 1961 – 2000. The WRIMS Run-32 Refuge model run provides simulated Klamath River flows at Iron Gate and Upper Klamath Lake elevations using target flows provided by Alt X Yurok, Upper Klamath Lake elevation targets (Alt Y) described in Hetrick et al. (2009), and management objectives provided in the KBRA with the model priorities set to provide agricultural irrigation deliveries to Klamath Reclamation Project irrigators as described in Part IV of the KBRA. This also includes those benefits associated with both the Water Use Retirement Program (additional 30,000 acre feet) and increased water storage capacity in Upper Klamath Lake through restoration of Williamson River Delta, Agency Lake and Barnes Ranches, and Wood River wetlands. The model results do not include any additional benefits that may occur as a result of the implementation of a drought plan, which had not been developed at the time of this analysis. The results of WRIMS Run 32 Refuge are presented in Table I-5 and I-7 in Hetrick et al. (2009). Appendix E-5 of the KBRA also provides the results for three similar WRIMS (referred to as KLAMSIM) model simulations for Klamath River flows at Iron Gate and Upper Klamath Lake elevations.

As described in Hetrick et al. (2009), percent habitat area, based flow- habitat relationships in the Hardy Phase II Report, for WRIMS Run-32 Refuge model output flows were consistently higher than percent habitat area calculated for actual flow releases observed below Iron Gate Dam during water years 1961-2000 for the March – May emergence and rearing life stages of Chinook salmon, and for the June juvenile rearing period for coho salmon for exceedences greater than 10 percent (extremely wet years or drier). Percent habitat areas calculated for the WRIMS Run-32 Refuge model output flows and Hardy Phase II flow recommendations for the March – April period differed little, if at all, for all exceedence levels with the exception of the March time step for a 10 percent (extremely wet year) exceedence level, in which case the habitat value for the Hardy Phase II flow was about 25 percent higher than the habitat value calculated for the WRIMS Run-32 Refuge model output flows. Chinook salmon spawning percent habitat areas in October and November from WRIMS Run-32 Refuge were generally higher for the 10 percent (extremely wet year) exceedence level, similar for the 30, 50, and 70 percent (wet, normal, and dry) exceedences, and less at the 90 percent (critically dry year) exceedence level than the percent habitat areas calculated for actual flows

downstream from Iron Gate from 1961-2000 and Hardy Phase II flow recommendations. Both the WRIMS Run-32 Refuge modeled flow outputs and the Hardy Phase II flow recommendations provide habitat values above 70 percent of the maximum available habitat for priority anadromous fish species and life stages for a greater length of time (more time steps) than were provided under the actual flows below IGD during water years 1961-2000. For Upper Klamath Lake, the WRIMS Run 32 Refuge model run predicted that, in general, the lake would fill to elevations necessary to allow Lost River and shortnose sucker unrestricted access to critical spawning locations (Hetrick et al. 2009).

Results of the WRIMS Run 32 Refuge simulation indicate that in critically dry water years (similar to 1992 and 1994) there is a substantial reduction in Upper Klamath Lake elevations resulting in corresponding reductions in habitat that would negatively impact anadromous fish in the Klamath River and suckers in Upper Klamath Lake (Hetrick et al. 2009). These results demonstrated the critically important need for the development and effective implementation of a drought plan capable of reducing these potential impacts to both anadromous fish and suckers when critically dry conditions at the 95 percent exceedence level exist. Section 19.2 of the KBRA describes the process used for development of a drought plan (KBCC. 2011) that may reduce some of these potential impacts.

Appendix E of Reclamation (2011a) contains a description of the methods and assumptions that were incorporated into the hydrology simulations for the No Action Alternative (2010 Biological Opinion flows) and the Dam Removal Alternative (KBRA flows) used in the analysis. Previous hydrology simulations conducted by the Technical Team using the WRIMS (WRIMS Run 32 Refuge) model and described by Hetrick et al. (2009) were used to simulate conditions during the interim period prior to dam removal and did not incorporate several aspects of the KBRA (Drought Plan), and therefore were not appropriate for use in the EIS/EIR analysis of the Proposed Action or other alternatives. At the time when the Technical Team was conducting their analysis, the KBRA was still being developed and the Drought Plan had not been written. Under KBRA, the Technical Advisory Team (TAT) would also implement management of environmental water in real time; therefore, simulation of unknown future hydrologic and biological conditions is problematic. In addition, the previous analysis only addressed flows downstream from Iron Gate and did not consider flow needs that would likely be required for anadromous fish that would have access to areas upstream of Iron Gate Dam after proposed dam removal in 2020 as well as protections that may be required in future Biological Opinions under the ESA. Therefore, the Federal Team for the Secretarial Determination needed to incorporate several assumptions into the KBRA hydrology model simulations that attempt to provide adequate protections for anadromous fish and suckers that may be representative of potential recommendations by the TAT in the future that would include additional conservation measures that could be anticipated to be available through implementation of a Drought Plan in critically dry water years. To meet these requirements the following assumptions, which are also described in Appendix E of Reclamation (2011a), were incorporated into the KBRA flow simulations:

- Incorporation of a minimum flow of 100 cfs at Link River to provide adequate passage through the fish ladder and stream channel.
- Incorporation of a minimum flow at Keno Dam of 300 cfs to provide adequate fish passage.
- Minor adjustment of KBRA flow targets for use in the hydrology model for the time steps from July 1 through the end of September to improve flow conditions for adult migration and reduce the potential for fish die off. The changes that were implemented include reducing the target from 921 to 840 cfs for July 1 to 15, increasing the target from 806 to 840 cfs for July 16 to 31, increasing the target from 895 to 1110 cfs in August, and increasing the targets from 1010 to 1110 cfs in September.
- Incorporation of minimum Ecological Base Flow (EBF) levels during the periods from March 1 through June 30 and during the months of August and September. The EBF volumes are those proposed by the Hardy Phase II 95% exceedence flow levels.
- Incorporation of pulse flows into the disaggregated daily data to realize potential benefits of these flows to reduce disease infection rates through disruption of the parasite's life cycle.
- Minor adjustment to the flow targets for the month of March for water years represented by the 70% Exceedence. These adjustments include reductions in the targets from 2358 to 2085 cfs (March 1-15) and from 2343 to 2149 cfs (March 16-31). The change is consistent with rate of change for wetter water years.
- Incorporation of minimum base flows of 800 cfs during the months of October through February. The minimum of 800 cfs is considered to be necessary to prevent adverse impacts to salmonids during the winter months.
- Redistribution of irrigation and refuge supplies during shortage years to reflect KBRA language. KPSIM does adjustments on annual basis as a post process. Monthly adjustments are done as a post process in a workbook by the data manager which runs both models.
- Minor adjustments were made to UKL elevation criteria in association with shortage adjustments.
- Net evaporation and riparian evapotranspiration gain was added.
- A method was implemented to create imperfect knowledge of forecasts. Because operational decisions are made based upon forecasts and not perfect knowledge of future flows, it is necessary to simulate this process in the model.

The Hardy et al. (2006) Phase II flow exceedence recommendations do not consider physical, biological, and chemical alterations to the Klamath system resulting from dam removal. The anticipated future changes to the system that would occur under the KHSA and KBRA led Hardy (2008) to conclude that future flow releases as described in the KBRA are a logical extension of the Hardy Phase 2 Flow recommendations, balancing multiple needs, including those of anadromous salmonids. Improved water quality conditions (primarily increased minimum dissolved oxygen and more natural water temperatures), restoration of sediment transport processes, potential reductions in disease,

restored access to thermal refugia and instream habitats upstream are all factors that led Hardy (2008) to conclude "that the threshold flow at which significant concerns over thermal and disease factors will drop well below 1000 cfs to something on the order of 700 to 800 cfs." Consistent with these findings the Federal Team for the Secretarial Determination incorporated minimum base flows of 800 cfs into the KBRA flow simulations during the period from October through February (Reclamation 2011, Appendix E). Base flows of 800 cfs at Iron Gate Dam, along tributary accretions downstream, currently provide greater than 75 percent of the available Chinook salmon spawning habitat from the R-Ranch study site downstream to the Brown Bear study site (Hardy et al. 2006) and flow levels of this magnitude would be adequate for adult coho salmon to migrate freely upstream. However, real time flow management envisioned by Hetrick et al. (2009) under KBRA would create variable flows during the spawning season that would actually have potential to increase the abundance of spawning habitat above what could be provided under a single static flow condition (Hetrick et al. 2009).

In the mid 2000s, NOAA Fisheries Service, FWS and Reclamation worked together to better understand and consider the conservation needs of listed fish (SONCC coho salmon, Shortnose and Lost River suckers) that reside in the Klamath River or in the Upper Klamath Basin. The agencies worked to improve inter-agency cooperation to promote efficient utilization of limited water resources for listed species, refuges and Project water users and to better harmonize the analyses and any potential conditions imposed by the final biological opinions prepared by the FWS and NOAA Fisheries Service. In October of 2007 Reclamation requested formal consultation under section 7 of the ESA for operation of Reclamation's Klamath Project from 2008 through 2018. In the years immediately following, NOAA Fisheries Service worked collaboratively with Reclamation and FWS, and met with technical experts from Klamath Basin Tribes, to develop a reasonable and prudent alternative to avoid jeopardizing listed coho salmon. The final biological opinion which includes a reasonable and prudent alternative that addresses instream flow needs for SONCC coho salmon was released in 2010 (see Section 3.6.3.2 and Table 3.6-1 for additional description).

Under the No Action Alternative, Klamath River flows were simulated following the instream flow requirements established for operation of Reclamation's Klamath Project under the reasonable and prudent alternative (RPA) described with in the 2010 Biological Opinion (NOAA Fisheries Service 2010a). In developing the RPA, NOAA Fisheries Service concluded that the implementation of Hardy Phase II flow exceedence recommendations at Iron Gate Dam will sufficiently provide fluvial conditions necessary for the conservation of coho salmon. NOAA Fisheries Service also adopted flows for certain time periods that reflect Hardy Phase II flows and determined that this action provided both a reasonable and prudent approach consistent with avoiding jeopardy of Southern Oregon and Northern California Coast (SONCC) coho salmon. As a result, the hydrology simulation results used in the analysis of the EIS/EIR for the No Action Alternative (NOAA Fisheries Service 2010a BO flows) and the Proposed Project (KBRA Flows) are similar in many aspects as described in Reclamation (2011a).

However, one aspect of the RPA flows that could not easily be incorporated into the hydrologic model for the No Action Alternative is the requirement to include a fall and winter flow variability program. The purpose of the Fall Winter Flow Variability Program, included in the RPA, is to enhance flow variability that would result from additional tributary inflow during fall and winter rainfall events. To accomplish this purpose, the RPA sets aside 18,600 acre feet of water for this purpose (NOAA Fisheries Service 2010a). In projection of the no-action Alternative, rather than attempt to simulate uncertain future implementation of this fall and winter flow variability program, the hydrologic modeling increased the base flow for the month of October from 1,000 cfs to 1,300 cfs which is roughly equivalent to the 18,600 acre feet provided under the RPA. Incorporation of this assumption increases simulated flows during the month of October under the No Action Alternative.

Klamath River Estuary and Pacific Ocean

Flow-related habitat has not been described for the Klamath River estuary.

3.3.3.3.8 Critical Habitat

The ESA requires that USFWS and NOAA Fisheries Service designate critical habitat[2] for the listed species they manage. Critical habitat has been designated for three species within the area of analysis: coho salmon, green sturgeon, and bull trout, and has been proposed for an additional two: shortnose and Lost River suckers. An endangered population of killer whales that includes Klamath River salmon in its diet is also discussed here.

Coho Salmon

Critical habitat for the SONCC Coho ESU was designated on May 5, 1999 and includes all river reaches accessible to listed coho salmon between Cape Blanco, Oregon and Punta Gorda, California, and includes water, substrate, and adjacent riparian zones of estuarine and riverine reaches, including off-channel habitat. "Accessible reaches" are defined as those within the historical range of the ESU that can still be occupied by any life stage of coho salmon. Specifically, in the Klamath Basin, all river reaches downstream ~~of~~from Iron Gate Dam on the Klamath River and Lewiston Dam on the Trinity River are designated as critical habitat (NOAA Fisheries Service 1999b).

~~Essential features~~Features of critical habitat considered essential for the conservation of the SONCC ESU (NOAA Fisheries Service 1997b) include (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. Primary Constituent Elements (PCEs) for SONCC coho salmon are described in NOAA Fisheries Service (1999b) as follows: ~~"~~ "In addition to these factors, ~~NMFS~~NOAA Fisheries Service also focuses on the known physical and biological features (~~primary constituent~~

[2] The ESA defines critical habitat as "the specific areas within the geographical area occupied by the species, at the time it is listed, on which are found those physical or biological features (I) essential to the conservation of the species and (II) 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 that are determined by the Secretary to be essential for the conservation of the species."

~~elements~~PCEs) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation~~."~~."

Shortnose Sucker and Lost River Sucker

~~The USFWS proposed critical habitat for the shortnose sucker and Lost River sucker of approximately 182,400 hectares and 170,000 hectares, respectively, of stream, lake, and shoreline areas, but critical habitat has not yet been formally designated. The proposed designation includes six habitat units across the range of the two species: (1) Clear Lake and Watershed; (2) Tule Lake; (3) Klamath River; (4) Upper Klamath Lake and Watershed [excluding Williamson and Sprague rivers]; (5) Williamson and Sprague Rivers; and (6) Gerber Reservoir and watershed (USFWS 1994). Proposed critical habitat for the Lost River sucker includes all of the above habitat units except Gerber Reservoir and watershed. The PCEs identified in the critical habitat proposal are as follows: (1) water of sufficient quantity and suitable quality; (2) sufficient physical habitat, including water quality refuge areas and habitat for spawning, feeding, rearing, and travel corridors; and (3) a sufficient biological environment, including adequate food levels, and patterns for predation, parasitism, and competition that are compatible with recovery (USFWS 1994). A Recovery Plan was written for both species (USFWS 1994), but did not include critical habitat. A new draft recovery plan and proposed critical habitat is currently being developed and expected to be released in 2011 (L. Sada, pers. comm., 2011). Predominate threats to these suckers are lack of spawning habitat, continued loss of habitat, lake elevation fluctuations that reduce access to vegetative habitat, water diversions, competition and predation by introduced species, hybridization with other sucker species, isolation of remaining habitats, and drought (USFWS 1988). Decreases in water quality resulting from timber harvest, dredging activities, removal of riparian vegetation, and livestock grazing may also cause problems for these species (USFWS 1988).~~

Critical habitat was originally proposed but not finalized by the USFWS for the Lost River sucker and shortnose sucker in 1994 (USFWS 1994). Critical habitat for the two species was reproposed on December 7, 2011 (USFWS 2011b). The proposed new critical habitat area is within Klamath and Lake Counties, Oregon, and Modoc County, California. The two proposed critical habitat units include: (1) approximately 146 stream miles (234 km) and 117,848 acres (47,691 ha) of lakes and reservoirs for Lost River sucker; and (2) approximately 128 stream miles (207 km) and 123,590 acres (50,015 ha) of lakes and reservoirs for shortnose sucker (USFWS 2011b). The USFWS considers the physical and biological features essential to the conservation of the species which may require special management considerations or protection when proposing critical habitat. These include, but are not limited to: (1) space for individual and population growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing (or development) of offspring; and (5) habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species. PCEs are the specific elements of physical and biological features that are

essential to the conservation of the species. The PCEs identified in the critical habitat proposal are as follows: (1) water in sufficient depths and quantity; (2) spawning and rearing habitat; and (3) areas contain abundant food (USFWS 2011b). A revised draft recovery plan was released in 2011 (USFWS 2011a) and is expected to be finalized with the new critical habitat in 2012 once public comments are addressed. The draft recovery plan cites predominant threats to these suckers as lack of spawning habitat, continued loss of habitat, lake elevation fluctuations that reduce access to vegetative habitat, water diversions, competition and predation by introduced species, hybridization with other sucker species, isolation of remaining habitats, and drought (USFWS 2011a). Decreases in water quality resulting from timber harvest, dredging activities, removal of riparian vegetation, and livestock grazing may also cause problems for these species (USFWS 2011a).

Green Sturgeon

In 2009, NOAA Fisheries Service designated critical habitat for the Southern DPS of green sturgeon, which encompasses all coastal marine waters of the United States less than 60 fathoms deep (approximately 110 m) from Monterey Bay, California north to Cape Flattery, Washington. The estuary portion of the Eel and Klamath/Trinity Rivers was specifically excluded from the critical habitat designation (NOAA Fisheries Service 2009b).

Bull Trout

Critical habitat designations for bull trout were finalized in 2005, but were then remanded in 2009 and republished in 2010. The final 2010 rule designates 277 miles of stream shoreline and 9,329 acres of reservoirs or lakes as critical habitat within the Klamath River Recovery Unit. This habitat includes Agency Lake and its tributaries and an assortment of headwater streams. A ~~map of~~ designated critical habitat map is available from the USFWS (http://www.fws.gov/oregonfwo/Species/Data/BullTrout/Maps/final_krb.pdf). Critical habitat areas have at least one PCE essential to the conservation of bull trout. These features are the PCEs laid out in the appropriate quantity and spatial arrangement for conservation of the species. These include: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species.

Eulachon

~~NOAA Fisheries Service proposed critical habitat for eulachon on January 5, 2011 (NOAA Fisheries Service 2011). The proposed critical habitat designation for the Southern Eulachon DPS included 12 areas comprising freshwater streams, rivers, and estuaries along the coast of Washington, Oregon, and California. The proposed designation does not include the Klamath River.~~

Critical habitat for the Southern DPS eulachon in the Klamath River was designated by the NOAA Fisheries Service on 20 October 2011 (NOAA Fisheries Service 2011).

NOAA Fisheries Service designated approximately 539 miles of riverine and estuarine habitat in California, Oregon, and Washington within the geographical area occupied by the southern DPS of eulachon. The designation includes 16 rivers and creeks extending from and including the Mad River, California to the Elwha River, Washington. NOAA Fisheries Service did not identify any unoccupied areas as being essential to conservation and thus, did not designate any unoccupied areas as critical habitat. NOAA Fisheries Service excluded from designation all lands of the Lower Elwha Tribe, Quinault Tribe, Yurok Tribe, and Resighini Rancheria. In the Klamath River, designated critical habitat extends from the mouth of the Klamath River upstream to Omogar Creek, a distance of 10.7 miles, and includes only the Federal, State, and private lands within the Yurok Reservation and Resighini Rancheria. The physical or biological features essential for conservation of this species include: (1) Freshwater spawning and incubation sites with water flow, quality, and temperature conditions and substrate supporting spawning and incubation, (2) Freshwater and estuarine migration corridors free of obstructions with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Southern Resident Killer Whale

In November 2006, NOAA Fisheries Service designated critical habitat for Southern Resident Killer Whales (NOAA Fisheries Service 2006b). Critical habitat includes all waters relative to a contiguous shoreline-delimited by the line at a 20-foot depth relative to extreme high water within three designated areas: (1) the Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca. ~~Coastal~~ Coastal and offshore areas have not been designated as critical habitat, though they are recognized as important for the Southern Resident Killer Whales and NOAA Fisheries Service anticipates additional information on coastal habitat use from research projects in the coming years (NOAA Fisheries Service 2006b).

Based on the natural history of the Southern Residents and their habitat needs, the following physical or biological features were identified as essential to conservation: (1~~)~~) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (71 FR 69054). There is the potential for Southern Resident Killer Whales to feed on Klamath River salmonids during the period from about September through May when they spend more time in outer coastal waters and may range from central California to northern British Columbia (Hanson et al. 2010). Southern Resident Killer Whales would not be expected to be affected by any of the alternatives, apart from their effects on salmon production.

3.3.3.3.9 Essential Fish Habitat

EFH is designated for commercially fished species under the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (Magnuson-Stevens Act). The Magnuson-Stevens Act requires ~~federal~~Federal fishery management plans, developed by

NOAA Fisheries Service and the ~~Pacific Southwest Fisheries~~Regional Fishery Management Councils, to describe the habitat essential to the fish being managed and to describe threats to that habitat from both fishing and nonfishing activities. To protect EFH, ~~federal~~Federal agencies are required to consult with the NOAA Fisheries Service on activities that may adversely affect EFH.

EFH has been designated for 3 species of salmon, 83 groundfish species, and 5 pelagic species. Descriptions of EFH within the area of analysis are provided below.

Chinook and Coho Salmon

Coho salmon are also managed under the Magnuson-Stevens Act, under the authority of which EFH for coho salmon is described in Amendment 14 to the Pacific Coast Salmon Fishery Management Plan (50 CFR 660.412). EFH for Chinook salmon is also described in the same management plan, and is identical to that for coho salmon in the Klamath ~~basin~~Basin. EFH has been designated for the mainstem Klamath River and its tributaries from its mouth to Iron Gate Dam, and upstream to Lewiston Dam on the Trinity River. EFH includes the water quality and quantity necessary for successful adult migration and holding, spawning, egg-to-fry survival, fry rearing, smolt migration, and estuarine rearing of juvenile coho and Chinook salmon.

~~Although specific Habitat Areas of Particular Concern have not been established for coho or Chinook salmon in the Klamath Basin, the Preliminary Draft of the Pacific Coast Salmon EFH Review recommend designating complex channels and floodplain habitats: meandering, island-braided, pool-riffle and forced pool riffle habitats; thermal refugia; spawning habitat; estuaries; and marine and estuarine submerged aquatic vegetation (NOAA Fisheries Service 2010a).~~

Groundfish

~~NOAA Fisheries Service defined~~The Magnuson-Stevens Act defines EFH to include those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (16 USC 1802 (10)). EFH for Pacific Coast groundfish includes all waters and substrate within areas with a depth less than or equal to 3,500 m (1,914 fm) shoreward to the mean higher high water level or the upriver extent of saltwater intrusion (defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow). The Klamath River Estuary, which extends from the river's mouth upstream to near the confluence with Ah Pah Creek, is included in the Pacific groundfish EFH (50 CFR § 660.395).

Pelagic Fish

EFH for coastal pelagic species, including finfish (northern anchovy, Pacific sardine, Pacific (chub) mackerel, and jack mackerel) and market squid occurs from the shorelines of California, Oregon, and Washington westward to the exclusive economic zone and above the thermocline where sea surface temperatures range from 10 to 26ºC. During colder winters, the northern extent of EFH for coastal pelagic species may be as far south as Cape Mendocino, and during warm summers it may extend into Alaska's Aleutian Islands. In each of these seasonal examples the Klamath Estuary and coastline would be included as EFH for these species.

3.3.4 Environmental Consequences

3.3.4.1 Environmental Effects Determination Methods

This section provides a brief overview of the methods used in the evaluation of important factors to aquatic resources. More complete descriptions are provided in the Methods and Criteria Technical Memorandum (Reclamation ~~2011~~2012), Appendix E for suspended sediment~~,~~ and Appendix F for bedload sediment.

3.3.4.1.1 Suspended Sediment

As described in Appendix E, the potential effects of suspended sediment on anadromous fish species for the Proposed Action and alternatives were assessed using SRH-1D (Huang and Greimann 2010, as summarized in ~~Greimann et al. 2010~~Reclamation 2011). The SRH-1D model provides an estimate of SSCs at different points on the river on a daily average estimate. This information is used to assess the impacts of SSCs on fish based on the concentration and duration of exposure using Newcombe and Jensen's (1996) approach. Duration of exposure is based on the time a species and lifestage would be exposed to elevated SSCs. These effects are compared to those that fish would be expected to encounter under baseline conditions. Estimated existing conditions were also simulated using the
SRH-1D model, to provide a comparison of what SSCs would be with and without dam removal in the years 2020 and 2021 (No Action/No Project Alternative). This approach is similar to that used in Stillwater Sciences (2008, 2009a, 2009b).

Daily durations of SSC concentrations were modeled assuming the Proposed Action occurred within each of the 48 years in the available hydrology record since 1961. For each simulation year in the 48 year record, the duration of SSCs over a given threshold was calculated for each species and life-history stage (e.g., duration of SSC over 1,000 mg/L during spring-run Chinook salmon adult upstream migration). The results of modeling all potential years were summarized for each life-stage of each species assessed. Because the suspended sediment varies with hydrology, and in order to account for (and compare) the range of results and impacts that might occur under each alternative, two scenarios were analyzed for the Proposed Action, and for action alternatives, with the goal of predicting the potential impacts to fish that has either a 50~~%~~

percent (likely to occur) or 10~~%~~ percent (unlikely, or worst case) probability of occurring, defined as follows:

3.3.4.1.2 For Existing Conditions and the No Action/No Project Alternative:

- **Normal conditions:** ~~suspended sediment concentrations~~SSCs and durations with a ~~50~~ 50 percent exceedance probability for the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded ~~for each assessed species and life-stage~~ in any one year is 50 percent). Exceedance probabilities were based on modeling SSC ~~using hydrologic data from~~ for all water years subsequent to 1961 with facilities in place. To assess "normal conditions" the median (50 percent) ~~suspended sediment concentration~~SSC and duration from these results was estimated~~.~~ (Appendix II, Volume E, page E-3). "Normal conditions" is a description of the SSCs that commonly occur under existing conditions during most years, such as during typical winter flows.
- **Extreme conditions:** ~~suspended sediment concentrations~~SSCs and durations with a ~~10~~ 10 percent exceedance probability ~~-~~(i.e., the probability of these concentrations and durations being equaled or exceeded ~~for each assessed species and life-stage~~ in any 1 year is ~~10~~ 10 percent). "Extreme conditions" is a description of infrequent SSCs events in the Klamath River under existing conditions, such as a flood (Appendix II, Volume E, page E-4).

3.3.4.1.3 For the Proposed Action– Full Facilities Removal of Four Dams:

- **Most likely scenario:** ~~suspended sediment concentrations~~ SSCs and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any one year is 50 percent). Exceedance probabilities were based on the results of modeling suspended sediment in the Klamath River downstream ~~of~~ from Iron Gate Dam in all water years observed since 1961 with facility removal. To ~~assess~~ predict the "most likely scenario" that will occur under the Proposed Action, the median (50 percent exposure concentration) was estimated.

- **Worst-case scenario:** ~~suspended sediment concentrations~~ SSCs and durations with a 10 percent exceedance probability (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any 1 year is 10 percent). "Worst-case scenario" is a prediction of an unlikely, but potential scenario of high SSCs that could occur under if the Proposed Action occurs under a sequence of rare hydrologic conditions.

3.3.4.1.4 Bedload Sediment

As described in Appendix F, the analysis of potential changes to bedload sediment also relied upon output from the SRH-1D model (Huang and Greimann 2010). The changes in bedload were evaluated for a range of hydrologic conditions for short-term (2-year) and long-term (5-, 10-, 25-, 50-year) changes using a range of flows taken from historical hydrology. A long-term simulation was not conducted for the Klamath River upstream of Iron Gate Dam under the assumption that the bedload sediment conditions at the end of ~~2~~ 2 years are representative and would persist through time, allowing for mild fluctuations

as a function of hydrology (Reclamation ~~2011; D. Varyu, pers. comm., January 4, 2011~~2012).

The effects determination used results from the analysis and knowledge of habitat requirements of affected fish species to determine how changes in bed elevation and substrate composition would affect aquatic resources (e.g., pool habitat, spawning gravel, benthic habitat). Changes in substrate composition occurring as a result of dam removal that decreased habitat suitability were assumed to be deleterious to salmonids. Bedload transport in the area upstream of the influence of J.C. Boyle Reservoir are not anticipated to be affected by dam removal and are not expected to be substantially affected by the Proposed Action, and are not evaluated further in this document. Link and Keno Dams would remain in place and would continue to affect hydrology and sediment transport in much the way they do currently.

3.3.4.1.5 Water Quality

The analysis of potential short- and long-term water quality-related effects on fish ~~were~~is based on the corresponding water quality effects determinations (see Section 3.2, Water Quality) for parameters to which fish are most sensitive (i.e., water temperature, sediment and turbidity, dissolved oxygen, pH, and ammonia toxicity), as well as effects determinations for ~~state~~State and approved tribal designated beneficial uses that are directly related to fish (see Table 3.2-3).

As described in Section 3.2., Water Quality, implementation of the Oregon and California Total Maximum Daily Loads (TMDLs) is considered to be a reasonably foreseeable action associated with water quality during the period of analysis (i.e., 50 years) (see Section 3.2.4.1, Environmental Effects Determination Methods), and is expected to generally improve water quality conditions in the Klamath River. Modeling efforts for development of the TMDLs included four simulated scenarios and both "dams in" and "dams out" conditions (see Appendix D, Section D.1 for additional detail on modeling scenarios). TMDL model results for water temperature, dissolved oxygen, pH, and nutrients provide one set of quantitative, predictive information under the alternatives and so these results are discussed as part of the water quality analysis (Section 3.2.4.3, Effects Determinations) and the corresponding aquatics analysis (below). However, since no one existing model captures all of the elements analyzed for water quality in this Klamath Facilities Removal EIS/EIR, where possible, model outputs are used in combination to assess similar spatial and temporal trends in predicted water quality parameters (Section 3.2.4.1, Environmental Effects Determination Methods).

Potential effects of sediment-associated toxins on fish under the dam removal alternatives were evaluated using the results of multiple screening level comparisons of sediment contaminant levels identified in reservoir sediments that are currently trapped behind the dams. These water quality methods are described in greater detail in Section 3.2~~, Water Quality~~.4.1.7.

3.3.4.1.6 Water Temperature

Potential impacts of water temperature on species within each analysis area were evaluated using available modeled water temperatures (PacifiCorp 2004c; Dunsmoor and

Huntington 2006; FERC 2007; Tetra Tech 2009, Perry et al. 2011). Because model results were not developed for ~~all~~scenarios covering each of the alternatives, this evaluation assumes that the Partial Facilities Removal Alternative would result in temperatures similar to those that would occur under the Proposed Action. It is assumed that the Fish Passage at Four Dams Alternative would result in similar temperatures to ~~the No Action/No Project Alternative~~existing conditions. The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative was assumed to result in temperatures intermediate to the Proposed Action and ~~No Action/No Project Alternative~~existing conditions. Because the remaining reservoirs are small relative to Copco 1 and Iron Gate Reservoirs, with correspondingly lower amounts of thermal heating and residence time, the temperatures under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would likely be more similar to those under the Proposed Action than they would be to the No Action/No Project Alternative. Water temperature data were compared to the thermal tolerances of focal species and associated life stages as determined from the literature to determine relative suitability for these species under the various alternatives.

~~Neither implementation of total maximum daily loads (TMDLs) nor~~

No one available water temperature model includes all of the reasonably foreseeable actions associated with water temperature. Implementation of TMDLs is included in the TMDL models (Tetra Tech 2009) and climate change ~~was~~and KBRA hydrology are incorporated into the ~~existing models~~RBM10 model (Perry et al. 2011) (see Section 3.2.4.1.1 and Appendix D for additional detail). Implementation of TMDLs and climate change are not explicitly incorporated into the Chinook salmon life cycle model (EDRRA) developed by Hendrix (2011). For purposes of the ~~analysis~~ water quality and aquatics analyses it ~~was~~is assumed that TMDL water temperature objectives ~~would~~ can be met ~~within the analysis period (see Section 3.2, Water Quality) and~~; however the timeframes for achieving allocations required under the TMDLs will depend on the measures taken to improve water quality conditions (see Section 3.2.4.3.1). It is also assumed that climate change would result in ~~2.5~~1.0 to 3.0°C warming of median air temperature by the end of the analysis period (Snyder et al. 2004; Bartholow 2005; ~~Stillwater Sciences 2009a~~Perry et al. 2011) (see also Section 3.2.4.1.1).

3.3.4.1.7 Fish Disease and Parasites

Fish diseases, specifically *C. shasta* and *P. minibicornis*, can contribute to ~~reduced survival~~ mortality and have periodically contributed to substantial mortality for Klamath River salmonids. Generally, Klamath River steelhead are resistant to *C. shasta* (Administrative Law Judge 2006). Environmental variables such as temperature, flow, sediment (bedload composition and stability), plankton (high quality food abundance), and nutrients are thought to affect the abundance of *P. minibicornis* and *C. shasta* via habitat for the intermediate host; therefore, differences in river habitat conditions that could occur under the Proposed Action and alternatives could affect the abundance of these parasites and their infection rates in Klamath Basin fish. Bartholomew and Foott (2010) prepared a compilation of available information regarding Myxozoan disease relative to the Klamath River and, in their analysis they considered several factors that could, if co-occurring, lead to high ~~infections~~disease infection rates of fish:

- Physical habitat components that support the invertebrate host species (pools, eddies, sediment, mats of filamentous green algae [periphyton])
- Microhabitats with low velocity and unnaturally stable flows
- Close proximity to spawning areas
- ~~Temperatures~~Water temperatures higher than 15 °C

3.3.4.1.8 Aquatic Habitat

Changes to habitat area were assessed for each life stage qualitatively, using knowledge of habitat requirements and expected changes under the alternatives. Quantitative descriptions of the relationship between fish habitat and flow are available for the current channel configuration at some locations (Bureau of Land Management 2002; Hardy et al. 2006). However, extrapolation of these relationships to describe the habitat changes that would be anticipated under each of the proposed alternatives would not provide an appropriate method to assess the effects of the project alternatives because the channel configuration itself is anticipated to change as a result of alterations to sediment supply and the temporal resolution (mean monthly or biweekly time steps) of modeled flows would not accurately represent daily flow conditions. Qualitative analyses relied on data evaluated for other affected factors (water temperature and fish passage) and expected changes in geomorphic processes, such as short- and long-term changes in sediment transport and deposition, to determine increases or decreases in habitat relative to existing conditions for the different species and life stages in the various reaches.

3.3.4.1.9 Critical Habitat

NOAA Fisheries Service has designated critical habitat for coho salmon~~ and~~, Southern Resident Killer Whales, and eulachon, and the USFWS has designated critical habitat for bull trout. Within critical habitat, NOAA Fisheries Service has determined that the PCEs essential for the conservation of these species are those sites and habitat components that support one or more life stage~~, as described in Section 3.3.3.3~~. Critical habitat for Southern Resident Killer Whales does not extend into coastal or offshore habitats (71 FR 69054).The effects of each alternative on critical habitat were based on evaluation of the physical, chemical and biological changes that were expected to occur to designated critical habitat within the area of analysis and how those changes would affect the PCEs for that critical habitat in the short and long term.

3.3.4.1.10 Essential Fish Habitat

The effects of each alternative on EFH were based on evaluation of the physical, chemical and biological changes that were expected to occur to EFH within the area of analysis and whether those changes would have beneficial effects on this habitat in terms of its quantity and quality in the short and long term.

3.3.4.1.11 Freshwater Mussels

Increased levels of fine sediment, both suspended in the water column and along the channel bed, can inhibit the growth, production, and abundance of freshwater mussels and clams. Therefore, the analysis of impacts associated with dam removal focused on short- and long-term changes in SSCs (Aldridge et al. 1987, as cited in Henley et al. 2000) and stream substrate texture (Howard and Cuffey 2003; Vannote and Minshall 1982). The evaluation focuses on freshwater mussels because of the lack of information regarding the effects of SSCs and sediment transport on clams. Suspended sediment impacts on freshwater mussel species were evaluated using output from the SRH-1D (Huang and Greimann 2010) sediment transport model as discussed above for suspended and bedload sediment.

Aldridge et al. (1987, as cited in Henley et al. 2000) showed that exposure to SSCs of 600-750 mg/L led to reduced survival of freshwater mussels found in the eastern United States. No duration of exposure was cited in the study. No comparable data are available for the species in the Klamath River. Using 600 mg/L as the minimum SSCs that would be detrimental to freshwater mussels, alternatives were compared to each other by determining the number of days during which this criterion threshold would be exceeded.

Analysis of impacts due to changes in bedload transport on the four species of freshwater mussels considered modeled changes in median sediment size, under the Proposed Action and each project alternative. The effects of changes in water quality on freshwater mussels were evaluated in the same manner as described for fish. The analysis presented here, focuses on effect on freshwater mussels because of their longer lifespan and a lack of information on the effects of water quality on clams.

3.3.4.1.12 Benthic Macroinvertebrates

Suspended sediment and turbidity can cause stress to ~~benthic macroinvertebrates~~BMIs through impaired respiration, reduced feeding, growth, and reproductive abilities, and reduced primary production (Lemly 1982; Vuori and Joensuu 1996). Therefore, potential short-term and long-term effects of the Proposed Action and alternatives on ~~benthic macroinvertebrates~~BMIs were evaluated for both short- and long-term changes in SSCs and bedload sediment. Suspended sediment impacts on ~~benthic macroinvertebrates~~BMIs were evaluated using output from the SRH-1D (Huang and Greimann 2010) sediment transport model as discussed above for suspended and bedload sediment.

Changes in substrate size or embeddedness may influence the distribution, abundance, and community structure of ~~benthic macroinvertebrates~~BMIs (Bjornn et al. 1977; McClelland and Brusven 1980; Ryan 1991). Bed texture changes that would occur under the Proposed Action and alternatives were qualitatively evaluated to determine whether changes in substrate composition would likely decrease macroinvertebrate abundance or alter the community composition to the extent that these communities could no longer support sufficient fish populations in the Klamath system.

The effects of changes in water quality, Biochemical Oxygen Demand/Immediate Oxygen Demand, and toxicity effects on BMIs were based on water quality determinations (see Section 3.2, Water Quality) and evaluated in the same manner as described for fish and mollusks. Potential toxicity to BMIs was also evaluated using the results of bioassays.

~~-~~*3.3.4.2 Significance Criteria*

The Proposed Action and alternatives could affect aquatic resources directly or indirectly through a variety of mechanisms, as described in the preceding section. These effects could be additive or offsetting. For purposes of this evaluation, the Lead Agencies considered the total effect of the factors described above on native fish populations and their habitat. These impacts could vary substantially in intensity, geographic extent, and duration. The intensity of an impact refers to how severely it affects an organism. This severity can range from sublethal behavioral adaptations such as avoidance of a specific

condition, to mortality. The geographic extent refers to how much of the species' potential habitat and what proportion of the total population is expected to be affected. The temporal duration refers to how long the effect is anticipated to persist (hours, days, months, or years). The Lead Agencies considered effects in the short term (less than ~~2~~ 2 years) and the long term (more than 2 years), but either short- or long-term impacts could be significant.

For the ~~purposes~~analysis of Aquatic Resources in this EIS/EIR, the following determinations were considered:

- No ~~change~~ from existing conditions: Effect would not result in alterations to existing conditions.
- Significant: As defined below.
- Less-than-significant: Effect influences an aquatics species, but does not result in a significant effect.
- Beneficial: Results in a substantial increase in the abundance of a year class in the short or long term.

For the purposes of this EIS/EIR, effects would be significant if they would result in the following:

Short term:

- Substantially reduce the abundance of a year class in the short term.
- Substantially decrease the habitat quality or availability for a native species over a large proportion of the habitat available to it in the short term.
- Substantially decrease the quality or availability of a large proportion of critical habitat under the ESA or EFH under the Magnuson-Stevens Fishery Conservation and Management Act in the short term.

Long term:

- Substantially reduce the population of a native species for more than two generations after removal of all dams (if removed all at once) or after the last dam (if removed sequentially).
- Substantially decrease the habitat quality or availability for a native species or community in the long term.
- Substantially decrease the habitat quality or availability for a native species over a large proportion of the habitat available to it in the long term.
- Substantially decrease the habitat quality or availability of a large proportion of critical habitat under the ESA or EFH under the Magnuson-Stevens Fishery Conservation and Management Act in the long term.
- Continue or worsen conditions that are currently causing a species to decline in the long term.
- Eliminate a year class of salmon or steelhead, thereby ~~jeopardizing~~impacting the long-term viability within the Klamath Basin. Because of the fixed, 3-year timing

of the coho salmon life cycle, which has little to no plasticity, this criterion was added for the protection of coho salmon in particular and could result in a jeopardy decision.

3.3.4.3 Effects Determinations

3.3.4.3.1 Alternative 1: No Action/No Project

Under this alternative, none of the actions under consideration would be implemented. The Klamath Hydroelectric Project would continue current operations under the terms of an annual license until a long-term license is finalized. Annual licenses would not include actions associated with the KHSA and KBRA. Several Interim Measures (IMs) from the KHSA would be implemented through other PacifiCorp's Habitat Conservation Plan or other means; these measures are included in the No Action/No Project Alternative. In addition, continued expenditures of $10 to 20 million a year on various basin-wide restoration projects (e.g., stream habitat improvements), and other basin conservation plans will continue to provide aquatic habitat improvements. Some KBRA actions have already been initiated and would continue under the No Action/No Project Alternative. These include the Williamson River Delta Project, the Agency Lake and Barnes Ranch Project, fish habitat restoration work, and ongoing climate change assessments. The TMDLs would be implemented under all alternatives as they are an unrelated regulatory action; however, TMDL goals would likely be met at a later date than under alternatives with KBRA. Hydroelectric operations would continue as they have been, providing peaking power generation during the summer as demand requires and conditions allow. Iron Gate Hatchery would continue to operate at current levels of production in order to meet mitigation requirements.

Key Ecological Attributes

Suspended Sediment

Suspended sediment effects under the No Action/No Project Alternative are described in detail in Appendix E, and summarized here. Under the No Action/No Project Alternative, suspended sediment would be the same as under existing conditions. Most suspended sediment is supplied by tributaries; Iron Gate Dam currently interrupts both fine and coarse sediment transport, so suspended sediment generally increase in a downstream direction. The lowerLower Klamath River downstream of from the Trinity River confluence (RM 40.0) to the estuary mouth is listed as sediment impaired under Section 303(d) of the Clean Water ActCWA (see SectionTable 3.2.2-8). Under both normal and extreme conditions, the magnitude and duration of the SSCs modeled for the No Action/No Project Alternative are expected to cause major stress to migrating adult and juvenile salmonids primarily during winter (, with a Newcombe and Jenson Jensen (1996;) Severity Index predicted to be higher than 8 for most of the winter (see Appendix E). for detailed analysis).

Bedload Sediment

Bedload sediment effects under the No Action/No Project Alternative are described in detail in Appendix F, and summarized here.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

Under the No Action/No Project Alternative, the Klamath Hydroelectric Project dams

would continue to trap fine and coarse sediment~~ and reduce the storage capacity of the reservoirs. Reclamation (2011) estimates that the four subject reservoirs would store 2.35 million yd^3 of fine and coarse sediment by 2061. As reservoir water storage capacities decreased (i.e., as they filled with sediment), sediment trapping efficiency could also decrease, allowing sediment to pass through reservoirs.~~. The No Action/No Project Alternative would have no effects associated with bedload sediment relative to existing conditions for any aquatic species in this reach.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Under the No Action/No Project Alternative, the ~~channel directly downstream of Iron Gate Dam would continue to coarsen over time due to retention of fine and coarse~~ Project dams would continue to interrupt the transport of bedload. These periodic inputs of bedload sediments are necessary for the long-term maintenance of aquatic habitats. As a result of the interception of sand, gravel and coarser sediment supply from sources upstream of Iron Gate Dam the channel downstream from Iron Gate Dam would continue to coarsen and decrease in mobility (Reclamation ~~2011), but this~~ 2012), providing fewer components of habitat, in particular spawning habitat, and decreased quality habitat over time. This effect would gradually decrease in the downstream direction as coarse sediment ~~was~~ is resupplied by tributary inputs (Hetrick et al. 2009), and would be substantially reduced at the Cottonwood Creek confluence (PacifiCorp 2004b). ~~The~~ As occurs under existing conditions, the coarser bed material is mobilized at higher flows that occur less frequently, resulting in channel features that are ~~more stable. This impact would be limited to the area upstream of Cottonwood Creek. Under the No Action/No Project Alternative, rearing habitat would be expected to remain similar to existing conditions~~unnaturally static and provide lower value aquatic habitat (Buer 1981).

Klamath River Estuary The No Action/No Project Alternative would not change bedload transport to the estuary or Pacific Ocean, relative to existing conditions.

Water Quality

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. ~~These dissolved~~Dissolved oxygen levels ~~would not consistently meet Oregon and California Basin Plan~~ are particularly low during the summer in this reach, with typical levels ranging from <1 mg/L to 5 mg/L. Such low levels do not meet Oregon water quality objectives for dissolved oxygen, and ~~would~~they do not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning~~ and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses~~.

Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly increase dissolved oxygen in this reach. Klamath TMDL model results for riverine conditions between Link River Dam and the upstream end of J.C. Boyle Reservoir predict that dissolved oxygen concentrations ~~will~~ would meet

the 6.5 mg/L objective year round~~ and achieve the modeled natural conditions baseline during the~~ , including the warm summer and fall months (see ~~Section~~ subsection to Section 3.2.4.3.1~~.4~~, Upper Klamath Basin~~). Thus, full attainment of the Oregon TMDLs would eventually be beneficial for dissolved oxygen in this reach. Under full TMDL compliant conditions, the California 85 percent saturation objective (based on natural receiving water temperatures) is also met at state line under the No Action/No Project Alternative (see Section 3.2.4.3.1.4). Thus, full attainment of the Oregon and California TMDLs would eventually be beneficial for dissolved oxygen in the Hydroelectric Reach.~~). Full attainment could require decades to achieve and it is highly dependent on improvements in dissolved oxygen in Upper Klamath Lake~~ and the upstream reach from Link River Dam to J.C. Boyle Dam (particularly Keno Impoundment and Lake Ewauna).~~ .

~~The overall anticipated effect on dissolved oxygen in the Upper Klamath Basin under the No Action/No Project Alternative would be an increasing trend toward compliance with water quality objectives and support of designated beneficial uses, but may not meet minimum dissolved oxygen objectives for California at the downstream end of the Hydroelectric Reach during the late summer/early fall months.~~

~~Restoration~~Additionally, restoration activities such as floodplain rehabilitation, riparian vegetation planting, and purchase of conservation easements/land related to nutrients under the No Action/No Project Alternative are currently ongoing in the Upper Klamath Basin and are expected to continue to improve long-term ~~pH~~dissolved oxygen in the Upper Klamath Basin. These restoration actions and implementation of water quality improvement measures under Oregon ~~and California~~ TMDLs to address water quality impairments are also expected

to improve pH during the period of analysis (50 years) ~~under the No Action/No Project Alternative~~by decreasing algal bloom populations and rates of photosynthesis and correspondingly decreasing observed pH maximums in the Upper Klamath Lake and its tributaries.

Hydroelectric Reach~~:~~: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the No Action/No Project Alternative, continued high rates of algal photosynthesis in the two largest reservoirs in the Hydroelectric Reach (Copco 1 and Iron Gate) would result in dissolved oxygen and pH values that would not consistently meet applicable ODEQ and California Basin Plan water quality objectives (see Section 3.2, Water Quality). The bottom waters (i.e., hypolimnion) of Copco 1 and Iron Gate Reservoirs would continue to have very low oxygen levels (< 1 mg/L to 5 mg/L) during summer stratification periods (FERC 2007). Based on existing conditions, pH during summer through fall ~~within the reservoirs~~in Copco 1 and Iron Gate Reservoirs would continue to range from just above neutral (7) to greater than 9 (slightly basic~~)~~), with the highest values occurring during algal blooms. The ongoing presence of the two largest reservoirs in ~~the~~ the Hydroelectric Reach (Copco 1 and Iron Gate) would also continue to provide ~~the~~ the conditions necessary for large seasonal blue-green algae blooms, including *M*~~.~~. *aeruginosa*, which can produce a toxin and contribute to reduced health

and increased mortality rates for fish and other aquatic resources both within the reservoirs and in areas downstream. ~~The lower levels of the J.C. Boyle, Copco, and Iron Gate Reservoirs would continue to have very low oxygen levels when stratified (FERC 2007). This would affect dissolved oxygen levels downstream of these reservoirs~~As with the upstream reach, full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly improve seasonal dissolved oxygen and pH levels in the Hydroelectric Reach. Full attainment could require decades to achieve and it is highly dependent on improvements in dissolved oxygen in Upper Klamath Lake and the Keno Impoundment/Lake Ewauna.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Ongoing efforts to improve water quality conditions are underway through the TMDL process and considerable efforts to improve habitat are also underway (Hamilton et al. 2011). Once implemented, these efforts could reduce existing conditions that contribute to reduced health and increased mortality rates for aquatic resources (described below) to some extent, but this process would be slower and more challenging than with the dams removed. In the interim, water quality conditions that may reduce survival of fish and other aquatic resources would persist downstream ~~of~~ from Iron Gate Dam.

Given existing conditions, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability and would not consistently meet California Basin Plan and Hoopa Valley Tribe water quality objectives for dissolved oxygen and they would not consistently support designated beneficial uses in the ~~lower~~Lower Klamath River downstream ~~of~~ from Iron Gate Dam.

Modeling conducted for development of the California Klamath River TMDL indicates that under the No Action/No Project Alternative, dissolved oxygen concentrations immediately downstream ~~of~~from Iron Gate Dam~~ to the Shasta River (RM 176.7)~~, without additional mitigation, would not meet the North Coast Basin Plan water quality objective of 85 percent saturation (see Tables 3.2-4 and 3.2-5) during ~~July~~August–September and ~~from the Shasta River to approximately the Scott River (RM 143) from September~~the 90 percent saturation objective from October–November (~~see Section 3.2.4.3.1.4 Lower Klamath Basin). Farther downstream~~Figure 3.2-18). Further downstream, near the confluence with the Shasta River, dissolved oxygen concentrations under the No Action/No Project Alternative would not meet the 90 percent saturation objective from October–November (Figure 3.2-19). In the Klamath River at Seiad Valley, concentrations would be mostly in compliance, with the exception of modeled values in November that are just above the 90 percent saturation objective (Figure 3.2-20). By the Salmon River (RM 66.0) confluence, with full attainment of TMDL allocations, predicted dissolved oxygen concentrations would remain at or above the 85 percent saturation objective (as well as the 90 percent saturation objective, where applicable), meeting the North Coast Region Basin Plan ~~water quality objective from Seiad Valley (RM 129.4) to the Klamath Estuary.~~

requirements.

Under the No Action/No Project Alternative, continued high rates of algal photosynthesis in the reservoirs would result in high pH values in the ~~lower~~Lower Klamath River downstream ~~of~~ from Iron Gate Dam (see Section 3.2, Water Quality). Under the No Action/No Project Alternative, pH would continue to be elevated with high diurnal variability during summer and early fall months.

The overall anticipated effect on dissolved oxygen in the ~~lower~~Lower Klamath River under the No Action/No Project Alternative would be an increasing trend toward compliance with water quality objectives and support of designated beneficial uses, but with possible continued seasonally low dissolved oxygen downstream ~~of~~ from Iron Gate Dam, and so would not consistently meet California Basin Plan and Hoopa Valley Tribe water quality objectives for dissolved oxygen. ~~Turbine venting studies, currently ongoing as part of KHSA IMs (see Section 3.2, Water Quality), could be used to further increase dissolved oxygen in the river downstream of the dam in the long term under the No Action/No Project Alternative. However, results from turbine venting studies are inconclusive at this time and it is uncertain whether or not increases of dissolved oxygen downstream of Iron Gate Dam can be consistently achieved.~~ The No Action/No Project Alternative would continue to periodically result in dissolved oxygen levels that may be deleterious to aquatic resources ~~below~~ downstream from Iron Gate Dam, but this effect would be similar to or less than that which currently occurs.

Water Temperature

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the No Action/No Project Alternative, ~~the~~ water temperature in the upper Klamath River would remain similar to existing conditions in the near term, but would be expected to show a gradual cooling trend through implementation of the TMDLs.

~~Climate~~ However, climate change ~~is expected to play a role in future temperatures~~would partially offset temperature improvements (see also the subsection of Section 3.2.4.3.1). Climate change impacts on the Klamath River and Estuary are based on current estimates of potential future changes in air temperature and precipitation patterns for the California North Coast hydrologic region (Stillwater Sciences 2009a). Regional climate models estimate that median annual air temperature would increase ~~2.5~~1.0 to ~~3~~3 ºC by 2050 (Snyder et al. 2004). These ambient air temperatures could in turn raise water temperatures. Additionally, decreases in snowpack from higher air temperatures from January to March are also predicted, resulting in a more modest spring runoff peak. In the Klamath Basin as a whole, increasing air temperatures and decreasing flows in the summer months would be expected to cause general increases in summer and fall water temperatures on the order of 2–3 °C (3.6–5.4 °F) (Bartholow 2005). Despite climate predictions, temperatures in Upper Klamath Lake have exhibited a downward trend from 1990 to 2009 (Jassby and Kann 2010).

As described in ~~Section 3.2, Water Quality, the Wood River Wetland Restoration Project~~ the subsection of Section 3.2.4.3.1, based on a programmatic assessment the Williamson River Delta Project and the Agency Lake and Barnes Ranches Project represent a reasonably foreseeable set of actions under the No Action/No Project Alternative that

would ~~improve~~ provide favorable springtime water temperatures for rearing fish in the ~~upper basin~~Upper Klamath Basin. Specific options for both projects still need to be developed and studied as part of a separate project-level National Environmental Policy Act (NEPA) evaluation and ESA consultation.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the No Action/No Project Alternative, the effects of ongoing and future upstream water quality improvements under the TMDLs would improve water temperatures below Keno Dam. However, climate change would partially offset anticipated temperature improvements. The river's thermal regime downstream ~~of~~from the reservoirs would continue to be out of phase with the natural temperature regime (Hamilton et al. 2011). Unnatural temperature fluctuations would continue downstream from the J.C. Boyle Bypass Reach, from the mixture of cold-water inflow from Big Springs and the warmer water discharge from the J.C. Boyle Powerhouse (Hamilton et al. 2011). Similar impacts from climate change as described above are also predicted to occur in this reach; therefore, water temperatures are expected to remain similar to existing conditions. ~~Project operations have and continue to be deleterious to the resident trout fishery by: a) confining the resident trout between the Four Facilities and associated reservoir thereby impairing their utilization of the full range of life history strategies and spawning productivity; b) unscreened flow through Project turbines result in mortality of juvenile and adult trout migrating down stream; and the inability to effectively migrate will reduce the genetic health and long-term survival of the resident species (Administrative Law Judge 2006).~~

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam The ~~lower~~Lower Klamath River downstream ~~of~~ from Iron Gate Dam would continue to have elevated water temperatures in the summer and fall in the near term. ~~These elevated water temperatures are primarily influenced by the reservoirs and their perpetuation of an~~ The reservoirs have the effect of changing the timing and magnitude of the thermal regime by increasing water temperatures in the fall as a result of the increased hydraulic residence time and thermal mass (Bartholow et al. 2005). Bartholow et al. (2005) and PacifiCorp (2004a) showed that the reservoirs delay seasonal thermal signatures by 18 days. Implementation of the TMDLs in these mainstem and tributaries is expected to result in lower water temperatures over time; however, these improvements would ~~likely be~~be partially offset by the effects of climate change, as described above. In the long term, water temperatures in the mainstem and tributaries are expected to remain similar to existing conditions.

Under the No Action/No Project Alternative, dams would continue to increase late summer and early fall water temperatures in the Klamath River downstream from Iron Gate Dam (subsection of Section 3.2.4.3.1). Under existing conditions in the fall, the dams do not decrease temperatures of water that is transported downstream from Upper Klamath Lake. This is due to the fact that powerhouse withdrawals for Copco 1 and Iron Gate Dams are primarily from the epilimnion (surface waters) (see Appendix C, Section C.1.1.4) which is heated by ambient air under existing reservoir operations. Unlike Shasta Dam or other deep reservoirs that support downstream tailwater fisheries

by release of cool water from low level outlets, the location of dam outlets in the Klamath River cannot be adjusted to access large volumes of cool water in the bottom of the reservoirs (hypolimnion).

Under this alternative, the current phase shift and lack of temporal temperature diversity will persist, including current warm temperatures in late summer and fall (Hamilton et al. 2011). This phase shift and warm fall temperatures results in delayed adult upstream migration, which is speculated to delay fall spawning (Dunsmore and Huntington 2006). Current cooler ~~temperatures~~ temps in spring ~~and early summer could benefit both adult and juvenile salmonids migrating during spring. However,~~ likely delay emergence, and reduce growth rates of juveniles (Hardy et al. 2006). In addition, juveniles and adults migrating ~~later in the year~~ in late summer and fall would continue to experience warm temperatures ~~in late summer and fall~~ that could be deleterious to health and survival, including increased risk of disease, and high rates of delayed spawning and prespawn mortality (Hetrick et al. 2009).

~~In addition to the direct stress that increasing temperatures could place on salmonids, these increasing water temperatures could~~ In addition, the decrease in diel temperature variation compared with historical conditions is deleterious for salmonids. Historically, diel temperature variation would result in regular nighttime cooling of water, offering daily relief with significant bioenergetic benefits that helped fish persist under marginal conditions (NRC 2004). The current lack of diel temperature variation reduces the value of thermal refuge habitat (Dunsmoor and Huntington 2006) and reduces the suitability of rearing habitat in the mainstem Klamath River (NRC 2004).

In addition to direct thermal stress, the potential for continued elevated water temperatures in the late summer/fall (due to potential for climate change to offset anticipated TMDL temperature improvements) could result in indirect stressors on salmonids including an increased intensity and duration of algal blooms, decreased dissolved oxygen levels, and ~~increased parasite abundance.~~ conditions conducive to disease (Bartholomew and Foott 2010). These effects would ~~put additional stress on~~ adversely impact cold-water fish communities~~,~~ and would be deleterious to warm-water fish communities as well.

Klamath River Estuary and Pacific Ocean Nearshore Environment Under the No Action/No Project Alternative, ~~the temperature~~ water temperatures in the Klamath River Estuary and Pacific Ocean would remain similar to the existing conditions and climate change would continue to play a role in future temperatures as described above.

Fish Disease and Parasites

The ongoing presence of the dams under the No Action/No Project Alternative would continue to contribute to the ~~stable,~~static flows, immobile substrate, seasonally warm ~~habitat conditions~~ water temperatures, and planktonic food sources that are favorable for polychaetes and for *C.*~~.~~ *shasta* and *P. minibicornis*~~. The hatchery~~ (Hetrick et al. 2009). Iron Gate Hatchery would continue to operate and discharge ~~its~~ the same nutrient~~-~~ rich

~~effluent to~~water it receives from the ~~river~~reservoir intake at Iron Gate Dam. Salmon carcasses would continue to concentrate ~~below the~~ downstream from Iron Gate Dam, where the polychaete hosts are abundant, facilitating the cross infection between the fish and the polychaetes. Based on this scenario, mortality associated with *C. shasta* and *P. minibicornis* would be expected to worsen or remain similar to existing conditions. In particular these conditions would continue to adversely affect outmigrants from tributaries downstream from Iron Gate Dam, including those from the Shasta and Scott rivers. If temperatures warm over time with climate change, these infection rates could increase. The No Action/No Project Alternative would result in continued substantial deleterious effects on salmon in terms of fish disease.

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the No Action/No Project Alternative, high nutrient inputs supporting the growth of toxin-producing nuisance algal species such as *M. aeruginosa* in Upper Klamath Lake would remain similar to existing conditions for decades into the future. This would result in the potential for continued bioaccumulation of microcystin in suckers in Upper Klamath Lake and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would likely decrease (see Sections 3.2~~, Water Quality and 3.4, Algae~~.4.3.1.6 Chlorophyll-a and Algal Toxins – Lower Klamath Basin and 3.4.4.3.1 Alternative 1: No Action/No Project Alternative –Phytoplankton for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in suckers in the lake would ~~occur.~~

be expected.

Hydroelectric Reach: ~~from~~ From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would support growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in Copco 1 and Iron Gate Reservoirs, resulting in high seasonal concentrations of algal toxins in the Hydroelectric Reach for decades into the future. This would result in continued bioaccumulation of microcystin in fish tissue for species in the Hydroelectric Reach and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would likely decrease in the Hydroelectric Reach (see ~~Sections~~subsection of Section 3.2.4.3.1, Chlorophyll-a and Algal Toxins – Upper Klamath Basin, and Section 3.4.4.3.1, Alternative 1: No Action/No Project Alternative –Phytoplankton, for additional detail regarding TMDLs and algal growth in the Hydroelectric Reach). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Hydroelectric Reach would ~~occur~~be expected.

Lower Klamath River~~:~~: Downstream ~~of~~from Iron Gate Dam Continued impoundment of water at the Four Facilities under ~~the~~ the No Action/No Project Alternative ~~would~~ would continue to support ~~the seasonal~~growth conditions for toxin-

producing nuisance algal species such as *M. aeruginosa* in Copco 1 and Iron Gate Reservoirs and subsequent transport of ~~toxin-producing nuisance algae and microcystin to the Klamath River downstream~~ high seasonal concentrations of algal toxins to the Klamath River downstream from Iron Gate Dam. This would ~~result in~~also support continued bioaccumulation of microcystin in fish and mussel tissue for ~~species in~~species downstream from the ~~river and could be deleterious to fish health.~~ dam. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would decrease in the Hydroelectric Reach (see subsection of Sections 3.2.4.3.1, Chlorophyll-a and Algal Toxins – Lower Klamath Basin, and Section 3.4.4.3.1, Alternative 1: No Action/No Project Alternative – Phytoplankton, for additional detail regarding TMDLs and algal growth in the Klamath River downstream from Iron Gate Dam). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Klamath River downstream ~~of~~from Iron Gate Dam would ~~occur.~~ be expected.

Aquatic Habitat

Under the No Action/No Project Alternative, hydrology and aquatic habitat of the Klamath River from its headwaters to the estuary would generally remain the same as under existing conditions, subject to the influence of climate change (discussed under Section 3.10, Greenhouse Gases/Global Climate Change). As described in the subsection of Section 3.3.3.3.7, Under the No Action Alternative, Klamath River flows were simulated following the instream flow requirements established for operation of Reclamation's Klamath Project under the reasonable and prudent alternative (RPA) described with in the 2010 Biological Opinion (NOAA Fisheries Service 2010a).

Activities currently underway to improve aquatic habitat and recover salmonid and sucker populations within the Klamath Basin would continue at their current levels. The ongoing Wood River Wetland Restoration, Agency Lake and Barnes Ranches Project, and the Williamson River Delta Project would likely improve ~~springtime rearing habitat for~~ resident fish habitat in the ~~upper basin~~Upper Klamath Basin. Recovery actions to improve aquatic habitat under the Klamath River Coho Salmon Recovery Plan would continue, depending on available funding. These actions ~~would improve~~are anticipated to improve aquatic habitat conditions over time relative to current conditions. However, anadromous fish would continue to be blocked from access to historical habitat.

Under the No Action/No Project, PacifiCorp would need to obtain a long-term operating license for the Klamath Hydroelectric Project from FERC to continue operating the Project (FERC 2007). Until a new license is issued, operations would continue under the annual license terms, and effects on aquatic habitat would continue as described in Section 3.3.3.3.~~-~~7.

Aquatic Resources Effects

Critical Habitat

As described below, continued impoundment of water within reservoirs under the No Action/No Project Alternative could alter the water quality and habitat suitability within critical habitat.

Coho Salmon As described above in detail, under the No Action/No Project Alternative, habitat supporting PCEs for coho salmon will continue to be degraded (NOAA Fisheries Service 1999b, NOAA Fisheries Service 2010a). Spawning habitat would continue to be impaired by sediment and instream flows within tributary streams, with little mainstem spawning. Rearing habitat with food resources would continue to be impaired as result of habitat degradation, high water temperature, and disease within tributaries and the mainstem. Water quantity supporting PCEs would continue to be depleted both within tributaries and within the mainstem. The quality of PCEs would likely improve gradually over time, through the actions undertaken under the Klamath River Coho Salmon Recovery Plan. TMDL implementation is anticipated to result in improved water quality to meet PCEs; however, this could take decades to achieve, and water quality ~~would~~ initially would be reduced and remain poor similar to that under existing conditions.

~~However~~Also, ~~full~~ full attainment of the water temperature TMDLs ~~is likely to be~~would be partially offset by climate change. **The effect of the No Action/~~Np~~ No Project Alternative would be ~~would be~~ no change from existing conditions for coho salmon critical habitat in the short and long term.**

Bull Trout Because bull trout are restricted in distribution to the headwaters of limited number of streams, under the No Action/No Project Alternative, PCEs of critical habitat supporting bull trout are not expected to be affected by implementation of the Oregon TMDL processes. Over the long-term, climate change would be expected to result in warmer temperatures, although the headwater streams supporting bull trout may be ~~not be~~ affected less than other environments due to influence of groundwater. **The effect of the No Action/No Project Alternative would be no change from existing conditions for bull trout critical habitat in the short and long term.**

Southern Resident Killer Whale The Klamath River may affect PCEs of critical habitat for Southern Resident Killer Whales through its potential contribution of Chinook salmon to the food supply for Southern Resident Killer Whales, the survival and fecundity of which appears dependent upon the abundance of this species (Ward et al. 2009; Ford et al. 2009). Chinook salmon originating from the Fraser River are the dominant prey of resident killer whales in the summer months when they are usually in inland marine waters (Hanson et al. 2010). Less is known of their diet during the remainder of the year (September through May) when they spend much of their time in outer coastal waters, but it is believed likely that they preferentially feed on Chinook salmon when available, and roughly in proportion to their relative abundance (Hanson et al. 2010). The contribution of Klamath-origin salmonids to the diet of Southern Residents is unknown, but during this period they may travel from central California to northern British Columbia (Krahn et al. 2004, as cited in Hanson et al. 2010). No change from existing conditions is expected in the short term.

TMDL implementation in the ~~basin could~~ Basin is expected to improve water quality conditions over time~~, which~~ although they could take decades to achieve. Such improvements in water quality might result in increased Chinook salmon production over time. However, full attainment of the water temperature ~~TMDLs is likely to be~~TMDL would be partially offset by climate change. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Southern Resident Killer ~~Whales~~ Whale critical habitat in the short and long term.**

Eulachon

Under the No Action/No Project Alternative, PCEs of critical habitat supporting eulachon are not anticipated to change relative to existing conditions. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Eulachon critical habitat in the short and long term.**

Essential Fish Habitat

Dams and the continued impoundment of water within reservoirs under the No Action/No Project Alternative could alter the availability and suitability of ~~Essential Fish Habitat (~~EFH~~)~~.

Chinook and Coho Salmon EFH Under the No Action/No Project Alternative, EFH for Chinook and coho salmon would be expected to remain similar to its current condition. Access to habitat would be limited to its current levels; water quality would improve through TMDL implementation, but would ~~be~~be partially offset by warming expected as a result of climate change. The amount of suitable habitat in currently accessible tributaries would likely be reduced by climate change. Conditions under the No Action/No Project Alternative would continue to contribute to elevated concentrations of disease parasites and would provide the conditions required for the cross infection of fish and polychaetes (Hetrick et al. 2009; Hamilton et al. 2011). These interacting factors could decrease the viability of Chinook and coho salmon populations in the future (Hetrick et al. 2009; Hamilton et al. 2011). **The effect of the No Action/No Project Alternative would be no change from existing conditions for Chinook and coho salmon EFH in the short and long term.**

Groundfish EFH Under the No Action/No Project Alternative, sediment and habitat conditions in the estuary and nearshore ocean would remain the same as they are under existing conditions. **The effect of the No Action/No Project Alternative would be no change from existing conditions for groundfish EFH in the short and long term.**

Pelagic Fish EFH Under the No Action/No Project Alternative, sediment and habitat conditions in the estuary and nearshore ocean would continue to be the same as they are under existing conditions. **The effect of the No Action/No Project Alternative would be no change from existing conditions for pelagic fish EFH in the short and long term.**

Species-Specific Impacts

As described below, continued impoundment of water within reservoirs under the No Action/No Project Alternative, and the continued blockage of habitat access at project dams, could affect aquatic species.

Species-specific impacts are based upon existing conditions for key ecological attributes summarized above.

Fall-Run Chinook Salmon To help determine if the Proposed Action will advance restoration of the salmonid fisheries of the Klamath Basin, a Chinook Salmon Expert Panel was convened to attempt to answer specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011). In response to comments the Panel stated with certainty that under the No Action/No Project Alternative, fall-run Chinook salmon within the Klamath River will continue to decline[3]. However, as described in detail in Section 3.3.3.1.1.1.1, although abundances are low compared to

[3] Page 69 of Appendix C of the July 20, 2011 Addendum to Goodman et al. 2011.

historical numbers (Table 3.3-1), in a recent review of the population status of Chinook salmon, the BRT (Williams et al. 2011) concluded that the current population (which includes hatchery fish) appear to have been fairly stable for the past 30 years and is not currently in decline.

As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses. In addition, the thermal regimes downstream ~~of~~ from Iron Gate Dam would continue to be altered as a result of project facilities and operations, particularly retention time of water in the reservoirs. As a result, fall-run Chinook salmon spawning downstream from Iron Gate Dam would likely continue to be delayed, and prespawn mortality will continue to occur (Hetrick et al. 2009).

Under the No Action/No Project Alternative, Iron Gate Dam would continue to block fall-run Chinook salmon access to ~~an estimated 420~~ hundreds of miles of ~~their~~ historical habitat, which used to extend upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This includes around 76 miles of potential habitat within the Klamath Hydroelectric Project, based on approximately 53 miles of potential anadromous fish (steelhead) habitat in the Project Reach (Administrative Law Judge 2006)[4], taking into consideration the more limited distribution of Chinook salmon relative to steelhead (United States Department of the Interior (DOI) 2007), and including over 22 miles inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009). The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009). The consequences of this ongoing loss of habitat to the population could include reduced resilience to recover from catastrophic disturbances of natural or anthropogenic origin, such as wildfire or chemical spills. Under the No Action/No Project Alternative access to cold water habitat would continue to be severely limited. Because areas upstream of the ~~barrier~~ Iron Gate Dam include cold-water refugia, refugia for outmigrating smolts, and opportunities for the population to adapt to changing temperatures are reduced, whether these temperatures are a result of short- or long-term changes.

Under the No Action/No Project Alternative, the system of reservoirs and dams in the hydroelectric reach will continue to create conditions conducive to the spread of parasites among the fall-run Chinook salmon population downstream ~~of~~ from Iron Gate Dam, especially where adults (and carcasses) tend to congregate in high numbers, just downstream ~~of~~ from Iron Gate Dam (Stocking and Bartholomew 2007, Bartholomew and Foott 2010), but also in other locations further downstream. Additional factors related to

[4] This also takes into consideration slight differences in the Administrative Law Judge (2006) definition of the Project Reach from what is used in this report.

the project would continue to exacerbate the situation downstream ~~of~~ from Iron Gate Dam, including increased water temperatures and dampened flow and thermal variability, reduced dissolved oxygen concentrations, loss of sediment transport through the reach due to capture of sediment by the dams, and reservoirs contributing plankton to the filter-feeding polychaete hosts of the myxozoan parasites (Hamilton et al. 2011). Under the No Action/No Project Alternative, downstream-migrating juvenile Chinook salmon may continue to have high disease infection rates (Bartholomew and Foott 2010) during summer months in some years. Heavy parasite loads may increase disease-related mortality in outmigrant smolts, particularly when water temperatures are high, or may reduce ocean survival by affecting growth or fitness.

Effects of suspended sediment on fall-run Chinook salmon under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.1. Overall, fall-run Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Although SSCs under existing conditions and the No Action/No Project Alternative are relatively high in the mainstem downstream ~~of~~from Orleans, and even more so downstream ~~of~~from the Trinity River (California State Water Resources Control Board [SWRCB] 2006, NCRWQCB 2010) (see Section 3.2.3), they are relatively low in the reach downstream ~~of~~from Iron Gate Dam where most mainstem spawning occurs. Suspended sediment concentrations and durations during upstream and downstream migration, even under extreme conditions, are low enough that ~~effects are~~they have limited ~~to~~ effects on fish, although physiological stress and ~~possibly~~ reduced growth rates are possible. In general, fall-run Chinook salmon appear relatively unaffected by current ~~suspended sediment conditions~~SSCs because smolt outmigration primarily occurs when ~~SSC~~SSCs are naturally low.

Under the No Action/No Project Alternative, ongoing hatchery operations would continue to mitigate for habitat lost due to construction of ~~the dam~~Iron Gate Dam by releasing millions of juvenile and yearling Chinook salmon annually. These fish may compete with the progeny of naturally spawned fish for food and other limited resources, such as thermal refugia~~, or~~. In addition, hatchery releases can increase disease infection rates through crowding and, where mortality occurs, concentrated release of myxospores on top of the area of highest polychaete densities. In addition, some adult fish may stray and spawn with wild fish, which can reduce genetic and phenotypic diversity and reproductive success within the wild population (McLean et al. 2003, Araki et al. 2007, Araki et al. 2009, all as cited in Hamilton et al. 2011).

Under the No Action/No Project Alternative, the interruption of sediment transport processes by the dams would continue, reducing spawning gravel supply to downstream reaches and changing the dynamics of channel morphology and riparian vegetation communities that create and maintain rearing habitats for fry and juvenile fall-run Chinook salmon. ~~It may~~Lack of sediment transport is also likely to be contributing to the high densities of polychaetes downstream ~~of~~from Iron Gate Dam that host salmonid parasites, through reduction of scour that would otherwise help limit periphyton growth (FERC 2007; Hetrick et al. 2009.

The effect of the No Action/No Project Alternative would be no change from existing conditions for fall-run Chinook salmon in the short and long term.

Spring-Run Chinook Salmon In a recent review of the population status of Chinook salmon, the BRT (Williams et al. 2011) concluded that the current Chinook population (which includes hatchery fish) appear to have been fairly stable for the past 30 years and is not currently in decline, despite dramatic reductions in comparison to historical abundance (Table 3.3-1). However, the BRT was concerned about the relatively few populations of spring-run Chinook salmon and the low numbers of spawners within those populations (Williams et al. 2011).

Under the No Action/No Project Alternative, poor water quality conditions caused partly by nutrient enrichment during spring-run Chinook salmon upstream and downstream migration may cause high stress. Water quality in the mainstem Klamath River ~~below~~ downstream from Iron Gate Dam is characterized by altered seasonal water temperature patterns, dissolved oxygen, and increased nutrient input, as well occasional blooms of *M*~~.~~ *aeruginosa*. Although water quality tends to improve downstream ~~of~~ from the Salmon River (current upstream extent of spring-run distribution in the Klamath River), the effect of water quality alterations is that conditions (especially water temperature and ~~DO~~dissolved oxygen) are critically stressful for spring-run Chinook salmon for much of the summer ~~(~~if they were present during the period June through September~~)~~. Maximum temperatures often reach 25 °C during summer, considered lethal for most Pacific salmon (Sullivan et al. 2000). Spring Chinook salmon that are stressed by high temperatures, whether adults or juveniles, likely have lower survival rates, especially when challenged by additional water quality factors, such as low dissolved oxygen, the presence of toxic blue-green algae (*M. aeruginosa*) and fish diseases, and high pH and unionized ammonia. Under the No Action/No Project Alternative, downstream-migrating juvenile Chinook salmon may continue to have high disease infection rates (Bartholomew and Foott 2010) during summer months in some years. Heavy parasite loads may increase disease-related mortality in outmigrant smolts, particularly when water temperatures are high, or may reduce ocean survival by affecting growth or fitness.

High water temperatures during summer may also reduce the growth of juvenile fish ~~that~~ that are rearing and migrating downstream to the ocean due to greater metabolic requirements. Because size is correlated with ocean survival, this could lead to reduced smolt survival and subsequently, reduced escapement. Finally, high temperatures can selectively reduce the survival of fish migrating later in the summer (the "summer run"), thus reducing genetic and life-history diversity. High water temperatures likely limit adult holding and summer rearing habitat for spring Chinook salmon in main spawning tributaries, the Salmon and Trinity Rivers, which would likely reduce overall production. Low flows in dry years can cause migration barriers to form, reducing habitat available to spawning and rearing fish.

Under the No Action/No Project Alternative, Iron Gate Dam would continue to block spring-run Chinook salmon access to ~~an estimated 420 miles of~~ their historical habitat,

which used to extend upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This includes around 76 miles of potential habitat within the Project reach, based on approximately 53 miles of potential anadromous fish (steelhead) habitat in the Project Reach (Administrative Law Judge 2006)[5], taking into consideration the more limited distribution of Chinook salmon relative to steelhead (DOI 2007), and including over 22 miles inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009), and habitat within the bypass reaches. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009). In addition, access would continue to be blocked to hundreds of miles of habitat upstream of J.C. Boyle Reservoir (Hamilton et al. 2005). The consequences of this ongoing loss of habitat to the population could include reduced resilience to recover from catastrophic disturbances of natural or anthropogenic origin, such as wildfire or chemical spills. Because areas upstream of ~~the barrier~~Iron Gate Dam include cold-water refugia, opportunities for the population to adapt to changing climate are reduced, whether these changes are a result of short- or long-term cycles or trends.

Effects of suspended sediment on spring-run Chinook salmon under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.2. Overall, spring-run Chinook salmon mostly use the mainstem Klamath River as a migratory corridor during adult migration, and downstream smolt migration. Although suspended sediment under existing conditions and the No Action/No Project Alternative is relatively high in the mainstem Klamath River downstream ~~of~~ from Orleans, and especially downstream ~~of~~ from the Trinity River (Appendix E), increases in suspended sediment in the mainstem Klamath River during critical migratory periods are low enough in concentration and short enough in duration that effects are limited to physiological stress and possibly inhibited growth, even during extreme conditions. ~~Spring-run Chinook salmon appear less vulnerable to suspended sediment impacts than other Klamath River salmon populations (e.g., coho salmon and fall-run Chinook salmon).~~

One of the main spawning streams for spring-run Chinook salmon, the Salmon River has ~~double the historical~~dramatically increased sediment production ~~from~~ over historical conditions as a result of road construction, timber harvest, and wildfire disturbance (Elder et al. 2002). Habitat degradation is believed to be the primary cause of the decline of the spring-run salmon population in the Klamath River system. Under the No Action/No Project Alternative, spawning and rearing habitat would continue to be reduced in both quantity and quality, and production may be low in some years.

As described in the subsection of Section 3.3.3.1.1, the extirpation of at least seven spring-run populations from the Klamath-Trinity River system has been attributed to dams, overfishing, irrigation, and commercial hydraulic mining operations (Coots 1962;

[5] This also takes into consideration slight differences in the Administrative Law Judge (2006) definition of the Project Reach from what is used in this report.

Snyder 1931; Myers et al. 1998). Under this alternative, dams would continue to block access to historical habitat, and spring-run Chinook salmon are likely to remain at significantly suppressed levels over the years of analysis (50 years).

The effect of the No Action/No Project Alternative would be no change from existing conditions for spring-run Chinook salmon in the short and long term.

Coho Salmon As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses. In addition, the thermal regimes downstream ~~of~~ from Iron Gate Dam would continue to be altered as a result of project facilities and operations, particularly due to retention time of water in the reservoirs.

Under the No Action/No Project Alternative, Iron Gate Dam would continue to block coho salmon to ~~an estimated 68 miles of their~~ historical habitat~~, 45 of which would be in the mainstem Klamath River and tributaries (United States Department of the Interior [DOI] 2007; NOAA Fisheries Service 2007a) and an additional 23 miles of habitat currently inundated by the reservoirs (Cunanan 2009)~~ which used to extend upstream ~~to~~at least as far as Spencer Creek (Hamilton et al. 2005)~~.~~, including an estimated 76 miles of potential habitat within the Klamath Hydroelectric Project, based on approximately 53 miles of potential anadromous fish (steelhead) habitat in the Project Reach (Administrative Law Judge 2006),[6] taking into consideration the more limited distribution of coho salmon relative to steelhead (DOI 2007), and including over 22 miles inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009), and habitat within the bypass reaches. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009). The consequences of this ongoing loss of habitat to the population ~~could~~ would include reduced resilience to recover from catastrophic disturbances of natural or anthropogenic origin, such as wildfire or chemical spills (Hamilton et al. 2011). Under the No Action/No Project Alternative access to cold water habitat would continue to be severely limited. Because areas upstream of the Iron Gate Dam include cold-water refugia, refugia for outmigrating smolts, and opportunities for the population to adapt to changing ~~climate~~temperatures are reduced ~~under the No Action/No Project Alternative~~, whether these ~~changes~~temperatures are a result of short- or long-term ~~cycles or trends~~changes. The above factors could reduce the natural genetic and life-history diversity found in Klamath Basin subpopulations of coho salmon that make them ideally suited to adapting to changing watershed conditions.

[6] This also takes into consideration slight differences in the Administrative Law Judge (2006) definition of the Project Reach from what is used in this report.

~~Access to suitable habitat under the No Action/No Project Alternative is also limited by small dams and diversions, culverts, road crossings, and aggraded channels (NRC 2004, CalFish query 2008, http://www.calfish.org). These barriers prevent use of formerly available spawning and rearing habitat, which represents another factor suppressing production under the No Action/No Project Alternative.~~

Under the No Action/No Project Alternative, upstream-migrating adult coho salmon will continue to be exposed to high water temperatures and poor water quality in the mainstem Klamath River, which can cause physiological stress, delay migration, reduce coldwater refugia, and increase mortality from disease. Low flows and increased sedimentation in tributaries can create barriers at the mouths of spawning streams, which would reduce spawning habitat area and production under the No Action/No Project Alternative in some years.

Effects of suspended sediment on coho salmon under the No Action/No Project Alternative and existing conditions are described in Appendix E Section E.3.1.3. Overall, under existing conditions and the No Action/No Project Alternative, ~~SSC~~SSCs in the mainstem are sufficiently high and of long enough duration that major physiological stress and reduced growth of coho salmon are anticipated in most years. ~~Consistent with these findings, the lower Klamath River downstream of the Trinity River confluence (RM 40.0) to the estuary mouth (RM 0.0) is listed as sediment impaired under Section 303(d) of the Clean Water Act (SWRCB 2006, NCRWQCB 2010) (see Section 3.2.2). Relatively high SSC, in association with elevated water temperatures and disease may be contributing to the high smolt mortality that has been observed in the mainstem Klamath River (Beeman et al. 2007, 2008).~~

Suitable rearing habitat for juvenile coho salmon under the No Action/No Project Alternative would continue to be restricted by high temperatures in some areas. High water temperatures may promote higher incidence of disease or parasitism, which may increase direct and indirect mortality (Stutzer et al. 2006, NOAA Fisheries ~~Service~~Service 2010a). During a 2008 PIT-tag study of juvenile coho salmon in the Shasta River, Chesney et al. (2009) found juvenile coho salmon only in areas where temperatures were moderated by cold springs; the remainder of potential rearing habitat was too warm (>20°C). Rearing habitat would continue to be compromised by livestock grazing and the legacy of logging impacts in riparian habitat that simplify channel and floodplain interactions that are conducive to creating habitat for rearing coho salmon in the winter.

Under historical, unregulated conditions, an annual spring pulse flow occurred in the Klamath River and in its tributaries (NRC 2004). Under current conditions a spring pulse still occurs, but is altered by water management. The magnitude of the spring flow is believed to have historically resulted in higher survival of coho salmon juvenile outmigrants and smolts relative to current conditions through several mechanisms, including (1) reduced rates of infection in juvenile salmon by *C. shasta* and *P. minibicornis*, (2) a reduced period of residency spent in the mainstem prior to smolting, and (3) greater habitat availability in the mid-Klamath River (Hardy et al. 2006),

especially in the reach between Shasta River and Scott River where survival is particularly poor (Beeman et al. ~~2007,~~ 2008). It is speculated that this low outmigrant survival limits habitat restoration efforts on the Shasta and Scott rivers from realizing their potential to increase population abundance.

High numbers of hatchery fish may affect wild coho salmon in the Klamath Basin under the No Action/No Project Alternative. The vast majority of coho salmon that spawn in the Klamath Basin are believed to be of hatchery origin, although the percentage varies among years (Ackerman et al. 2006).

Coho salmon populations in the Klamath Basin are in decline; less than 70~~%~~ percent of streams historically used by coho salmon in the ~~basin~~ Basin still contain small populations (NRC 2004). The No Action/No Project Alternative would likely continue to produce the types of habitat alterations that have helped to cause this decline.

More detail on current conditions for coho salmon can be found in NOAA Fisheries ~~SErvice's~~Service's (2010a) ~~*Biological opinion*~~*BO on operation of the Klamath Project between 2010 and 2018*.

The effect of the No Action/No ~~Proeject~~Project Alternative would be no change from existing conditions for coho salmon from all populations within the Klamath River watershed in the short and long term.

Steelhead ~~-~~As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses. In addition, the thermal regimes downstream ~~of~~ from Iron Gate Dam would continue to be altered as a result of project facilities and operations, particularly by the retention time of water in the reservoirs.

Summer steelhead use the mainstem Klamath River primarily as a migration corridor because most spawning and rearing occurs in the tributaries. Under the No Action/No ~~Proeject~~Project Alternative, summer steelhead spawning and rearing habitat availability and distribution would continue to be restricted during summer and fall to reaches downstream ~~of~~ from Seiad Valley by high water temperatures farther upstream. ~~If water temperatures upstream of Seiad Valley were historically cooler, then this represents an ongoing loss of habitat that might otherwise be contributing to smolt production and escapement.~~ Conditions in the mainstem are generally suitable for adult upstream migration; however, high water temperatures in the late summer and fall may restrict movements and spawning distribution of later-arriving adults. Under a more normative flow regime, temperatures would be cooler in the summer and fall months for adult migrating fish (Bartholow et al. 2005; FERC 2007). Altered flow patterns downstream ~~of~~ from Iron

Gate Dam may thus be affecting the population by selecting for earlier-arriving fish, potentially reducing life-history diversity in the population. In addition, this represents an ongoing loss of habitat that might otherwise be contributing to smolt production, survival, and escapement. Water temperatures are likely to rise over the next decades as a result of climate change, which could result in further reduction of suitable habitat, with potential consequences for steelhead population abundance.

Fall and winter steelhead are more widely distributed than any other anadromous salmonid downstream ~~of~~from Iron Gate Dam. Under the No Action/No Project Alternative, they would continue to be restricted from ~~hundreds of~~360 miles of historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Huntington 2006), including access to cold-water refugia that could buffer the population to effects from climate change (Hamilton et al. 2005). In addition, there are around 80 miles of potential habitat within the Klamath Hydroelectric Project, based on around 53 miles of anadromous habitat with the Project reach (Administrative Law Judge 2006), including over 22 miles inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009), and habitat within the bypass reaches. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009). As with summer steelhead, ~~they~~ fall and winter steelhead use the mainstem primarily as a migration corridor to access tributaries for spawning. Increases in fine sediment in tributaries used by steelhead for spawning could be reducing egg-to-emergence survival in some tributaries.

Under the No Action/No Project Alternative, high summer water temperatures in the summer months can cause density-independent mortality on juveniles that have left spawning tributaries to rear in the mainstem. ~~In the winter months, velocity refuge habitat is often limiting to juvenile salmonids; juvenile steelhead seem to prefer hiding in the interstitial spaces between substrate particles to keep from being displaced by high flows. If fine sediment input has increased due to watershed disturbance, embeddedness of the substrate can reduce the availability of interstitial habitat, reducing the carrying capacity of these streams for juvenile steelhead and forcing them into suboptimal rearing habitats where growth rates are slower.~~

Effects of suspended sediment on steelhead under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.4. Overall, steelhead use the mainstem Klamath River as a migratory corridor during adult migration, and downstream smolt migration, and for juvenile rearing. Although SSCs under existing conditions and the No Action/No Project Alternative are relatively high in the mainstem Klamath River downstream ~~of~~from Orleans, and especially downstream ~~of~~from the Trinity River (SWRCB 2006, NCRWQCB 2010) (see Section 3.2.3), SSC in the mainstem Klamath River during critical migratory periods, even during extreme conditions, are low enough and exposure times short enough that effects are likely limited to physiological stress and possibly reduced growth rate. Conditions for fish rearing in the mainstem are likely worse, but in general steelhead appear resilient to suspended sediment regimes under existing conditions and the No Action/No Project Alternative.

Habitat conditions for juvenile steelhead rearing in the mainstem are generally suitable, except for reaches upstream of Seiad Valley where summer water temperatures are considered stressful. Juvenile outmigration peaks in the spring and extends through the summer and fall. Growth during their rearing and outmigration may be reduced by high temperatures due to increased metabolism, which can reduce ocean survival. High summer water temperatures causing physiological stress to fish can also make them more vulnerable to mortality from disease or other compounding factors.

The effect of the No Action/No Project Alternative would be no change from existing conditions for steelhead in the short and long term.

Pacific Lamprey Pacific lamprey populations appear to have been in decline since the late 1980s in the Klamath Basin; (Larson and Belchik 1998; Moyle et al. 2009; all as cited in Hamilton et al. 2011), and are considered "vulnerable" throughout their range by the American Fisheries Society (Jelks et al. 2008, as cited in Hamilton et al. 2011). Major factors believed to be affecting their populations include barriers to upstream migration at dams; dewatering of larval habitat through flow regulation; reducing larval habitat by increasing water velocity and/or reducing sediment deposition areas; and susceptibility to contaminants in the larval stage (Close et al. 2002, as cited in Hamilton et al. 2011).

Under the No Action/No Project Alternative, Iron Gate Dam would continue to form a barrier to Pacific lamprey migration, which represents an ongoing loss of available habitat and productive capacity. Although the exact upstream extent of suitable habitat for Pacific lamprey prior to the completion of the Four Facilities is unknown, it is believed that Pacific lamprey would have migrated at least as far as Spencer Creek (Hamilton et al. 2005, as cited in Hamilton et al. 2011). The loss of this portion of ~~historical~~ spawning and larval rearing habitat reduces the ~~basin's~~Basin's population viability through contracting their distribution within the watershed and reducing abundance~~, although the relative significance of the inaccessible areas upstream of Iron Gate Dam are unknown.~~

.

Under the No Action/No Project Alternative, the dams would continue to reduce sediment supply to the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam, which may limit availability of gravel-cobble substrates for nest building and fine sediment for burrowing; armoring of substrate would also be expected to reduce spawning habitat quality. The overall effect on the ~~basin~~Basin population is likely to be small because (1) the effects of the dam on fine sediment and gravel/cobble substrates diminish with distance downstream because of input from tributaries and become less significant downstream ~~of~~from Cottonwood Creek (RM 182.1), and (2) a large proportion of the population may spawn and rear in large tributaries to the mainstem, such as the Trinity, Salmon, Shasta, and Scott Rivers.

Effects of suspended sediment on Pacific lamprey under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.5. Overall, under both normal and extreme conditions, Pacific lamprey are anticipated to

suffer from stressful levels of suspended sediment while rearing and migrating through the mainstem Klamath River, with exposure durations generally much longer under extreme conditions. Because there are multiple year-classes of lamprey in the mainstem Klamath River at any given time, and since adults may migrate upstream throughout the year, Pacific lamprey populations may be well-adapted to persisting through years when ~~suspended sediment concentrations~~SSCs are high, especially since they remain within the sublethal range.

The effects of dams and reservoirs would continue to affect water quality downstream ~~of~~from Iron Gate Dam under the No Action/No Project Alternative, which may reduce habitat quality for spawning and rearing Pacific lamprey, as well as reproductive success. Stone et al. (2002) found dissolved oxygen to be positively associated with lamprey presence at the reach scale (P = 0.0002). Meeuwig et al. (2005) reported that survival of larval Pacific lamprey under laboratory conditions was optimal at 18°C, but declined sharply at 22°C, with eggs and larvae at these higher temperatures also exhibiting deformities. Under existing conditions and the No Action/No Project Alternative water quality would improve through TMDL implementation, but would be partially offset by warming expected as a result of climate change.

Flow management under a No Active/No Project Alternative would continue to modify temperature and instream flow patterns from pre-project conditions. Movements of adult, ammocoete, and macropthalmia Pacific lamprey life stages tend to occur in association with discharge, while temperature and day length may be of less importance as life-history cues (Stone et al. 2002, Luzier et al. 2009). Stone et al. (2002) observed downstream migration of macropthalmia (juvenile phase) in Cedar Creek in association with summer low flows, with larger ammocoetes also moving downstream during this period as well, indicating that such movements were voluntary. In contrast, Beamish and Levings (1991, as cited in Stone et al. 2002) found that macropthalmia downstream movements to be associated with high flows, but also observed greater downstream movement of larger, older ammocoetes during these periods.

High discharge appeared to result in involuntary downstream displacement of ammocoetes (especially of smaller individuals) and macropthalmia outside of their normal migration period, which may reduce survival (Stone et al. 2002).

Under the No Action/No Project Alternative, Pacific lamprey populations in the Klamath Basin may remain at current levels or population numbers may continue to decline over the long term (Close et al. 2010). Because so little is known of Pacific lamprey life history and habitat requirements compared to those of anadromous salmonids, it is more difficult to predict the potential effects of alternatives on their abundance and distribution. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Pacific lamprey in the short and long term.**

Green Sturgeon ~~-~~Green sturgeon spend a majority of their lives in estuaries, bays, and nearshore waters, with adults only returning to fresh water to spawn after more than ~~15~~

15 years, and spawning every ~~four~~4 years on average (Klimley et al. 2007). In the Klamath River mainstem, green sturgeon spawn and rear in the lower 67 miles, downstream ~~of~~from Ishi Pishi Falls.

The Klamath Basin supports the largest spawning population of Northern Green Sturgeon (Moyle 2002), so it plays a critically important role in the viability and persistence of the entire DPS. Concentration of spawning to only a very few areas renders these spawning populations vulnerable to local catastrophic impacts. A loss of any of the few spawning areas would have much greater effects than the loss of a spawning population of salmon that spawn in other streams throughout their range.

Under the No Action/No Project Alternative, temperatures in the ~~lower~~Lower Klamath River in dry years may be reducing reproductive success of green sturgeon (Van Eenennaam et al. 2005). Studies conducted by Van Eenennaam et al. suggest that temperatures above
17–18 °C are suboptimal for hatching and embryonic development, with temperatures from 23 °C to 26 °C resulting in 100~~%~~ percent pre-hatching mortality. Cech et al. (2000) put the lethal temperature for embryos at 20 °C.

Effects of suspended sediment on green sturgeon under the No Action/No Project Alternative and existing conditions are described in Appendix E. Overall, under existing conditions and the No Action/No Project Alternative, green sturgeon in the Klamath River mainstem are regularly exposed to ~~suspended sediment concentrations~~SSCs documented to cause major physiological stress, reduced growth, and mortality in other fish species, especially during their egg and larval stages, and the year-round juvenile rearing period. However, based on the persistence of their population under these conditions, these metrics likely overestimate effects on ~~sturgeon.~~

~~Under the No Action/No Project Alternative, changes in the timing and magnitude of high flows downstream of Iron Gate Dam that are related to hydroelectric project operations have the potential to reduce~~ green sturgeon~~ survival in the mainstem. Adult green sturgeon that have held over the summer in the river after spawning appear to migrate downstream in conjunction with increases in discharge in the fall. Attenuation of high flows downstream of Iron Gate Dam may affect a key environmental cue used to stimulate the fall outmigration of adult green sturgeon that have remained in holding pools over the summer (Benson et al. 2007). This lower portion of the river was quite responsive to discharge increases related to rainfall events; the timing of peak flows changed significantly following the construction of the Four Facilities (Balance Hydrologics Inc. 1996). Under existing conditions, the Four Facilities result in higher flows in October compared with historically, and lower flows in late spring and summer (Balance Hydrologics Inc. 1996). Because temperatures in the lower river are close to lethal for eggs and embryos in dry years, reductions in flows related to the Four Facilities may exacerbate the effects of temperature on reproductive survival in these years, as would any temperature increases occurring as a result of climate change in the future. Shifts in the timing of seasonal life-history cues could also affect survival rates by changing the timing of their entry into habitats, such as entry of juveniles into the estuary~~.

The effect of the No Action/No Project Alternative would be no change from existing conditions for green sturgeon in the short and long term.

Lost River and Shortnose Sucker

Upper Klamath Lake, one of the primary habitats of Lost River and shortnose suckers, has long been recognized as eutrophic, characterized by extremely high temperatures and pH in the summer, accompanied by huge daily fluctuations in dissolved oxygen and high ammonia concentrations. Recent land use disturbances and changes in hydrology have led to hypereutrophic conditions in Upper Klamath Lake that frequently violate water quality standards and place designated beneficial uses in the lake and in the receiving waters of the Klamath River at risk (Section 3.2.3.4). Although eutrophic conditions in Upper Klamath Lake have caused fish die-offs since the late 1800s, these have become more frequent and severe in recent years with the hypereutrophic conditions, with chubs and suckers being perhaps the hardest hit species (Perkins et al. 2000, Buchanan et al. 2011a, as cited in Hamilton et al. 2011). Upper Klamath Lake inflows and outflows have declined since the 1960s while demand for water has increased for both agriculture and endangered fish species recovery. Along with direct mortality, poor water quality in

Upper Klamath Lake affects endangered sucker species through suppressing growth, reducing resistance to disease and parasites, and reducing reproductive success~~.~~ (Hamilton et al. 2011).

Under current conditions, suckers in reaches of the Four Facilities suffer mortality by entrainment in hydroelectric project turbines (Gutermuth et al. 2000). (Partially effective fish screens at J.C. Boyle facility would continue to contribute to entrainment (Administrative Law Judge 2006)). Suckers would continue to be stranded due to Four Facilities operations and peaking.

~~Reservoir sucker populations are not believed to be self-sustaining or to contribute to populations upstream; but, under the No Action/No Project Alternative, they would persist, providing some additional insurance, no matter how small, that fish would be available for recolonization efforts if for some reason their primary populations underwent catastrophic decline. This would only be feasible with a species of this type, which is extremely long-lived.~~

Shortnose and Lost River suckers would continue to be subject to poor water quality within reservoirs. ~~But~~However, with little or no successful reproduction (Buettner et al. 2006), populations downstream ~~of~~from Keno Dam contribute minimally to conservation goals and insignificantly to recovery (Hamilton et al. 2011). Under the No Action/No Project Alternative this population would persist, providing some additional insurance, no matter how small, that fish would be available for recolonization efforts if for some reason their primary populations underwent catastrophic decline. This would only be feasible with a species of this type, which is extremely long-lived.

Under the No Action/No Project Alternative, existing efforts to restore habitat for shortnose and Lost River sucker and improve water quality conditions would continue. These actions would be expected to improve conditions for these species over time and their populations would be expected to increase. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Lost River and shortnose sucker populations in the short and long term.**

Redband Trout Resident trout upstream of Iron Gate Dam are considered to be redband trout. Before construction of the Four Facilities, redband trout in the area belonged to one population, with no migration barriers isolating populations from one another (Administrative Law Judge 2006). Under the No Action/No Project Alternative, genetic exchange and movement between reaches would continue to be limited by the J.C. Boyle fish ladder (Administrative Law Judge 2006) and lack of fish ladders at the Copco 1 and 2 Dams, as will access to productive spawning habitat in Spencer Creek by redband trout in the J.C. Boyle Bypass and Peaking Reaches (Administrative Law Judge 2006). The isolation of this population into several smaller subpopulations renders each more vulnerable to extinction due to stochastic events (wildfire, landslides, disease outbreaks, etc.) and limits genetic exchange among subpopulations.

Redband trout populations in the Four Facilities reaches and reservoirs are generally isolated from the larger populations upstream of Upper Klamath Lake, such as in the Williamson and Wood Rivers; little to no natural recruitment from the ~~upper basin~~Upper Klamath Basin to populations in project-affected reaches can occur, as may have occurred historically.

Under the No Action/No Project Alternative, water quality in the Keno Reach would continue to be influenced by Keno Impoundment/Lake Ewauna upstream. In the summer, problems with low dissolved oxygen, high nutrients, and warm temperatures (occasionally exceeding 21°C) may increase physiological stress on redband trout, making them more vulnerable to mortality from other stressors. Measures implemented to meet TMDL targets would likely improve water quality in this area to some degree.

Under the No Action/No Project Alternative, habitat connectivity for redband trout in the Klamath River would continue to be compromised by structural features of the Four Facilities as well as project operations. Fish downstream ~~of~~ from J.C. Boyle Dam would continue to be hindered or obstructed from migrating to spawning grounds in Spencer ~~and Shovel creeks~~Creek by requiring them to ascend a fish ladder at J.C. Boyle Dam (~~USFWS and ODFW 2004, as cited in~~ Hamilton et al. 2011). Spencer Creek is a highly productive spawning and rearing habitat for rainbow/redband trout. The stock of rainbow/redband trout in the bypass and peaking reaches below J.C. Boyle Dam is currently restricted from Spencer Creek and other suitable habitat upstream of the J.C. Boyle Dam (Administrative Law Judge 2006). Factors influencing their movements include the necessity of passage at the J.C. Boyle Dam fish ladder as well as stresses resulting from power peaking operations downstream ~~of~~from the dam. Migration over the Copco 1 and 2 Dams is in the downstream direction only, as there is no fishway at this ~~project~~ Project feature.

The lack of functioning fish screens at Iron Gate, Copco 1 and 2 Dams minimizes recruitment of redband trout to downstream reaches, another factor adding to isolation ~~of~~ of subpopulations in the Four Facilities area. At the J.C. Boyle facility, the partially effective fish screens would continue to contribute to entrainment (Administrative ~~-~~Law Judge 2006). The ~~use of a Francis turbine at the~~ J.C. Boyle facility ~~would result in high~~ uses Francis turbines, at an operational head of 440 feet. A 1987 report prepared by the Electric Power Research Institute (EPRI) concluded that fish mortality ~~rates for fish that~~ from entrainment at hydroelectric projects using Francis turbines averaged 24 percent. The EPRI report found that entrainment mortality at hydroelectric projects using Francis turbines with operational head greater than 335 feet ranged from 33-48 percent (Administrative Law Judge 2006). It is estimated that "several tens of thousands of resident fish" are annually entrained ~~by it (EPRI 1987~~at "each of the Projects" facilities (Administrative Law Judge 2006).

The health and productivity of redband trout in the J.C. Boyle Peaking Reach and J.C~~.~~ . Boyle Bypass Reach would continue to be affected under the No Action/No Project Alternative. Obstruction of sediment transport at J.C. Boyle Dam has altered substrates and channel features in the peaking and bypass reaches. High flows have mobilized and

removed sediment from storage sites and transported them downstream, reducing habitat quality for redband trout as well as for the macroinvertebrates they feed on. In the J.C~~.~~. Boyle Peaking Reach, redband trout numbers would continue to be subject to large fluctuations in flows that: (1) cause fluctuations in water temperature and pH, (2) strand fish, (3) displace fish downstream, (4) reduce fry habitat along channel margins, (5~~)~~) reduce access to suitable gravels where they are affected by flow fluctuations, and (6~~)~~) reduce macroinvertebrate food production by reducing the area of the channel suitable for their survival (City of Klamath Falls 1986, Addley et al. 2005, as cited ~~by~~in Hamilton et al. 2011). All of these conditions could result in substantial declines in redband trout abundance in this reach.

Diversion of water at Keno Diversion Dam would continue to alter flows downstream, reducing base flows in the summer when water quality is a concern, and reducing the magnitude and frequency of high flows important for creating and maintaining physical and ecological processes that affect habitat for trout, their macroinvertebrate food, and other aquatic organisms. Reduced flows in the 1.4 mile long Copco 2 Bypass Reach would continue to prevent redband trout from using what would otherwise be complex habitat suitable for spawning and rearing. Productivity of redband trout in the bypass and peaking reaches would continue to be suppressed by Four Facilities effects that limit spawning and rearing habitat in these reaches (Hamilton et al. 2011). Under existing conditions, spawning of redband trout in the Bypass Reach appears limited to an area just downstream ~~of~~from the emergency canal spillway (Hamilton et al. 2011). Patches of gravel that might otherwise be suitable for spawning are rendered inaccessible to redband trout by reductions in instream flows (~~FERC 1990,~~ ODFW 2003, Administrative Law Judge 2006, all as cited in Hamilton et al. 2011).

Reduced redband trout abundance and distribution upstream of Iron Gate Dam attributable to Four Facilities features and operations would continue under the No Action/No Project Alternative. Habitat connectivity and suitability are substantially reduced in some reaches, which also suppresses the full range of life-history options formerly available to them. Other features of the redband trout populations in these reaches would likely be sustained under the No Action/No Project Alternative, such as declines in size (Jacobs et al. 2008, as cited in Hamilton et al. 2011) and condition factor (ODFW 2003, as cited in Hamilton et al. 2011).

The effect of the No Action/No Project Alternative would be no change from existing conditions for redband trout in the short and long term.

Bull Trout The distribution and numbers of bull trout are believed to have declined in the Klamath Basin due to habitat isolation, loss of migratory corridors, poor water quality, and the introduction of nonnative species. The geographic isolation of the Klamath populations places them at greater risk of genetic effects and extirpation (NRC 2004).

The effect of the No Action/No Project Alternative would be no change from existing conditions for bull trout in the short and long term.

Eulachon The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California (NOAA Fisheries Service 2009a). On March 18, 2010, NOAA Fisheries Service listed the southern DPS of eulachon as threatened under the ESA (NOAA Fisheries Service 2010b). ~~The~~ Historically, the Klamath River ~~is near~~was described as the southern limit of the range of eulachon (~~Hubbs 1925, Schultz and DeLacy 1935, both as cited in BRT~~ Gustafson et al. 2010). ~~Large spawning aggregations of eulachon historically occurred regularly~~Moyle (2002) indicates that eulachon have been scarce in the Klamath River ~~(Fry 1979; Moyle et al. 1995; Larson and Belchik 1998; Moyle 2002; Hamilton et al. 2005; Wallace, pers. comm., 2011). However, CDFG did not capture any eulachon~~since the 1970s, with the exception of three years: they were plentiful in 1988 and moderately abundant again in 1989 and 1998. After 1998, they were thought to be extinct in the Klamath ~~River from 1989 to 2003 (Wallace, pers. comm., 2011), and clearly they are in decline.~~

Basin, until a small run was observed in the estuary in 2004. Under the No Action/No Project Alternative, habitat conditions in the estuary for eulachon would remain the same as they are under existing conditions. However, very little is known about the factors leading to decline of the eulachon.

The effect of the No Action/No Project Alternative would be no change from existing conditions for eulachon in the short and long term.

Longfin Smelt Longfin smelt are a ~~state~~State-listed threatened species throughout their range in California ~~(CDFG 2009)~~, but the USFWS denied the petition for ~~federal~~Federal listing because the population in California (and specifically San Francisco Bay) was not believed to be sufficiently genetically isolated from other populations (USFWS 2009). The importance of ocean rearing is unknown. Little is known about longfin smelt populations in the Klamath River, except that they are presumably small.

The effect of the No Action/No Project Alternative would be no change from existing conditions for longfin smelt in the short and long term.

Introduced Resident Species Introduced resident species occur in Lake Ewauna, Upper Klamath Lake, within reservoirs upstream of Iron Gate Dam, and infrequently downstream ~~of~~ from Iron Gate Dam. Under the No Action/No ~~Proejct~~Project Alternative, conditions favorable for introduced species would continue to occur within the Four Facilities reservoirs (Buchanan et al. 2011a). Because these species were introduced and they occur in other nearby water bodies, their abundance is not considered a benefit from a biological perspective.

The effect of the No Action/No Project Alternative would be no change from existing conditions for introduced resident species in the short and long term.

Freshwater mussels ~~Of~~The Klamath River appears unusual compared to other Pacific Northwest rivers in that western ridged mussels (*G. angulata*) dominate the freshwater mussel community; of the species found on the mainstem Klamath River, the western ~~ridge freshwater~~ridged mussel ~~(*G. angulata*)~~ seems to be the most abundant and is widely distributed between Iron Gate Dam and the confluence of the Trinity River; (Westover 2010). The floater species (*Anodonta spp*.) are less abundant, with the largest single bed found immediately ~~below~~downstream from Iron Gate Dam (Westover 2010). The western pearlshell (*Margaritifera falcata*) is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found ~~below~~downstream from the confluence of the Salmon River (Westover 2010).

The effect of the No Action/No Project Alternative would be no change from existing conditions for freshwater mussels in the short and long term.

Benthic Macroinvertebrates Under existing conditions, Klamath Hydroelectric Project peaking operations kill, through stranding, large numbers of young fish and aquatic invertebrates that are the primary prey food for resident trout (Administrative Law Judge 2006). Current peaking operations reduce the production of sessile organisms, like macroinvertebrates, by 10 to 25 percent (Administrative Law Judge (2006). Macroinvertebrate drift rates, a measure of food availability for trout, in the non-peaking Keno Reach were five to six times greater than in the peaking reach. Fluctuations in the peaking reach are considered to be a contributing factor to the lower macroinvertebrate drift rates (Administrative Law Judge (2006).

The effect of the No Action/No Project Alternative would be no change from existing conditions on macroinvertebrates in the short and long term.

Interim Measures

Implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement and the Coho Enhancement Fund could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under ~~this IM,~~ the J.C. Boyle Gravel Placement and/or Habitat Enhancement suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking Reaches beginning in the fall of 2011 for one year (it is assumed that work would cease in the event of a Negative Determination). This IM would involve placing gravel using a passive approach before high flow periods, or developing other habitat enhancement measures to provide equivalent fishery benefits in the Klamath River upstream of Copco Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal.

The Coho Enhancement Fund would provide funding for specific projects or actions that would create, maintain, and improve access by coho salmon to important tributary habitats downstream from Iron Gate Dam that are within the potential range of the Upper Klamath coho salmon population. The projects would involve removal of existing fish passage barriers, gravel augmentation, improving/maintaining habitat cover and complexity at coldwater refugia sites, increasing the duration and/or extent of coldwater

refugia sites, enhancing habitat in rearing tributaries, restoring connectivity of juvenile rearing habitat in tributaries of the Upper Klamath, Scott, and Shasta Rivers, funding a program to provide flow augmentation in key reaches used for coho spawning and juvenile rearing in the Upper Klamath, Scott, and Shasta Rivers, enhancing habitat in rearing tributaries of the Upper Klamath, Scott, and Shasta Rivers, and protecting summer rearing habitat in tributaries of the Upper Klamath, Scott, and Shasta Rivers (PacifiCorp 2011). **Based on anticipated improvements in habitat availability and habitat quality, implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement ~~in the fall of 2011~~and the Coho Enhancement Fund under the No Action/No Project Alternative would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the ~~basin~~Basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

Implementation of J.C. Boyle Bypass Barrier Removal could result in alterations to habitat availability, and affect aquatic species. Under this IM, the sidecast rock barrier located approximately three miles upstream of the J.C. Boyle Powerhouse in the J.C~~.~~ Boyle Bypass Reach would be removed. The objective of this IM is to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead, Pacific lamprey, and redband trout. This action would provide improvements in habitat availability for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability, implementation of J.C. Boyle Bypass Barrier Removal under the No Action/No Project Alternative would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, and redband trout. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the ~~basin~~Basin. Effects on bull trout, shortnose and Lost River suckers would be less-than-significant. Effects on macroinvertebrates, freshwater mussels, green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

3.3.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (the Proposed Action)

~~This~~ As described in detail in Section 2.4.3, this alternative includes the removal of the Four Facilities along with the ancillary facilities of each installation in a 20-month period which includes an 8-month period of site preparation and partial drawdown at Copco 1 and a 12-month period for full drawdown and removal of facilities. This includes the entire dam, the powerhouses, spillways, and other infrastructures associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to the Department of the Interior (DOI), and the implementation of the KBRA. Under the Proposed Action, hatchery production would continue for eight years following the

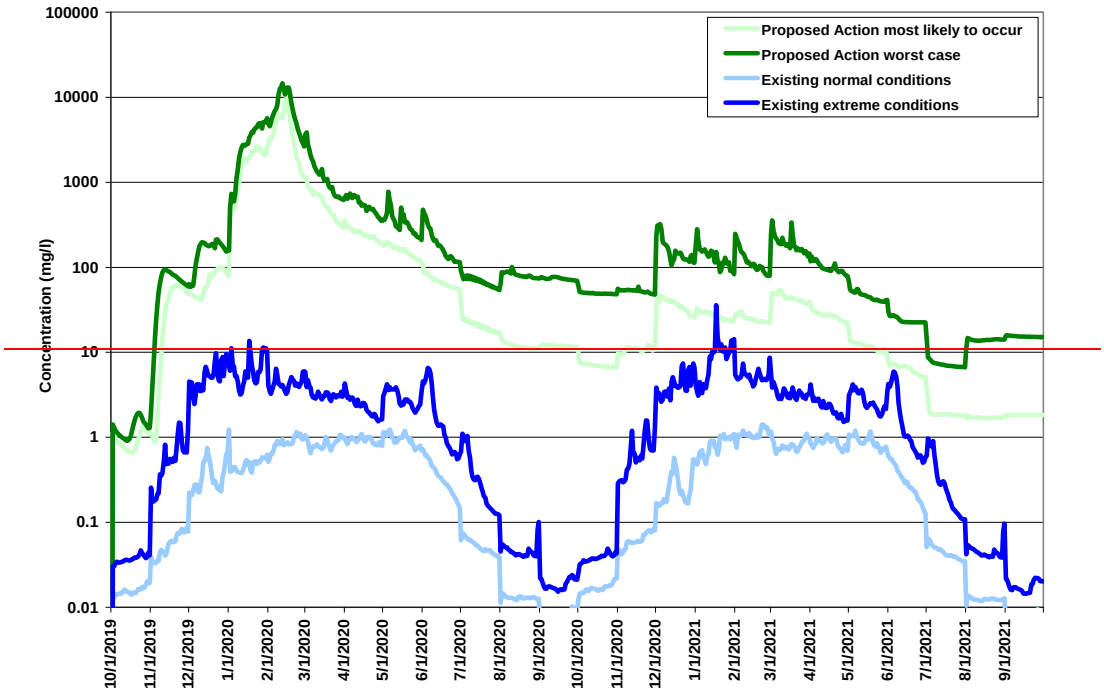
removal of Iron Gate Dam. The Proposed Action would result in effects on key ecological attributes that could affect aquatic resources, as summarized below. More detailed technical descriptions of the effects on suspended sediment, bedload sediment, and potential impacts on aquatic species, can be found in Appendices F and G.

Key Ecological Attributes

Suspended Sediment

Suspended sediment effects under Proposed Action are described in detail in Appendix E, and summarized here.

Lower Klamath River: ~~downstream of~~ Downstream from Iron Gate Dam Under the Proposed Action, full facility removal would result in the release of 5.3 to 8.6 million yd^3 (1.2 to 2.3 million tons) of sediment stored in the reservoirs into the Klamath River downstream ~~of~~from Iron Gate Dam (Reclamation ~~2011~~2012), resulting in higher SSCs than would normally occur under existing conditions (~~Figure 3.3-5). SSCs would begin to increase during reservoir drawdown, prior to the deconstruction of the dams and continue to rise through the spring runoff period as material behind the dams is mobilized downstream.~~Figure 3.3-9). Reservoir drawdown (lowering of reservoir water surface elevation) is expected to commence in November 2019 for Copco Reservoir and in December 2019 for J.C. Boyle and Iron Gate Reservoirs. Based on the suspended sediment modeling conducted to analyze each alternative (including facility removal) (Reclamation ~~2011~~2012), SSCs are expected to exceed 1,000 mg/L for weeks, with the potential for peak concentrations exceeding 5,000 mg/L for hours or days, depending on hydrologic conditions during facility removal. ~~At Iron Gate Dam (Figure 3.3-5~~ SSC would be highest during the period of greatest reservoir drawdown (January through mid-March 2020), as erodible material behind the dams is mobilized downstream (Reclamation 2012). During normal to dry water years, SSC concentrations would begin to decline in late March 2020 and would continue declining through early summer 2020 (Reclamation 2012). If it is a wet year, it may take longer to drain the reservoirs and the high concentrations may extend until June. The SSCs will be near background conditions for all water year types within the first year following removal. At Iron Gate Dam (Figure 3.3-9), where SSCs are artificially low under current conditions (because of sediment trapping by the dam) SSCs would remain elevated above existing conditions throughout the first 2 years. At Orleans (~~Figure 3.3-6~~Figure 3.3-10), where ~~SSC~~ SSCs under existing conditions is higher because of inputs of many tributaries, under a most-likely-to-occur scenario the effects of the Proposed Action would be similar to existing conditions by late April when ~~releases of SSC~~ SSCs from the Proposed Action are predicted to decrease. Under ~~extreme conditions,~~ a worst case scenario SSCs are projected to remain somewhat elevated above existing conditions until October.



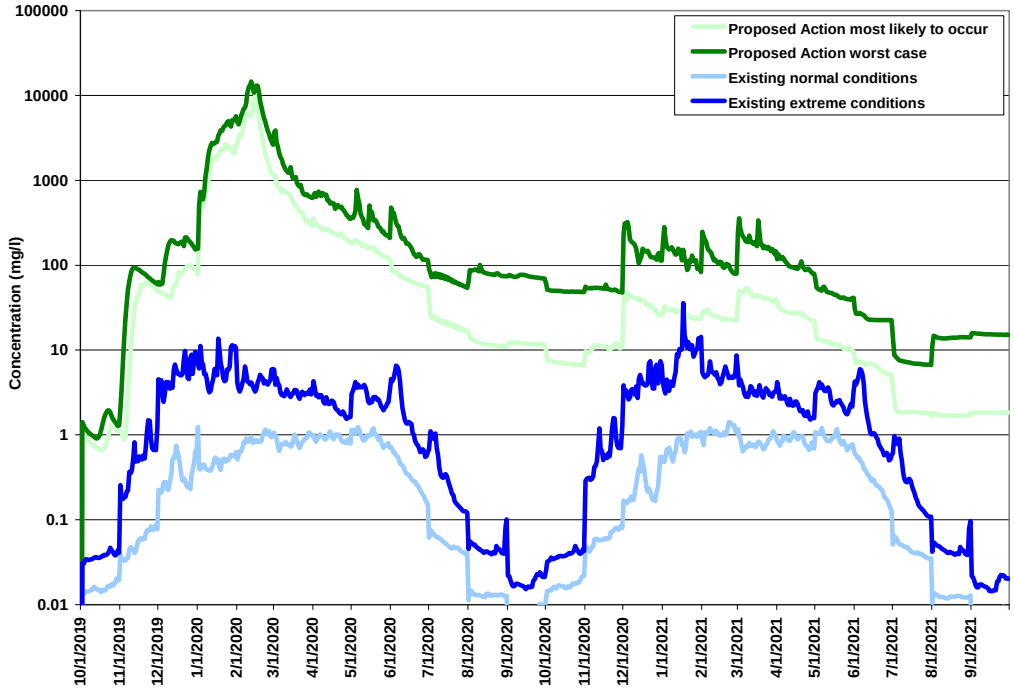
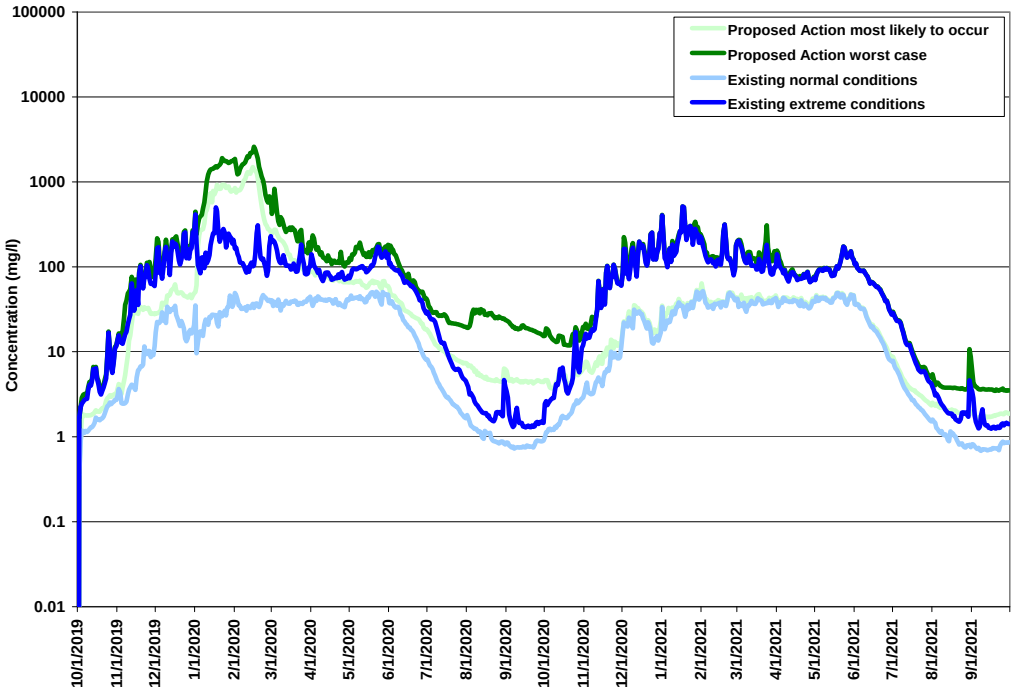


Figure 3.3-~~5~~-9. Comparison of SSCs under Proposed Action and Existing Conditions at Iron Gate Dam, as Predicted Using SRH-1D Model.


Proposed Action most likely to occur
Proposed Action worst case
Existing normal conditions
Existing extreme conditions
Concentration (mg/l)
100000
10000
1000
100
10
1
0.1
0.01
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
8/1/2020
9/1/2020
10/1/2020
11/1/2020
12/1/2020
1/1/2021
2/1/2021
3/1/2021
4/1/2021
5/1/2021
6/1/2021
7/1/2021
8/1/2021
9/1/2021

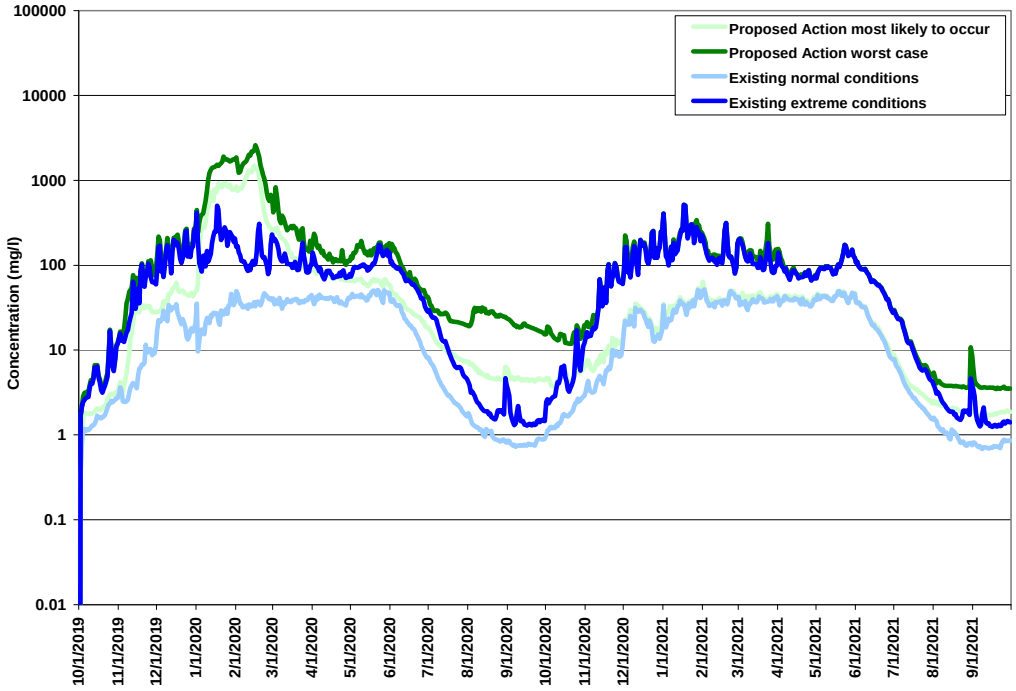
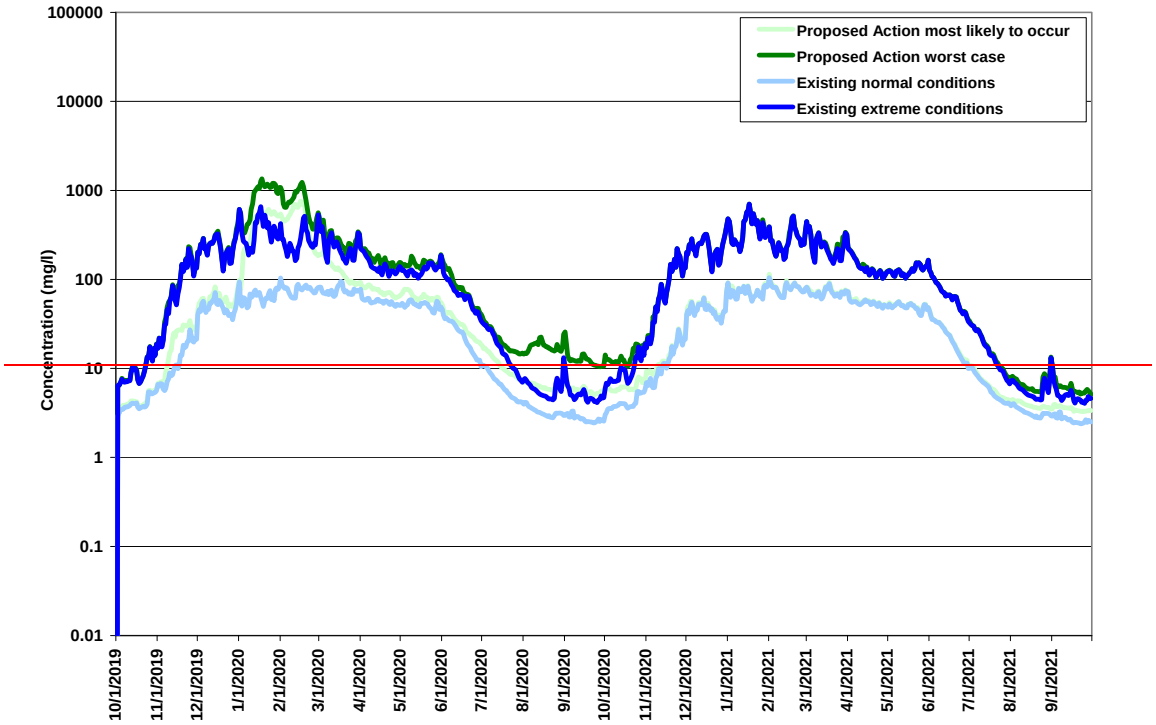


Figure 3.3~~-6~~-10. Comparison of SSCs under Proposed Action and Existing Conditions at Orleans, as Predicted Using SRH-1D Model.

Klamath River Estuary and Pacific Ocean Under the Proposed Action, sediment would be released from Iron Gate Dam, and would decline in concentration in the downstream direction as a result of dilution by input from downstream tributaries. Also, SSCs under existing conditions at Klamath Station are higher than at the upstream sites as a result of sediment input from tributaries. As a result, the difference of SSCs from the Proposed Action relative to existing conditions would be smallest in the Klamath River Estuary (~~Figure 3.3-7~~Figure 3.3-11). The SSCs under the most-likely-to-occur scenario would be similar to those that occur under existing extreme conditions, and so resemble those that would be expected to occur about 1 year in 10 on average. Under the worst-case simulation, SSCs concentrations are only marginally higher than those for the existing extreme conditions. Therefore, effects on aquatic species from SSCs within the estuary are not anticipated to be distinguishable from existing conditions.



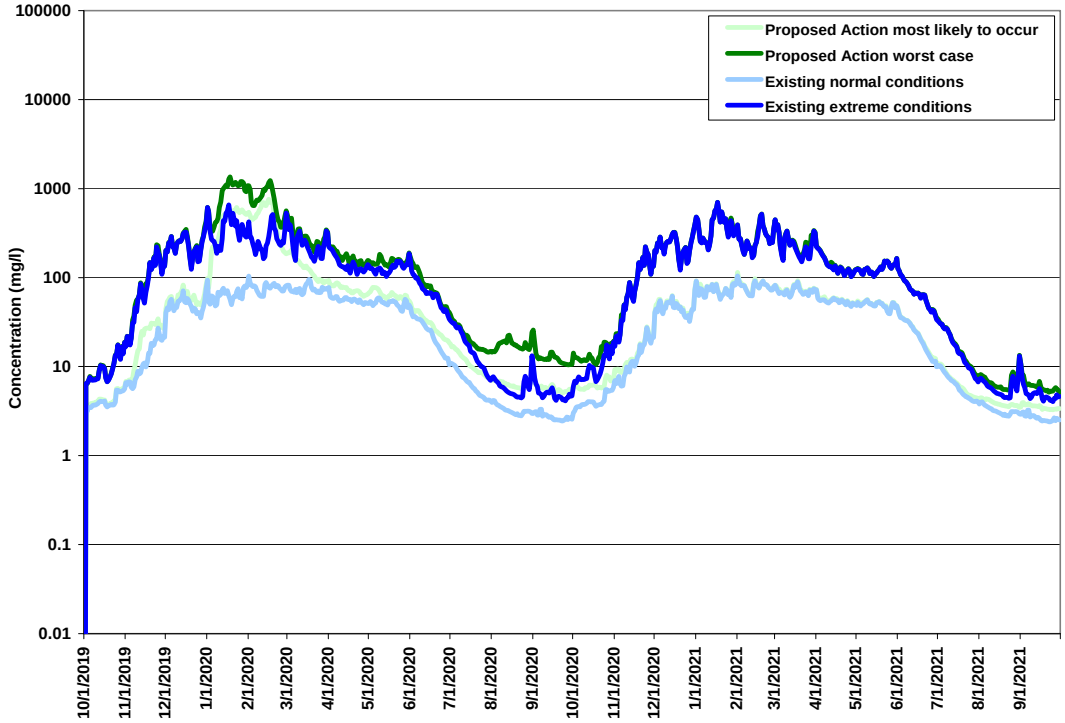


Figure 3.3~~-7~~-11. Comparison of SSCs under Proposed Action and Existing Conditions at Klamath Station, as Predicted Using SRH-1D Model.

Pacific Ocean Nearshore Environment In contrast to the ~~lower~~Lower Klamath River, modeled short-term SSCs following dam removal are not available for the nearshore marine environment adjacent to the Klamath River. Substantial dilution of the high (>1,000 mg/L) mainstem river SSCs is expected to occur in the nearshore under the Proposed Action; based on data from 110 coastal watersheds in California, where nearshore SSCs were measured at >100 mg/L during the El Nino winter of 1998 (Mertes and Warrick 2001), peak SSCs leaving the Klamath River Estuary may be diluted by 1 to 2 orders of magnitude from >1,000 mg/L to >10-100 mg/L. Based on the modeled SSCs at Klamath Station presented above, the SSCs in the nearshore ocean would be expected to be similar to what would occur during existing extreme conditions. ~~Overall,~~ As described in detail in the subsection of Section 3.2.4.3.2, during several large flood events on the geographically proximal Eel River in the winter of 1997 and 1998, Geyer et al. (2000) found the following: flood conditions were usually accompanied by strong winds from the southern quadrant. The structure of the river plume was strongly influenced by the wind-forcing conditions. During periods of strong southerly (i.e., downwelling favorable) winds, the plume was confined inside the 50-m isobath (i.e., sea floor contour at 50-m below the water surface), within about 7 km of shore. Based upon Eel River

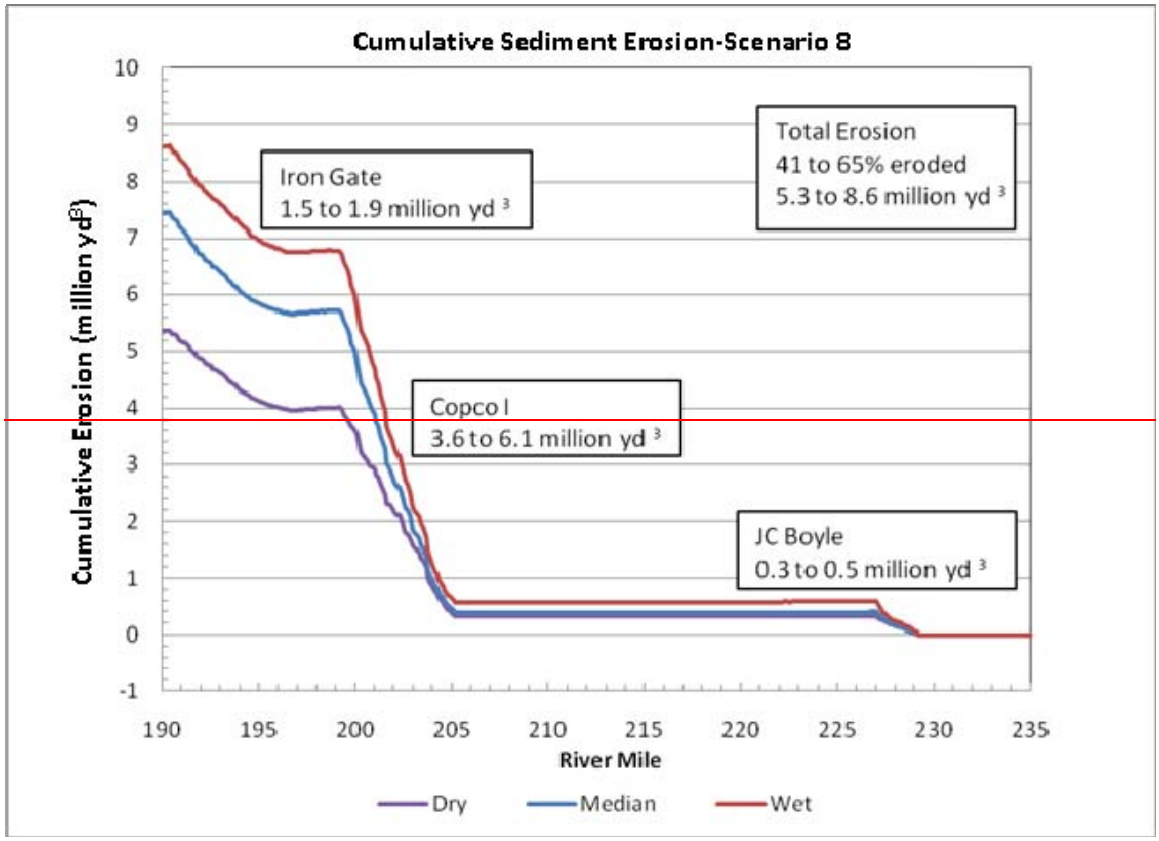
plume studies and current knowledge of northern California oceanographic patterns, the fine sediment discharged to the marine nearshore environment under the Proposed Action would likely be delivered to the ocean in a buoyant river plume that hugs the shoreline as it is transported northward. However, since the flushing of sediments from behind the dams will occur over a number of weeks to months (and perhaps to some degree over 1-2 years), the plume carrying reservoir sediments would likely be influenced by a range of meteorological and ocean conditions (e.g., storm and non-storm periods, differing storm directions). Therefore, some of the time the plume would likely be constrained to shallower nearshore waters, while at other times it would likely extend further offshore and spread more widely. While elevated SSCs (i.e., 10–100 mg/L) created in the nearshore plume would affect physical water quality characteristics specified in the Ocean Plan (i.e., visible floating particulates, natural light attenuation, the deposition rate of inert solids [Table 3.2-7]), the effects are likely to be within the range caused by historical storm events.

River plumes and the associated habitat conditions they create are considered to be areas of high productivity for marine organisms (Grimes and Funucane 1991, Morgan et al. 2005), and create abrupt changes in marine water quality conditions (e.g., water temperature, salinity, sediment) that support salmonids (Schabetsberger et al. 2003, DeRobertis et al. 2005). Due to the relatively small magnitude of SSCs released to the nearshore environment, the anticipated rapid dilution of the sediment plume as it expands in the ocean, and the relatively low rate of deposition of sediments to the marine nearshore bottom substrates, any SSCs elevations associated with the Proposed Action are not anticipated to have effects on species distinguishable from existing conditions.

Bedload Sediment

Bedload sediment effects under Proposed Action are described in detail in Appendix F, and summarized here. As a result of the Proposed Action, the bedload transport processes currently interrupted by the Project that salmon evolved with and depend upon to provide substrate suitable for spawning and early rearing in streams and rivers would be restored.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Dams in the Hydroelectric Reach currently store 13,150,000 yd^3 of sediment (Reclamation ~~2011).~~2012). No sediment is stored within the Copco 2 Reservoir, Copco 1 ~~Resevoir~~Reservoir stores the greatest amount, and J.C. Boyle Reservoir stores the least. Sediment would continue to accrue from existing conditions through 2020, when the dams would be removed. The SRH-1D model estimated ~~41~~36 to ~~66~~57 percent (5.3 to 8.6 million yd^3) of dam-stored sediment would be eroded the first year after dam removal depending on simulation type (wet, median, or dry) (~~Figure 3.3-8~~Figure 3.3-12). Of this sediment, about 15 percent would be transported as bedload. Sediment not eroded from the reservoirs during the first year would be stored in gravel bars and terraces~~, and~~. Some of this material would then be released more slowly through surficial and fluvial processes, but a large portion of the sediment left on the terraces is expected to remain indefinitely (Stillwater Sciences 2008).

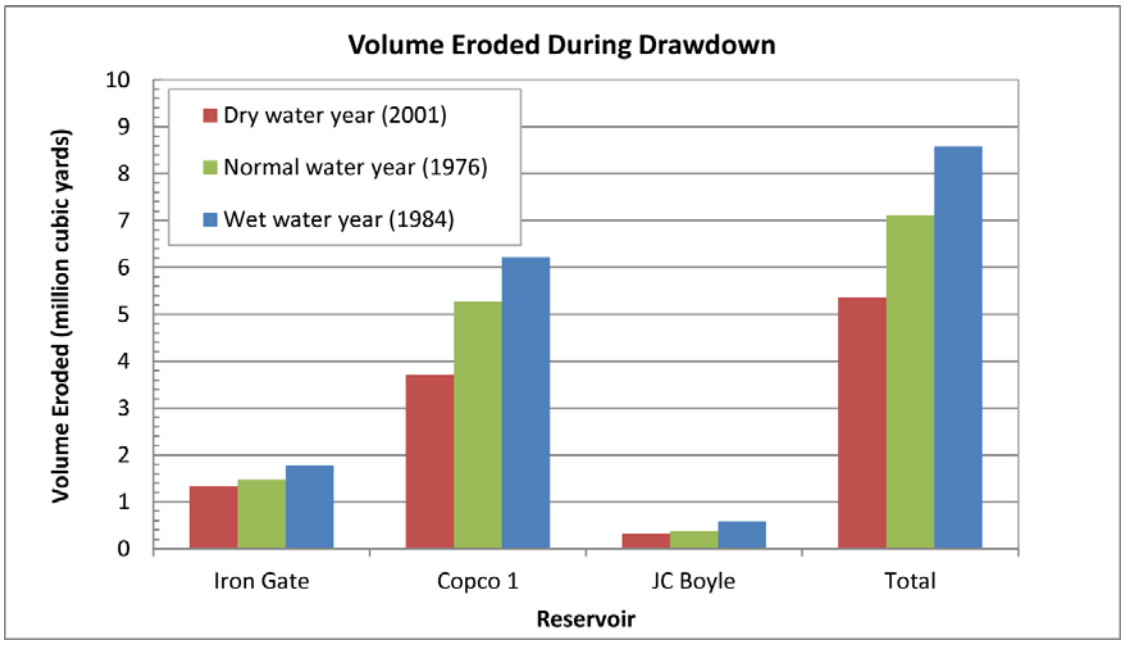


~~**Figure 3.3-8. Cumulative Sediment Erosion from Dams in the Hydroelectric Reach During 2020 Drawdown Beginning in January (Reclamation 2011).**~~

SRH-1D model results indicate decreases in bed elevation and increases in median substrate size within the reservoirs during drawdown (January 2020 to May 2020) (~~Figure 3.3-9 and Figure 3.3-10). These changes would stabilize within 5~~Figure 3.3-13). Within the reservoirs, SRH-1D modeling data for the first two years after dam removal show decreases in fine sediment and increases in median substrate size after completion of drawdown that stabilize as the bed returns to pre-dam elevation. The proportion of fine sediment decreases from 50 to 80 percent to near zero within 2 months after drawdown; the proportion of sand initially increases to 30 to 50 percent then decreases to 10 to 25 percent; the proportion of gravel changes (mostly increases) to 20 to 35 percent; and the proportion of cobble increases to 50 to 70 percent, depending on the reservoir and simulation water year type (i.e., wet, median, or dry). These changes would stabilize within six months as the bed within the historical river channel reaches pre-dam elevations (Reclamation ~~2011; B. Greimann, pers. comm., December 23, 2010~~2012). These river sections are expected to revert to and maintain a pool-riffle morphology due to restoration of riverine processes along the Hydroelectric Reach (PacifiCorp 2004a). Still, after dam removal, channels currently inundated by reservoirs would likely vary from narrow, single-threaded channels to wide and sinuous channels with the potential to

form complex features, such as meander cut-offs and vegetated islands (Reclamation ~~2011).~~ 2012).

The river reaches upstream of J.C. Boyle Reservoir and from Copco 1 Reservoir to J.C~~.~~ . Boyle Dam show little change in bed composition or median substrate size during drawdown (~~Figure 3.3-10~~Figure 3.3-13) (Reclamation ~~2011~~2012). Currently, these reaches are predominantly cobble (90 percent) with small fractions of gravel and sand. Very little temporal change in substrate size would be expected to occur in response to dam removal (Appendix E).



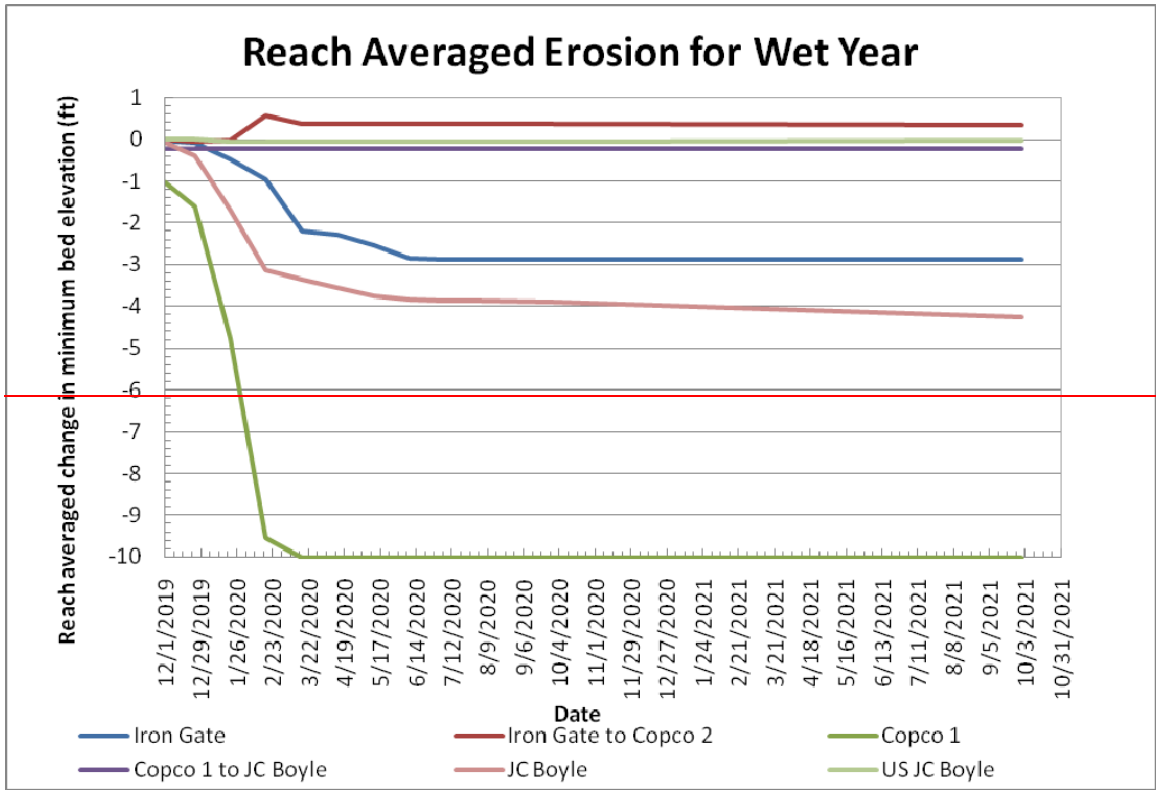


Figure 3.3-12. Sediment Erosion from Dams in the Hydroelectric Reach During 2020 Drawdown Beginning in January (Reclamation 2012).

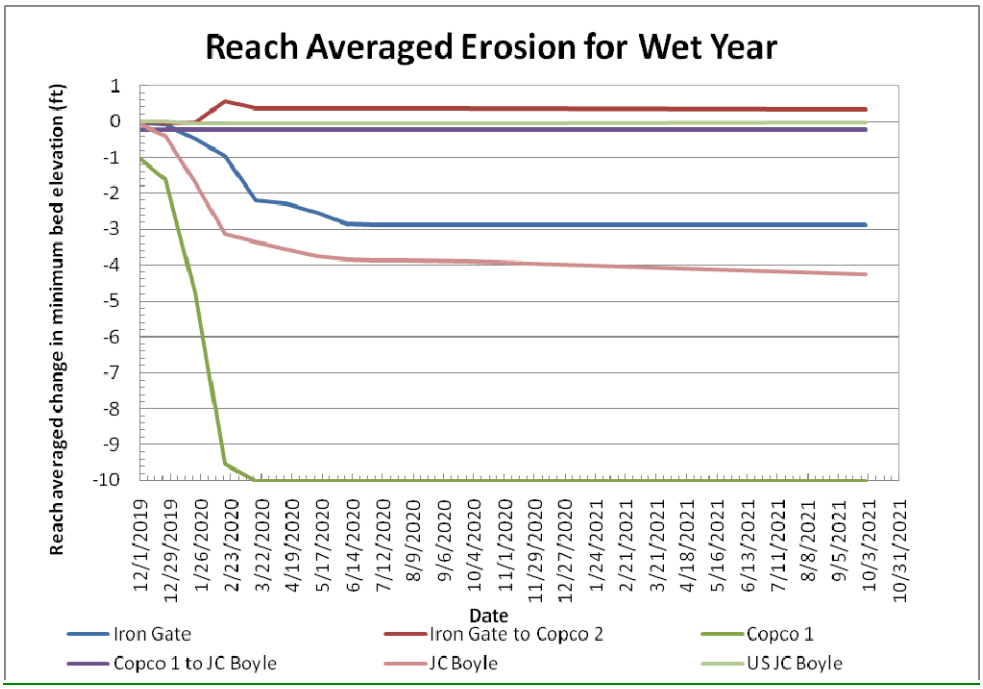


Figure 3.3-9-13. Reach-Averaged Erosion in the Hydroelectric Reach during Wet Year (Reclamation 2011 2012).

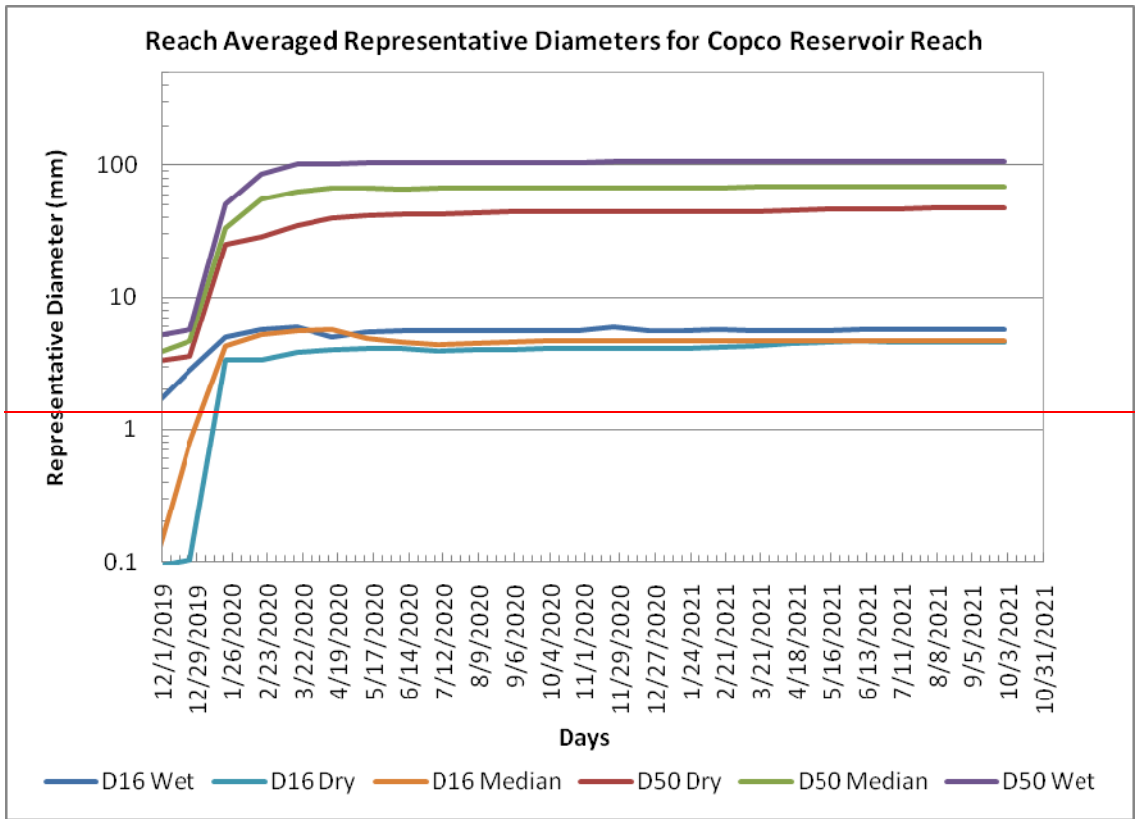


Figure 3.3-10. Reach-Averaged D16 and D50 in Copco 1 Reservoir Reach Following Dam Removal (Reclamation 2011).

The Copco 2 Dam to Iron Gate Reservoir reach shows increases in the proportion of sand to 35 to 45 percent shortly after drawdown (from January 2020 to February 2020) (Figure 3.3-11). In the dry simulation, the percent sand decreases to 20 percent from April 2020 to February 2021, then again to 10 percent from February 2021 to the end of the simulation. decreases in the combined proportion of sand and fine: the dry simulations show decreases to approximately 35 percent two years after drawdown (Figures 3.3-14).

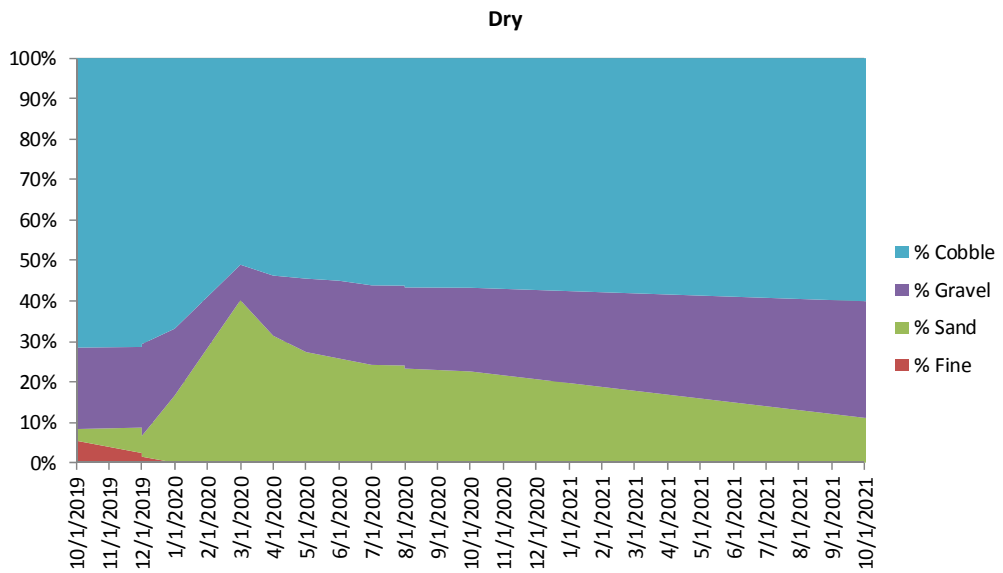
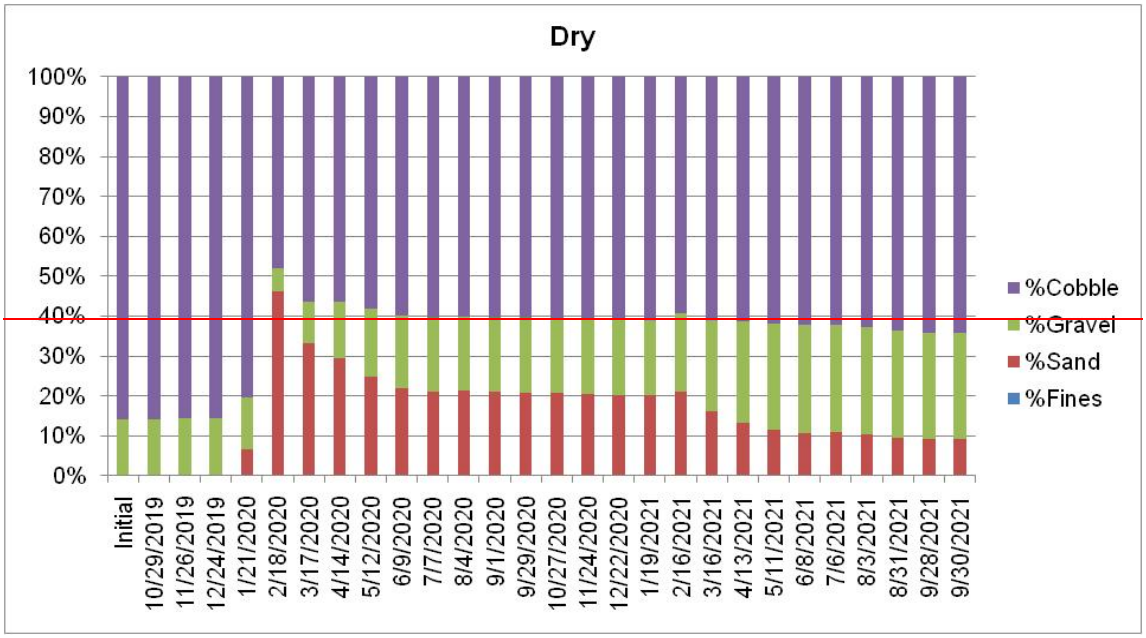


Figure 3.3-14. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years during and after Drawdown (Based on simulation results provided by Reclamation, March 2012).

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam ~~The~~Since the construction of the lower four PacifiCorp dams, there has been approximately 3.6 million tons of deposition within these reservoirs. Dam construction has interrupted the transport of sediment, including spawning gravel, below Iron Gate Dam necessary for the long-term maintenance of aquatic habitats (Buer 1981). Under the Proposed Action the streambed downstream ~~of~~ from Iron Gate Dam would be affected by dam-released sediment and reconnection of the natural sediment supply from upstream. The sediment stored within the reservoirs has a high water content and 85 percent of the particles are silts and clays (less than 0.063 mm) while 15 percent are sand or coarser (larger than 0.063 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences 2008; Reclamation ~~2011~~2012). As such, most sediment eroded from the reservoirs would be silt and clay (less than 0.063 mm) with smaller fractions of sand (0.063 to 2 mm), gravel (2 to 64 mm), and cobble (~~64~~ 64 to 256 mm) (Gathard Engineering Consulting 2006; Stillwater ~~Sciences~~Sciences 2010a; Reclamation ~~2011~~2012). A large portion of the silt and finer substrate would likely be transported as suspended sediment and would travel to the ocean shortly after being eroded and mobilized (Stillwater ~~Sciences2010a). Coarser~~Sciences 2010a). As described below, coarser (larger than 0.063 mm) sediment, including sand, would travel downstream more slowly, attenuated by channel storage and the frequency and magnitude of mobilization flows. ~~The amount of sand transported in suspension would vary with discharge, with greater proportions of sand in suspension at higher discharges. A substantial amount of sand may deposit on the channel, potentially embedding larger substrate.~~



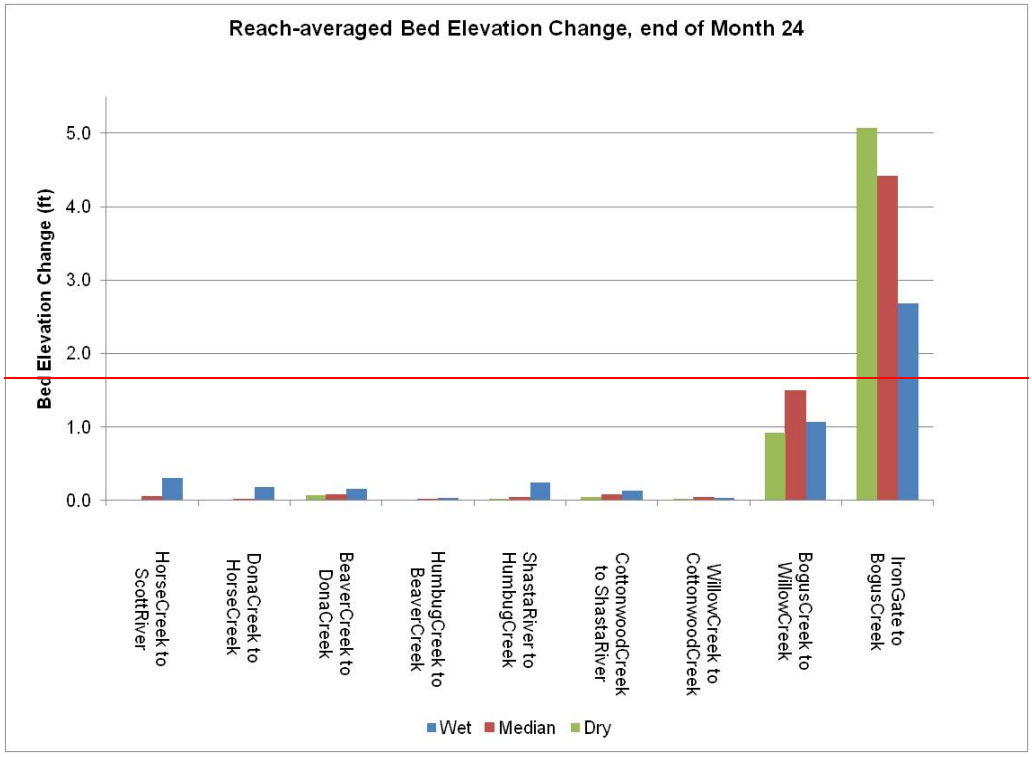
~~Figure 3.3-11. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years after Dam Removal.~~

~~The effect of dam-released sediment and sediment resupply would likely extend from Iron Gate Dam to Cottonwood Creek (Reclamation 2011). Estimates of reach-averaged stream power (the ability of the river to move sediment) show a decrease from Iron Gate Dam to Cottonwood Creek, with stream power then increasing again downstream of Cottonwood Creek. The increase suggests that short- or long-term sediment deposition, either from dam release or sediment resupply, is unlikely downstream of Cottonwood Creek. Using this point as the downstream extent of bedload-related effects, 8 miles of channel could be affected by sediment release and resupply. The affected channel represents 4 percent of the total channel length of the mainstem Klamath River downstream of Iron Gate Dam (190 miles).~~

Short-term (2-year) SRH-1D model simulations estimate up to ~~5 feet~~ 1 ft of reach-averaged deposition of fine and coarse sediment between Iron Gate Dam and Bogus Creek (~~RM~~ RM 189.8) (~~2.5 to 5 feet), decreasing to 1.~~0.3 to 1~~.5 feet~~feet and up to 0.8 ft of deposition between Bogus Creek and Willow Creek (RM 185.2~~), while reaches~~) (0.4 to 0.8 ft). Reaches farther downstream showed no apparent ~~increase (~~change (<0.5 ft) Figure 3.3-~~12~~15, Reclamation ~~2011).~~

~~Reach averaged bed elevation between Iron Gate Dam to Bogus Creek would increase by 5 feet after drawdown (January 2020) until March 2020 under dry and median simulations, and would increase by 3 feet after drawdown until April 2020 under the wet simulation (Figure 3.3-12). Elevations under the dry and median simulation would be expected to approach a level similar to the wet simulation (3 feet) over time as flows carry dam released sediment downstream directly below Iron Gate Dam. In the long-~~

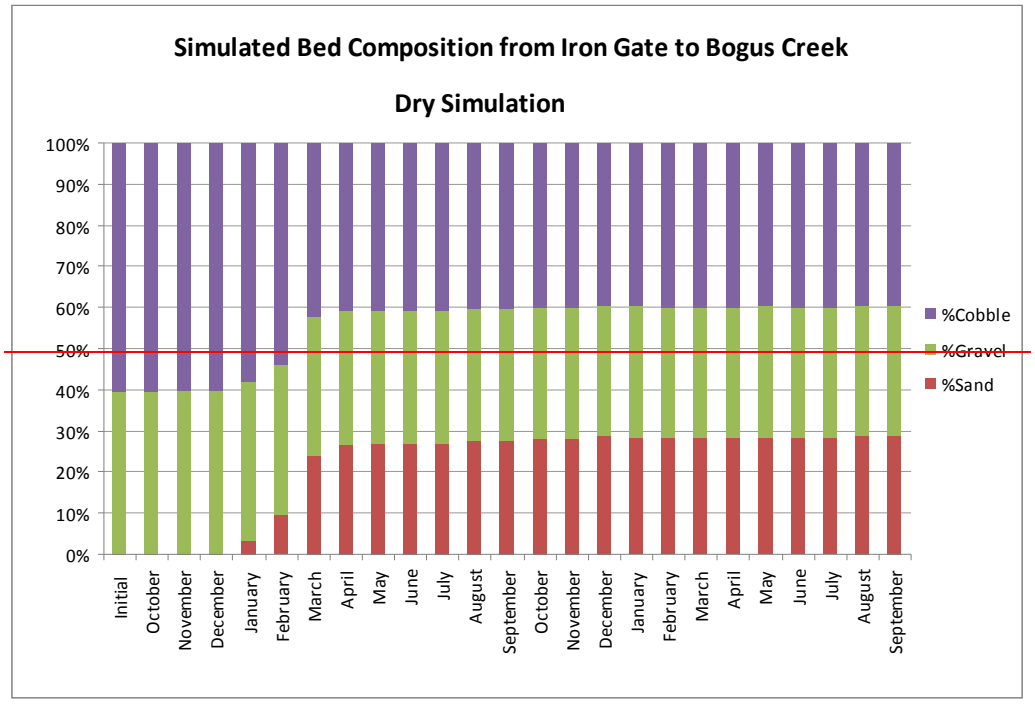
~~term (from 5 to 50 years), after downstream translation of dam released sediment, bed elevation would adjust to a new equilibrium, which includes sediment supplied by upstream tributaries that was formerly trapped by dams within the Hydroelectric Reach. The average bed elevation increase predicted over the next 50 years is 1.5 ft in the reach from Bogus to Willow Creek and less than 1 foot downstream from there (Reclamation 2011~~2012). In the long-term (from 5 to 50 years), after downstream translation of dam released sediment, bed elevation would adjust to a new equilibrium, which includes sediment supplied by upstream tributaries that was formerly trapped by dams within the Hydroelectric Reach. The average bed elevation increase predicted over the next 50 years is 1.5 ft in the reach from Bogus to Willow Creek and less than 1 foot downstream from there (Reclamation ~~(2011~~2012). Reclamation (2011a) expects 2 to 3 feet of aggradation between Iron Gate Dam and Cottonwood Creek over the next 50 years.



~~**Figure 3.3-12. Reach Averaged Bed Elevation during Two Successive Wet, Median, or Dry Water Years from Iron Gate Dam to Bogus Creek (Reclamation 2011).**~~

~~In the short-term (within 2 years), SRH-1D model output indicates dam released sediment and sediment resupply would increase the proportion of sand in the bed and decrease median bed substrate size (Figure 3.3-13 and Figure 3.3-14) (~~Under the Proposed Action, the flow magnitude required to mobilize sediment would likely decrease from existing conditions. Reclamation ~~2011). The model predicts that after two successive dry years, the proportion of sand on the bed would increase to 30 percent and median substrate size would decrease to 45 mm after drawdown in January 2020 to March 2020 and remain at these values though to September 2021. Longer-term (5, 10, 25, and 50 years) simulations show increases in the proportion of sand to 5 to 22 percent and decreases in D50 to approximately 50 to 55 mm (Appendix E) after 5 years that stabilize and continue through to year 50.~~

~~Under the Proposed Action, sediment mobilization flows would decrease from existing conditions. Reclamation (2011~~(2011a) estimated the magnitude and return period of flows required to mobilize sediment downstream ~~of~~ from Iron Gate Dam 50 years after dam removal using reach averaged, predicted grain sizes from long-term SRH-1D simulations. The estimates show that under the Proposed Action, sediment mobilization flows from Bogus Creek (RM 190.2) to Willow Creek (RM 185.5) and from Willow Creek to Cottonwood Creek (RM 182.5) would range from 3,000 to 7,000 cfs (1.5 to 2.5 year return period) and 5,000 to 9,000 cfs (1.5 to 3.2 year return period), respectively, lower than ~~existing conditions or the No Action/No Project Alternative (see Figure 3.3-4). Downstream of the Shasta River, there would be no difference in bed mobilization flows or return period between the Proposed Action and existing conditions or the No Action/No Project Alternative.~~Existing Conditions. This would have the effect of increasing bed mobilization at least down to the Shasta River (RM 177) under the Proposed Action.



Downstream from the Shasta River, there would be no significant difference in the flow required to mobilize the bed because the bed elevations of this reach are primarily controlled by relatively immobile large cobbles, boulders, and bedrock. Sediment is expected to quickly move through the reach with or without dam removal. However, there is expected to be higher transport of sand, silt, and clay transport through this reach because of the removal of the Project dams.

The effect of dam-released sediment and sediment resupply would likely extend from Iron Gate Dam to Cottonwood Creek (Reclamation 2012). Estimates of reach-averaged stream power (the ability of the river to move sediment) show a decrease from Iron Gate Dam to Cottonwood Creek, with stream power then increasing again downstream from Cottonwood Creek. The increase suggests that short- or long-term sediment deposition, either from dam release or sediment resupply, is unlikely downstream from Cottonwood Creek. However, while the area of significant sediment release and resupply of gravel and cobble under the Proposed Action is from Iron Gate Dam downstream to Cottonwood Creek, sediment transport rates of sand, silt and clay will increase downstream from Cottonwood Creek as well (Reclamation 2012).

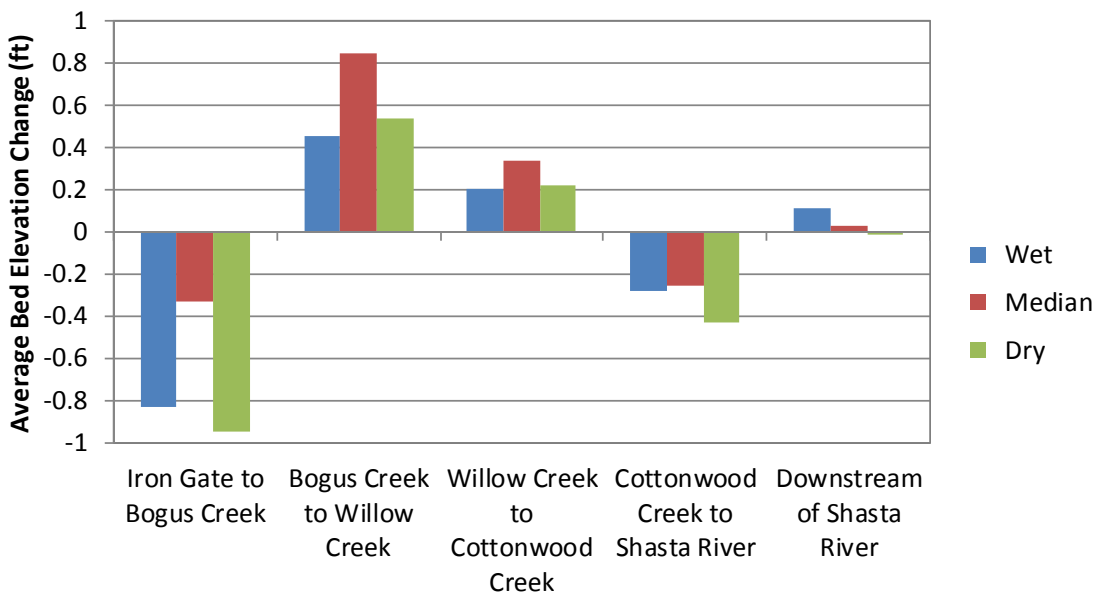


Figure 3.3-15. Reach Averaged Bed Elevation Change for Two Successive Wet, Median, or Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012).

In the short term (within 2 years), SRH-1D model output indicates dam released sediment and sediment resupply would increase the proportion of sand in the bed and decrease median bed substrate size (Figure 3.3-16 and Figure 3.3-17) (Reclamation 2012). Under wet, median and dry simulations, sand within the bed would increase to 30 to 35 percent by March to June 2020 following drawdown, gradually decreasing to 10 to 20 percent by September 2021, while median substrate size (D50) would fluctuate slightly before finally stabilizing to approximately the initial condition with a D50 of 100 mm (Appendix F). Longer-term (5, 10, 25, and 50 years) simulations show increases in the proportion of sand to 5 to 22 percent and decreases in D50 to approximately 50 to 55 mm (Appendix E) after 5 years that stabilize and continue through to year 50. In general, the effect of the Proposed Action will be a more dynamic and mobile bed downstream from Iron Gate Dam, with increased transport of sediment, and increased sediment supply, including spawning gravel.

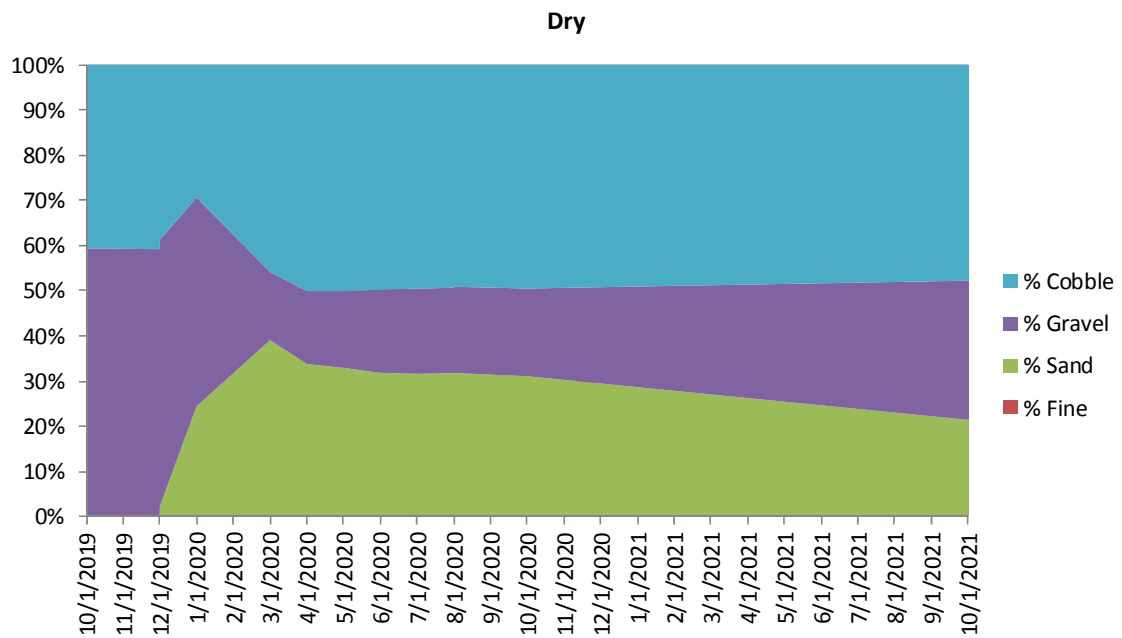
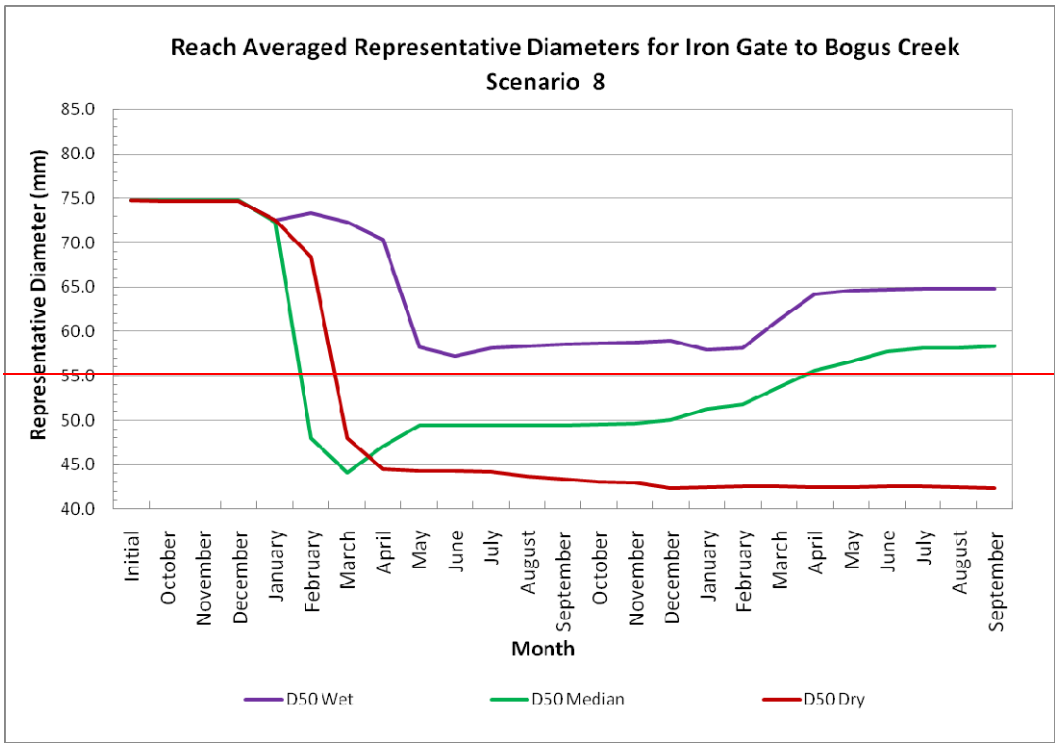


Figure 3.3-16. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years ~~Dam Removal.~~ Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012).


Reach Averaged Representative Diameters for Iron Gate to Bogus Creek
Scenario 8
Representative Diameter (mm)
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
Initial
October
November
December
January
February
March
April
May
June
July
August
September
October
November
December
January
February
March
April
May
June
July
August
September
Month
D50 Wet
D50 Median
D50 Dry

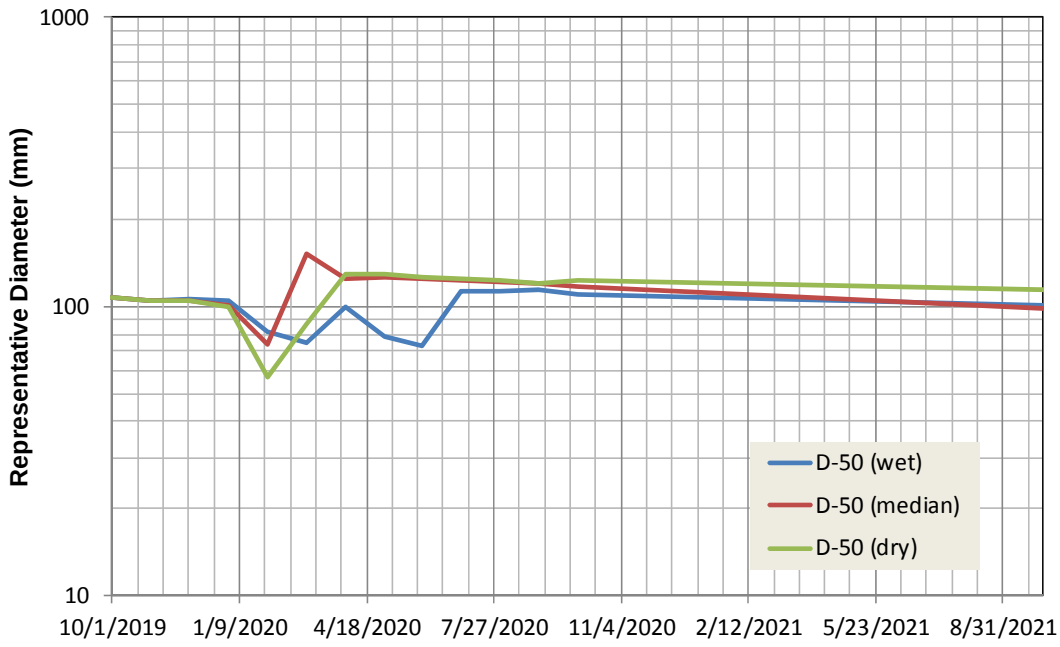


Figure 3.3~~-14~~-17. Simulated D50 (mm) from Iron Gate Dam to Bogus Creek during Successive Wet, Median, and Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012).

Water Quality

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir ~~The~~Dam removal activities under the Proposed Action ~~(independent of KBRA actions described below)~~ would not affect water quality in the following areas of the Upper Klamath Basin: Wood, Williamson, and Sprague Rivers, Upper Klamath Lake, and Link River to the upstream end of J.C. Boyle Reservoir.

Water quality problems (e.g., excessive water temperatures and low dissolved oxygen) in the Keno Impoundment/Lake Ewauna during late spring, summer, and early autumn, led NOAA Fisheries Service and the DOI to prescribe interim trap-and-haul measures to transport ~~juvenile and~~primarily adult ~~fish~~fall-run Chinook salmon past Keno Impoundment/Lake Ewauna during periods when conditions would be harmful to salmonids. During most years, the Keno Impoundment/Lake Ewauna ~~Reach~~ reach of the Klamath River (Link River Dam to Keno Dam) ~~has~~ exhibits dissolved oxygen concentrations greater than 6 mg/L from mid-November through mid-June~~; these~~. These measurements are ~~within United States Environmental Protection Agency criteria~~ generally acceptable for migrating adult anadromous salmonids (USEPA 1986) for these months ~~(DOI 2007). Interim~~and are typically above the ODEQ water quality objective for cool water aquatic life (6.5 mg/L minimum, see Table 3.2-3). Under the Proposed Action, interim, seasonal, upstream trap and haul for primarily fall-run adult Chinook salmon

around the Keno Impoundment/Lake Ewauna would be necessary when dissolved oxygen and ~~temperature exceed the United States Environmental Protection Agency criteria. Water quality would be expected to improve over the long term through the implementation of the TMDL process (DOI 2007).~~water temperature do not meet the applicable criteria (i.e., typically during July through October), since migrating salmonids would have access to this reach of the Klamath River. As described under the No Action/No Project Alternative (see subsections of Section 3.2.4.3.1, Water Quality, and Section 3.3.4.3.1, Aquatics), seasonal dissolved oxygen in the Keno Impoundment/Lake Ewauna would also be expected to improve under the Proposed Action following full attainment of the TMDLs, potentially eliminating the need for trap and haul activities.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam As described in the subsection of Section 3.2.4.3.2, Water Quality, the Proposed Action ~~could~~ would cause long-term ~~overall~~ increases in ~~dissolved oxygen, as well as increased diel variability in dissolved oxygen, in the Hydroelectric Reach. Facility removal under the Proposed Action would cause slight long-term increases in summer and fall~~ dissolved oxygen~~, increasing~~ in the Hydroelectric Reach . Dissolved oxygen in the current river reaches and the free-flowing river reaches replacing the reservoirs would no longer be affected by hydropower peaking flows or the extreme conditions of super-saturation (i.e., >100% saturation) in surface waters and hypolimnetic oxygen depletion in bottom waters of Copco 1 and Iron Gate Reservoirs during the April/May through October/November period. This would increase the likelihood of consistently supporting beneficial uses during this period.

~~California Klamath River TMDLs (NCRWQCB 2010) model results indicate that under the Proposed Action (analogous to the TMDL TOD2RN model run, which includes Oregon TMDL allocations)~~As described in the subsection of Section 3.2.4.3.2, Water Quality, under the Proposed Action, pH in the Hydroelectric Reach ~~immediately downstream of J.C. Boyle Dam would be slightly less between March and May than pH levels modeled under the No Action/No Project Alternative (analogous to the TMDL T4BSRN model run). At the California-Oregon state line, pH under the Proposed Action would exhibit lower values April through June and October through December, with slightly more diurnal~~would no longer experience daily variation ~~July through August than those predicted under the No Action/ No Project Alternative.~~

due to hydropower peaking flows or the high levels (pH > 9) resulting from seasonal algal growth in the surface waters of Copco 1 and Iron Gate Reservoirs. pH in the free-flowing reaches of the river replacing the reservoirs would not exhibit such extremes, instead possessing a more typical riverine signal. While slight increases in pH and daily fluctuation could occur due to increased periphyton growth in the river reaches previously occupied by reservoirs, the increases are expected to consistently meet the Oregon water quality objective to support beneficial uses and would therefore be less than significant (see Section 3.2.4.3.2).

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam Sediment release associated with the Proposed Action could cause short-term increases in oxygen demand

and reductions in dissolved oxygen~~ that could result in non-attainment of Basin Plan numeric water quality objectives for dissolved oxygen and contribute to reductions in beneficial uses in the lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment~~. As described in the subsection of Section 3.2.4.3.2, Water Quality, ~~model results indicate that short-term effects on dissolved oxygen would resolve well upstream of the Klamath River Estuary (at approximately 190 miles downstream of Iron Gate Dam) and, therefore, would not affect the Klamath River Estuary or the Pacific Ocean nearshore environment.~~

~~Overall,~~ predicted short-term increases in oxygen demand ~~and reductions~~ under the Proposed Action generally result in dissolved oxygen ~~under the Proposed Action would not cause dissolved oxygen concentrations to fall below the minimum acceptable dissolved oxygen concentration (5 mg/L) for salmonids. However, short-term dissolved oxygen would fall~~concentrations greater than 5 mg/L. Exceptions to this would occur four to eight weeks following reservoir drawdown (i.e., in February 2020) for median and dry year hydrologic conditions, when dissolved oxygen would drop to levels below ~~the~~5 mg/L from Iron Gate Dam to near the confluence with the Shasta River (RM 176.7). Recovery to the North Coast Basin Plan ~~numeric~~ water quality objective ~~(>8.1 to 8.8~~of 90 percent saturation (i.e., 10–11 mg/L) ~~and~~ would ~~contribute to reductions in the most sensitive beneficial use (SPWN) for the mainstem river approximately 30 to 60 miles downstream of Hydroelectric Reach, or generally~~occur in the reach ~~downstream of the Beaver Creek confluence and~~ from Seiad Valley~~.~~

to the mainstem confluence with Clear Creek, and would therefore not affect dissolved oxygen in the estuary or the nearshore environment.

Facility removal under the Proposed Action could cause long-term overall increases in dissolved oxygen, as well as increased diel variability in dissolved oxygen, in the ~~lower~~ Lower Klamath River, particularly for the reach immediately downstream ~~of~~from Iron Gate Dam. Effects would diminish with distance downstream ~~of~~from Iron Gate Dam, such that no effects on dissolved oxygen would occur by the confluence with the Trinity River.

Water Temperature

Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir ~~This region is upstream of any proposed dam~~Dam removal~~; therefore,~~ activities under the Proposed Action would not affect ~~water temperature. Any changes in~~ water temperature in ~~this region would be a result of other factors, including climate change. The effects in this area would be similar to those described for the No Action/No Project Alternative~~the following areas of the Upper Klamath Basin: Wood, Williamson, and Sprague Rivers, Upper Klamath Lake, and Link River to the upstream end of J.C. Boyle Reservoir. KBRA implementation would have some effects on water temperature in these areas, which are discussed in the subsection of Section 3.2.4.3.2, Water Quality.

Water quality problems (e.g., excessive water temperatures and low dissolved oxygen) in the Keno Impoundment/Lake Ewauna during late spring, summer, and early autumn, led NOAA Fisheries Service and the DOI to prescribe interim trap-and-haul measures to transport primarily adult fall-run Chinook salmon past Keno Impoundment/Lake Ewauna during periods when conditions would be harmful to salmonids. Under the Proposed Action, interim, seasonal, upstream trap and haul for primarily fall-run adult Chinook salmon around the Keno Impoundment/Lake Ewauna would be necessary when dissolved oxygen and water temperature exceed the EPA criteria of 20 ^{o} C (typically during July through October), since migrating salmonids would have access to this reach of the Klamath River. As described for water temperature under the No Action/No Project Alternative (see subsection of Section 3.2.4.3.1, Water Quality, and Section 3.3.4.3.1.1.3, Aquatics), seasonal water temperature in the Upper Klamath Basin are expected to improve following full attainment of the Oregon TMDLs, potentially eliminating the need for trap and haul activities. However, TMDL-related improvements to water temperature in the upper basin would be partially offset by climate change.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam -Under the Proposed Action, the Klamath River would no longer be dominated by hydropower peaking events and flows in the former Hydroelectric Reach would more closely mimic the natural hydrograph.~~ The removal of the dams could also provide habitat for anadromous fish (Hetrick et al. 2009).~~

In the absence of the reservoirs, hydraulic residence time in this reach would likely decrease from several weeks to less than a day, and water quality would also be improved ~~by nutrient assimilation in this reach (Hamilton et al. 2011)~~(Hamilton et al. 2011). Removal of the Project reservoirs will result in a slight increase in flow as the evaporative losses would be reduced. Evaporation from the surface of the reservoirs ~~(~~is currently about 11,000 acre~~ feet [Reclamation 2011]) would be reduced, adding to the river flow~~-feet/year and after dam removal the evapotranspiration in the same reaches is expected to be approximately 4,800 acre-feet/year, resulting in a gain in flow to the Klamath River of approximately 6,200 acre-feet/year (Reclamation 2011). The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of

cooler water that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). Water quality conditions would also improve further downstream in the Hydroelectric Reach. From Copco 1 to Iron Gate Reservoir, removal of the Four Facilities would result in a 2-10°C decrease in water temperatures during the fall months and a 1-2.5^{o}C increase in water temperatures during spring months (PacifiCorp 2004a, Dunsmoor and

Huntington 2006, NCRWQCB 2010~~a~~, Perry et al. 2011; see also ~~Section 3.2.4.3.2.1), an increase dissolved oxygen concentrations (PacifiCorp 2004b, NCRWQCB 2010; see also Section 3.2.4.3.2.4), and eliminate reservoir habitat that creates ideal conditions for seasonal nuisance and/or noxious phytoplankton blooms (see Section 3.4, Algae).~~

subsection of Section 3.2.4.3.2). The effects of changes in temperature regimes within this reach will be similar to those discussed in detail below for the reach downstream from Iron Gate Dam.

Removing the dams would allow access to at least 49 tributaries upstream of Iron Gate Dam that could provide ~~420~~hundreds of miles of habitat for anadromous fish (DOI 2007), including groundwater-fed areas resistant to water temperature increases caused by changes in climate (Hamilton et al. 2011). In addition, the mainstem downstream ~~of~~from Iron Gate Dam would reflect natural temperature regimes (Hamilton et al. 2011). ~~An~~ The conversion of an additional 22~~.4~~ miles ~~of~~of reservoir habitat to riverine and riparian habitat would improve water quality by restoring the nutrient cycling and aeration processes provided by a natural channel. These improvements resulting from the Proposed Action would likely moderate the anticipated stream temperature increases resulting from climate change.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam The thermal lag formerly caused by water storage in reservoirs and the associated increased thermal mass would be eliminated in the ~~lower~~Lower Klamath River (subsection of Section 3.2.4.3.2). This elimination would cause water temperatures to ~~have natural diurnal variations and~~ become more in sync with historical migration and spawning periods for the Klamath River ~~Chinook salmon~~, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions (~~Stillwater Sciences 2009b;~~ Hamilton et al. 2011). ~~These~~

Under the Proposed Action, warmer springtime temperatures would result in fry emerging earlier (Sykes et al. 2009), encountering favorable temperatures for growth sooner than under existing conditions (Figure 3.3-18), which could support higher growth rates and encourage earlier emigration downstream, thereby reducing stress and disease (Bartholow et al. 2005; FERC 2007). A predicted earlier outmigration in response to elevated water temperatures in the spring is also supported by a vast body of literature relating to increased growth rates and thermal response of outmigrating salmonids (Hoar 1988). In addition, fall-run Chinook salmon spawning in the mainstem during fall would no longer be delayed (reducing prespawn mortality) (Figure 3.3-19), and adult migration would occur in more favorable water temperatures than under existing conditions (Figure 3.3-19). Overall, these changes would result in water ~~temperature~~ temperatures more favorable for salmonids in the mainstem~~.~~ Klamath River downstream from Iron Gate Dam.

The elimination of the thermal lag would also cause water temperatures to have natural diel variations (Figure 3.3-19) similar to what would have occurred historically in the Klamath River. This effect would be most pronounced downstream from Iron Gate Dam, would decline with distance downstream, and by the confluence of the Salmon River (RM 66) would exhibit no difference between the Proposed Action and existing conditions. The highest temperatures experienced by aquatic species would increase during summer (June through August), which could increase physiological stress, reduce growth rates, and increase susceptibility to disease during summer (Figure 3.3-19).

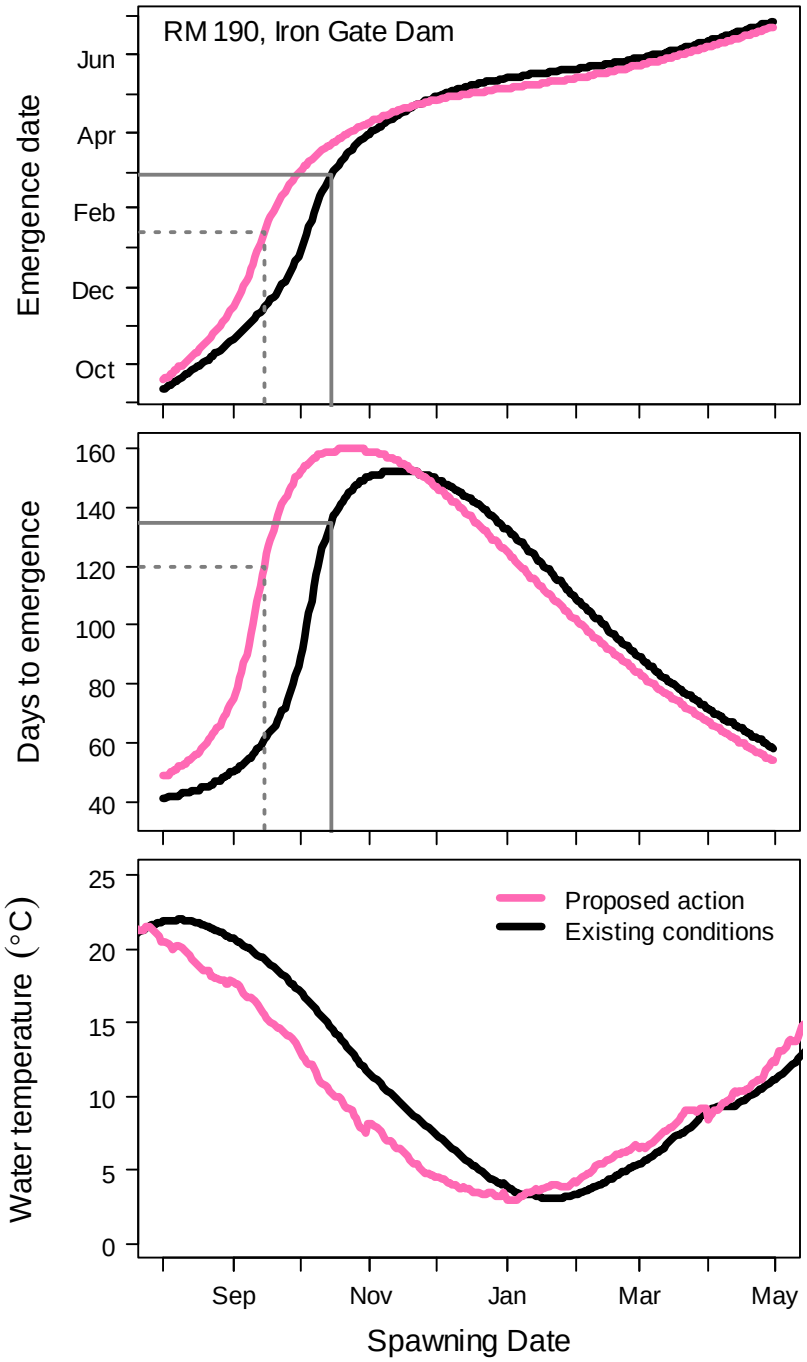


Figure 3.3-18. Time series of average daily mean water temperature (lower panel) forecasted at Iron Gate Dam (RM 190) for the Index Sequential climate scenario spanning years 2020 to 2061, for Proposed Action and Existing Conditions. Days to emergence (middle panel) and date of emergence (upper panel) for fall-run Chinook salmon was estimated as a function of spawning date assuming

that emergence would occur at 889 degree days after spawning. (Perry et al. 2011)

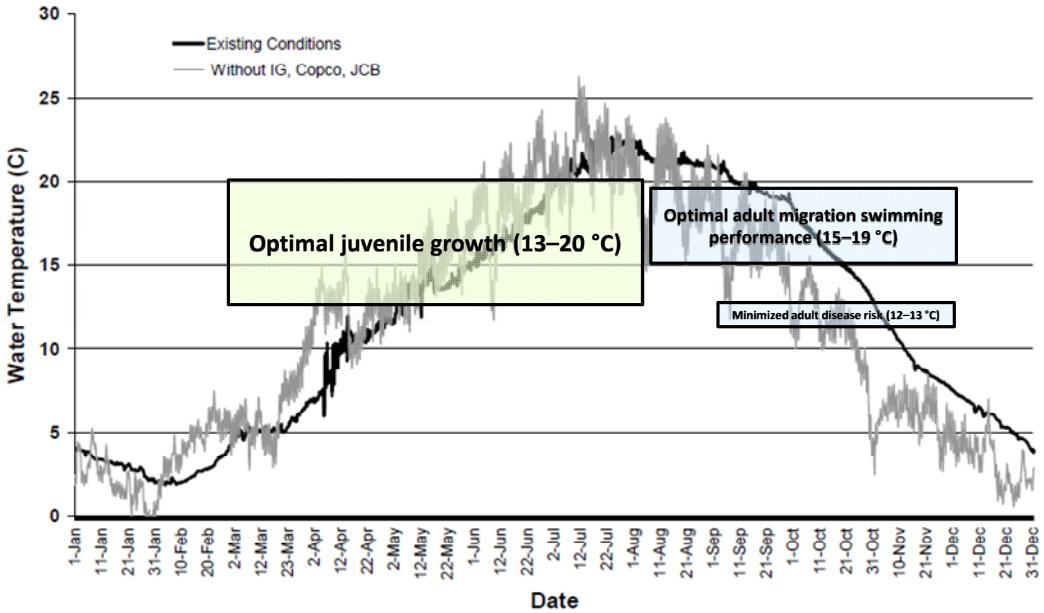


Figure 3.3-19. PacifiCorp (2005) Simulated hourly water temperatures below Iron Gate Dam based on a dry water year (WY 2002) for existing conditions compared to the Proposed Action (without Project dams), and USEPA (2003) water temperature criteria for salmonid growth and migration.

However, the FERC (2007) states that the increase in average and maximum daily temperatures may be compensated for by lower temperatures at night, which NRC (2004) concludes may allow rearing fish to move out of temperature refugia to forage at night, allowing growth to occur even when ambient day time temperatures are above optimal. Foott et al. (2012) observed positive growth and no overt effect of elevated temperature on immune function or fitness in Klamath River juvenile Chinook salmon held over a 23 day period under conditions in the laboratory that simulated fluctuating water temperature profiles similar to what would be observed in the Klamath River under the Proposed Action. Salmonids in the Klamath River have been observed to use cooler hours to migrate between thermal refugia (Belchik 2003), and the decrease in minimum temperatures during the spring, summer, and fall under the Proposed Action would be a benefit for fish (Figure 3.3-19). Increased nighttime cooling of water temperatures is important to salmonids in warm systems, providing regular thermal relief, time for repair of proteins damaged by thermal stress, and significant bioenergetic benefits that help fish persist under marginal conditions (Schrank et al. 2003, NRC 2004). In addition, Dunsmoor and Huntington (2006) suggest that lower nighttime temperatures with dam

removal would allow fish to leave thermal refugia in the Klamath River to forage and thereby allow more effective use of the available refugia habitat. Overall, the Proposed Action reductions in minimum daily temperatures below those under existing conditions would benefit salmonids in the Klamath River mainstem, helping them to tolerate the warmer periods of the year when dwelling in the mainstem, but also allowing feeding excursions when confined to refugia during the warmer times of the day.

Simulations of water temperatures without the reservoirs (as discussed in Hamilton et al. 2011) show that the temperature difference with and without dams would be greatest downstream ~~of~~ from Iron Gate Dam, but could extend an additional 120 ~~to~~to 130 miles downstream. Estimated decreases in stream temperature with dam removal relative to current conditions are likely to be smaller with continued climate change; however, temperature conditions would be much improved under the Proposed Action as compared to the No Action/No Project Alternative (See ~~Water Quality~~subsection of Section 3.2.4.3.2.~~1).~~ , Water Quality).

Klamath River Estuary and Pacific Ocean Nearshore Environment The influence of the Proposed Action would likely decrease with distance downstream ~~of~~from Iron Gate Dam (PacifiCorp 2004b), and it is unlikely that facility removal would have detectable effects on temperatures in the Klamath River Estuary and Pacific Ocean nearshore environment.

Fish Disease and Parasites

The Proposed Action would be expected to reduce impacts on ~~salmonids~~ salmon from fish disease. The ~~main factors contributing to parasitic fish~~ greatest disease ~~in the Klamath River include habitat (pools, eddies, and sediment); microhabitat characteristics (stable flows and low velocities); host proximity to spawning areas; and water temperatures greater than 15°C (Bartholomew and Foott 2010).~~

~~The removal of the Four Facilities would be likely to reduce habitat quality for the polychaete host by reducing reservoir habitat, and restoring seasonal flow patterns and sediment dynamics that reduce the stability of the host's favored habitats. The removal of Iron Gate Dam would also remove a major barrier to fish migration, reducing the concentration of adults that presently occurs downstream of the dam. Greater dispersal of spawning adult salmon would reduce their proximity to dense populations of polychaetes.~~

~~Daily water temperature ranges would be expected to be more variable under the Proposed Action than under existing conditions. Fish might avoid migrating during periods when temperatures are high, or smolts might begin to move downstream earlier in spring, thus reducing their risk of being infected.~~

~~Short-term increases in sediment below Iron Gate Dam during drawdown of the reservoirs could also reduce the population density of polychaetes (Bartholomew and Foott 2010). This effect might be limited, as not all populations would be affected, and recolonization could occur following drawdown. However, increased variability in flow management, and the restoration of a more natural sediment regime, would likely reduce~~

~~the suitability of habitat conditions for *M. speciosa*, the invertebrate host for~~ related mortality is due to *C. shasta* and *P. minibicornis* ~~and *C. shasta*. In some areas, increased mobilization of the substrate would help reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007).~~

in the Lower Klamath River downstream from Iron Gate Dam. Among all of the ~~salmonid~~ salmon lifestages, juvenile salmon tend to be most susceptible to *P.minibicornis* and *C. shasta*, particularly during their outmigration in the spring months (Beeman et al. 2008). ~~Infection rates are related in part to warm water temperatures~~ The main factors contributing to risk of infection by *C. shasta* and *P. minibicornis* include availability of habitat (pools, eddies, and sediment) for the polychaete intermediate host; microhabitat characteristics (static flows and low velocities); polychaete proximity to spawning areas; increased planktonic food sources from Project reservoirs; and water temperatures greater than 15°C (Bartholomew and Foott 2010).

The removal of Iron Gate Dam would reduce the concentration of adults that presently occurs downstream. Greater dispersal of spawning adult salmon would reduce their proximity to dense populations of polychaetes. FERC's analysis (FERC 2007) concluded that restoring access to reaches above Iron Gate Dam for anadromous fish would allow adult fall-run Chinook salmon to distribute over a greater length of the river, reducing crowding and the concentration of disease pathogens that currently occur in the reach between Iron Gate Dam and the Shasta River. In addition, Bartholomew and Foott (2010) suggested that with dam removal it is likely that a greater diversity of salmon life histories will evolve, with some of those types more likely to avoid parasite exposure by migrating earlier or over wintering in tributaries and migrating in the fall. Although their research was focused on dam removal, the same effects are anticipated for this alternative. FERC (FERC 2007) concluded that restoring natural sediment transport processes would likely contribute to the scour of periphyton (attached algae) downstream from the current site of Iron Gate Dam, and deposited gravel and sand would provide a less favorable substrate for periphyton because of its greater mobility during high flow events than the existing armored substrate (see also the subsection of Section 3.4.4.3.2, Periphyton). The reduction in periphyton would provide less favorable habitat for the polychaete intermediate host of *C. shasta* and *P. minibicornis*, which should reduce the infection rate of juvenile salmonids downstream from Iron Gate Dam (FERC 2007).

Under the Proposed Action, sediment bedload transport rates would increase downstream from the current location of Iron Gate Dam which includes habitats with large populations of polychaetes. Actinospores released from this portion of the Klamath River pass downstream and infect juvenile salmon in the current infectious zone downstream from the Shasta River to Seiad (RM 130) (Bartholomew and Foott 2010). In addition, while the area of significant bedload deposition under the Proposed Action is located upstream of Cottonwood Creek, sediment transport rates will also increase downstream from Cottonwood Creek (Appendix F). This increased movement and transport of sediment (sand, silt, and clay) is anticipated to disrupt polychaete habitat from the current location of Iron Gate Dam to downstream from Shasta River.

The net result of these effects would also depend on temperature. Dam removal would mean cooler temperatures in the late summer and fall, but slightly warmer temperatures during spring and early summer. FERC (2007) concluded that dam removal would enhance water quality and reduce the cumulative water quality and habitat effects that contribute to disease-induced salmon die-offs in the Klamath River downstream from Iron Gate Dam. In turn, this would benefit salmon outmigrants from tributaries downstream from Iron Gate Dam, such as the Shasta and Scott rivers. While Bartholomew and Foott (2010) stated that the effect of cooler temperatures in the early fall on the intermediate host or *C. shasta* is unknown, they also stated that a reduction in temperature could have the result of reducing polychaete reproductive rates (Bartholomew and Foott 2010). Reduced disease in the mainstem is anticipated to increase the likelihood that benefits to outmigrating smolts from restoration in the Shasta and Scott rivers are realized. In addition, with dam removal it is likely that a greater diversity of salmon life histories will evolve, with some of those types more likely to avoid parasite exposure by migrating earlier or over wintering in tributaries and migrating in the fall (Bartholomew and Foott 2010).

The net result of these effects would also depend on smolt behavior. FERC (2007) concluded that more rapid cooling of river temperatures in the fall with the project dams removed may also allow for fall Chinook salmon spawning to occur earlier in the fall. Bartholow et al. (2005) and FERC (2007) also both suggest that earlier warming of the river system could trigger juvenile salmonids to out migrate earlier, This is consistent with findings that accumulated temperature units are more important predictors of migration of juvenile Chinook salmon than flow or photoperiod (Sykes et al. 2009). A predicted earlier outmigration in response to elevated water temperatures in the spring is also supported by a vast body of literature relating to increased growth rates and thermal response of emigrating salmonids (Hoar 1988). This, in turn, would likely result in earlier emergence and growth, and encourage earlier emigration. In addition, a slight increase in the rate at which water temperatures increase in the spring would be likely to improve the growth rates of newly emerged fall Chinook salmon fry (FERC 2007). Earlier emigration and improved growth would likely mean most outmigrants would avoid periods of high disease infection of juvenile salmon.

Flows also play an important role in the regulation of disease in the Klamath River. If flows increase during spring, juvenile migration time could be decreased, potentially resulting in reduced disease exposure, especially for fish originating from ~~lower Klamath River tributaries. The net result of these effects would also depend on temperature and smolt behavior.~~ Lower Klamath River tributaries. The Proposed Action would create a flow regime that more closely mimics natural conditions in the Lower Klamath River by increasing spring flow and by incorporating more variability in daily flows (Hetrick et al. 2009). Implementation of the KBRA will provide flexibility to manage flows that respond to real-time climatic and biological conditions. This would allow for management of out migration flows, as well as enhancing the diversity in flow and water temperature. Restoring these dynamic conditions in the Klamath River will create instability and disturbance in microhabitat conditions that are expected to reduce polychaete populations (Stocking and Bartholomew 2007) and presumably, reduce

infection rates within polychaete populations (Hetrick et al. 2009). The removal of the Four Facilities would also be likely to reduce habitat quality for the polychaete host by reducing reservoir water quality effects and reducing planktonic food sources (Hetrick et al. 2009; Hamilton et al. 2011).

Periphytic algae would also play a role in disease in the Klamath River. Under the Proposed Action additional periphytic growth including *Cladophora* is anticipated within the Hydroelectric Reach, following the initial drawdown period, which could provide habitat for the intermediate host of *C. shasta*. Additional periphytic growth would be a direct result of the conversion of the lacustrine environment in the reservoirs, which fosters growth of phytoplankton algae, to a flowing, riverine habitat that fosters growth of attached aquatic vegetation (including both periphyton and macrophytes), in combination with already ample nutrient concentrations. In the absence of other factors, this could possibly increase the prevalence of the intermediate host for *C. shasta*. However, dam removal would also create other conditions that tend to offset the growth of aquatic vegetation. These conditions include a restoration of bedload sediment transport, a more mobile river bed, increased high flows during spring, more variable flows, and a more normal (and variable) temperature regime with substantially cooler fall water temperatures. FERC (2007) concluded that restoring natural sediment transport processes would likely contribute to the scour of attached vegetation in the Klamath River. Finally, under KBRA, progress toward achievement of TMDL targets, including the reduction of nutrients, would be accelerated compared to existing conditions and would eventually help control growth of periphyton or macrophytes.

There remains some uncertainty of the contribution of nutrients in increasing habitat for the intermediate host for *C. shasta*, the conditions that would offset the growth of aquatic vegetation, and the longitudinal gradations of these conditions. Given the already high concentrations of nutrients, increases in biomass of attached aquatic vegetation would be more attributable to the new habitat area than changes in nutrient concentrations. However, the net long-term effect of the Proposed Action is anticipated to be a slight- to moderate decrease in Cladophora and aquatic vegetation as a result of disruption by the flow and bedload conditions listed above and, ultimately, reductions in nutrients resulting from the TMDLs or other nutrient management techniques in the Upper Klamath Basin. A decrease in Cladophora and aquatic vegetation would likely decrease habitat for the intermediate host which would reduce the incidence of *C. shasta*. This effect is likely to be reach dependent, with in aquatic vegetation possible in the Hydroelectric Reach. Nevertheless, increased dispersal of spawners and carcasses, transport of bedload, and establishment of variable flows, would likely reduce the severity of exposure to the infection to levels below critical thresholds (Bartholomew and Foott 2010), even if infection itself is not eliminated.

Removal of the Four Facilities would allow anadromous ~~salmonid migration upstream in the mainstem Klamath River and tributaries. Movement of adult salmon into the Upper Klamath Basin would result in introduction of new parasite genotypes that were previously restricted~~ to ~~the lower river (e.g., Chinook salmon migrating~~ move upstream ~~could introduce the Type I genotype to~~ in the mainstem Klamath River and tributaries. However, evidence indicates that fish passage would not

increase the risk of disease for resident species that occur upstream ~~areas~~of Iron Gate Dam (Administrative Law Judge 2006). *C. shasta and P. minibicornis* exist throughout the Klamath River System in both the Upper and Lower Basins, so migration of wild anadromous fish upstream of downstream from Iron Gate Dam would not increase the risk of introducing pathogens to resident trout residing above Iron Gate Dam (Administrative Law Judge 2006). In addition, native Klamath River trout are generally resistant to *C. shasta*. The remaining known pathogens do not impact non-salmonids, with the exception of *F. columnaris* and *Ich*.

Available information also indicates that risks associated with dam removal to anadromous fish upstream of Iron Gate Dam are minimal. For example, steelhead within the Klamath River system are generally resistant to *C. shasta*, (Administrative Law Judge 2006). Since salmon and associated disease pathogens were present historically above Iron Gate Dam, C. shasta genotype movement would be a reintroduction of associated risk to these anadromous species.

While it is possible that the current infectious nidus (breeding place) for C. shasta and P. minibicornis may move upstream where ~~it does not presently~~salmon spawning congregations occur~~). Some degree of~~, the likelihood of this happening has uncertainty associated with it. However, any creation of an infectious zone (or zones) would be the result of the synergistic effect of numerous factors, such as those that occur within the current disease zone in the reach from the Shasta River downstream to Seiad Valley (factors noted by FERC (2007) and others). Reestablishment of a more natural flow and sediment transport rates to the river downstream from the current location of Iron Gate Dam would develop natural geomorphic channel forming processes to the river (Hetrick et al. 2009) which would make this synergy unlikely. The conditions that contribute to a current infectious nidus below IGD or would contribute to the same zone above IGD would not exist with dam removal.

In the Williamson River there is currently an infectious area due to the continual introduction of non-resistant rainbow trout that become infected and die within a reasonably small reach of the river. However, reintroduced salmon that would become infected are likely to migrate through this reach; dispersing spores over a greater area and more of these spores will be lost to the system, resulting in low spore concentrations.

Recently several new *C. shasta* genotypes have been discovered in the Klamath River. In this regard, risk is related to host specificity, which appears to exist at least to some degree (Atkinson and Bartholomew 2010~~), indicating that newly exposed species, such as redband trout, would not likely be susceptible to the new genotypes of *C. shasta* introduced into the upper watershed.~~). As an example, redband trout are thought to be susceptible to Type 0, which already occurs in the upstream ~~basin~~ Basin and Chinook salmon are susceptible to Type I, which occurs in the ~~lower basin. But~~ Lower Klamath Basin. Type 0 genotype occurs in low densities and it is not very virulent (infection results in low or no mortality); if Type I genotype were to ~~move~~ be reintroduced above Iron Gate Dam, it would affect only Chinook salmon~~.~~. It is not expected that introduction of *C. shasta* genotypes upstream would be deleterious because fish in the upstream ~~basin~~Basin have

shown resistance to the downstream genotypes~~. Prior to the installation of Copco 1 Dam in 1918, Chinook salmon are known to have accessed the upper watershed, including tributaries to Upper Klamath Lake.~~ . Redband trout would presumably have been exposed to genotypes of *C. shasta* ~~at that time~~during the pre-dam period, and their populations were abundant~~.~~ . Because the salmonid species in the Klamath Basin already co-occur with the genotype of *C. shasta* to which they are susceptible, and the salmonid species are less susceptible to other genotypes of *C. shasta*, expanding the distribution of the different genotypes of *C. shasta* would be unlikely to be deleterious to salmonids~~. New~~. Recently discovered *C. shasta* genotypes and research findings in the past ~~five~~several years do not appear to contradict the finding that movement of anadromous salmonids into the Upper Klamath Basin presents a relatively low risk of introducing pathogens to resident fish (Administrative Law Judge 2006, USFWS/NOAA Fisheries Service Issue 2(B)).

In addition, a Chinook Salmon Expert Panel convened to attempt to answer specific questions formulated by the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011), concluded that the Proposed Action offers greater potential than the current conditions in reducing disease-related mortality in Klamath River Chinook salmon.

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir This region is upstream of any proposed dam removal; therefore, removal of the reservoirs at the Four Facilities under the Proposed Action would not affect fish health as related to algal toxins. Any changes in algal toxin production in this region would be a result of other factors, including TMDL implementation. The effects in this area would be similar to those described for the No Action/No Project Alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Removal of the reservoirs at the Four Facilities under the Proposed Action would eliminate growth conditions for toxin-producing nuisance algal species such as *M*~~.~~ . *aeruginosa* in the Hydroelectric Reach, alleviating high seasonal concentrations of algal toxins and associated bioaccumulation of microcystin in fish tissue for species in this reach. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Hydroelectric Reach and would be beneficial.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam Removal of the reservoirs at the Four Facilities under the Proposed Action would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*, alleviating the transport of high seasonal concentrations of algal toxins to the Klamath River downstream ~~of~~ from Iron Gate Dam. This would also decrease the associated bioaccumulation of microcystin in fish tissue for species downstream ~~of~~ from the dam. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due

to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Klamath River downstream ~~of~~from Iron Gate Dam and would be beneficial.

Aquatic Habitat

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

Under the Proposed Action access would be restored to an estimated 360 miles of potential anadromous fish habitat upstream of Upper Klamath Lake and Keno Impoundment/Lake Ewauna (Huntington 2006; DOI 2007; NOAA 2007). However, in their analysis the FERC (2007) excluded this 360 miles of anadromous fish habitat based upon poor water quality conditions in these water bodies during summer months. The Chinook Expert Panel (Goodman et al. 2011) also concluded that substantial gains in Chinook salmon abundance for areas upstream Keno Impoundment/ Lake Ewauna would be contingent upon successfully resolving limitations associated with poor water quality problems in Upper Klamath Lake and Keno Impoundment/ Lake Ewauna. The Coho Steelhead Expert Panel (Dunne et al. 2011) stated that poor water quality in Keno Impoundment/ Lake Ewauna and in Upper Klamath Lake, and the possibility of difficult passage at Keno Dam, could impede steelhead from reaching improved habitat upstream of the Project Reach.

These concerns for Chinook salmon and steelhead migration and spawning overstate the seasonal habitat limitations of Keno Impoundment/ Lake Ewauna and Upper Klamath Lake for two main reasons. First, a recent study examined the response of salmon to Upper Klamath Lake under existing conditions. Iron Gate Hatchery Chinook salmon were tested in the lake and the lower Williamson River to assess whether current conditions would physiologically impair salmon reintroduced into the Upper Klamath Basin. Juvenile Chinook salmon were tested in cages in 2005 and 2006. These juveniles showed normal development as smolts in Upper Klamath Lake and survived well in both locations (Maule et al. 2009). This study strongly suggests that Upper Klamath Lake habitat is suitable to support salmonids for at least the October through May period. Maule et al. (2009) concluded that there was little evidence of physiological impairment or significant vulnerability to *C. shasta* that would preclude this stock from being reintroduced into the Upper Klamath Basin. In addition, the life history of type I fall-run Chinook salmon generally does not include a freshwater phase from June through September. Thus, conditions for juvenile fall-run Chinook emigration through Upper Klamath Lake appear favorable. Due to the timing of the migration period for spring-run Chinook salmon and steelhead, these runs would generally avoid the period of poor water quality in Upper Klamath Lake. Cool groundwater spring inputs in the Williamson River and on the west side of Upper Klamath Lake would likely provide thermal refugia for the year-round life-histories of spring-run Chinook salmon and steelhead. Under a scenario of potential dam removal, Bartholomew and Foott (2010) noted that it is likely that a greater diversity of salmon life histories will evolve, with some of those types more likely to avoid parasite exposure by migrating earlier or over wintering in tributaries and migrating in the fall. These life histories would also likely be able to avoid periods of poor water quality.

Second, water quality issues in Keno Impoundment/Lake Ewauna and Upper Klamath Lake are not year round. Both DOI and NOAA Fisheries Service have long recognized the issue of seasonally poor water quality in Keno Impoundment/ Lake Ewauna. When water quality is poor, which occurs seasonally between June 15 and November 15, both DOI and NOAA Fisheries Service prescribed the transfer of primarily adult Chinook salmon upstream of the Keno between June 15 and November 15 for the purposes of restoration and the safe, effective, and timely passage (DOI 2007; NOAA 2007). In the Klamath Facilities Removal Draft EIS/EIR, accommodation for related short distance, seasonal trap and haul facilities is made under all of the action alternatives other than the No Action/No Project Alternative analyzed below. Migrants of other species, if present, would be transported as well. Thus, under the action alternatives other than No Action/No Project Alternative, all anadromous species and life histories would be able to migrate to and from habitat upstream of Upper Klamath Lake, realize associated benefits provided by these habitats, and complete their life cycles.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the Proposed Action, short-term effects would include the release of water stored in the Four Facilities. Based on modeling results, this release is expected to last about 4 months, from January 1 into April 2020, but could vary depending on hydrologic conditions (Reclamation ~~2011~~2012), increasing flows downstream ~~of~~ from the dams during the drawdown period. River flows would be expected to remain below the 10-year flood event of 11,000 cfs. Flows would increase not only in the bypass reaches, but also all other mainstem reaches due to changes in operations and the absence of reservoir evaporation. Hydrology in the J.C. Boyle Peaking Reach would follow the natural hydrograph more closely, including increased duration and magnitude of high flows, and cessation of daily extreme flow fluctuations (characteristic of hydroelectric peaking operations). Seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle Bypass Reach by increasing the sediment deposit within the channel and decreasing reed canary grass (Administrative Law Judge 2006). The more normative flow regime associated with this alternative would provide these seasonal high flows.

These flow increases would provide more habitat than under existing conditions for redband/rainbow trout and other resident riverine species, as well as anadromous fish or lamprey that reestablish in this area. These flows are expected to meet channel maintenance needs to route coarse sediments, build bars, erode banks, flush fine sediments, scour vegetation and undercut and topple large woody riparian vegetation NRC 2008). The removal of project dams would reestablish geomorphic and vegetative processes that form channels that provide fish habitat and spawning gravels in this reach, especially in the former bypassed reaches (FERC 2007). In addition, the impacts associated with daily extreme flow fluctuations resulting from peaking operations, such as stranding, displacement, reduced food production, and increased stress, would no longer occur. The removal of the Four Facilities would eliminate existing habitat for adult shortnose and Lost River suckers, as well as nonnative species occupying the reservoirs. The few shortnose and Lost River suckers that have been observed in these reservoirs are believed to be fish that have moved down from the upstream areas, but are

not thought to represent a viable, self-supporting population (Buettner et al. 2006). The Proposed Action would restore 22~~.4~~ miles of riverine habitat (Cunanan 2009) for resident and anadromous fish through removal of reservoirs. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009).

Overall, because the Proposed Action would result in flows more favorable to all life stages, eliminate peaking operations, and remove barriers that have isolated populations~~,~~; the Proposed Action would result in benefits to salmonid populations and their habitat.~~—~~

Following drawdown of the reservoirs, revegetation efforts would be initiated to support establishment of native wetland and riparian species on newly exposed reservoir sediment. No short-term effects are anticipated from these reservoir restoration efforts, and in the long-term aquatic habitat may be improved from restored riparian vegetation.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam As described above, the Proposed Action would result in elevated flows for about 4 months once drawdown begins, but the flows would be expected to remain below the 5-year flood event. These elevated flow rates could have the beneficial effect of maintaining unsuitable habitat conditions for introduced species in the river downstream ~~of~~from Iron Gate Dam. These increased flows could result in faster transport of outmigrant fish and slower upstream migration of adult fish in the Klamath River during this time.

Over the long term, the Proposed Action would alter the hydrograph so that the duration, timing, and magnitude of flows would be more similar to the unregulated conditions under which the native fish community evolved (Hetrick et al. 2009). While mean annual flows would not substantially change from existing flows due to the lack of active reservoir storage (Stillwater Sciences 2009b; ~~Greimann et al. 2010~~Reclamation 2012), flow variability would increase.

The Proposed Action would substantially decrease the transit time of water in the Hydroelectric Reach, because it would no longer be detained by the reservoirs, resulting in a shift in the timing of the minimum flows (Balance Hydrologics Inc. 1996; NRC 2004, Fig. 4-2, p. 148, ~~accessible at~~ http://www.nap.edu/openbook.php?record_id=10838&page=144). These hydrologic effects would likely be more important in upstream areas (directly downstream ~~of~~from Iron Gate Dam) than downstream areas (~~below~~downstream from the confluence of the Scott River) due to the substantial flow contribution of tributaries to the Klamath River (Reclamation ~~2011~~2012, Hydrologic modeling, Appendix E). In addition, these hydraulic changes would result in changes to water quality, water temperatures, sediment transport, and riparian habitat, as described in subsequent sections.

Klamath River Estuary and Pacific Ocean Nearshore Environment Modeling results indicate that because of the influence of the tributaries entering the Klamath River downstream ~~of~~from Iron Gate Dam, the flow changes for the Proposed Action would not substantially affect the flows entering the estuary. Section 3.6, Flood Hydrology,

provides further information on this effect. Therefore, the Proposed Action would not affect flow-related fisheries habitat in the estuary or the Pacific Ocean.

Aquatic Resources Effects

Critical Habitat

As described below, ~~lowering the water surface elevation of the reservoirs~~ reservoir drawdown associated with dam removal under the Proposed Action could alter the quality of critical habitat. In addition, the removal of dams and reservoirs could alter the availability and quality of critical habitat.

Coho Salmon Elevated levels of SSCs occurring during 3 to 4 months of drawdown would degrade critical habitat for coho salmon. Bedload movement following dam removal would ~~cause substantial aggradation and~~ increase supply of gravel ~~below~~ downstream from the dam as far downstream as Cottonwood Creek. This effect would potentially improve critical habitat for coho salmon by reducing median substrate to a size more favorable for spawning (Reclamation ~~2011).~~

2012).

The Proposed Action would increase the amount of habitat available to coho salmon upstream of currently designated critical habitat and improve water quality in the mainstem Klamath River within current critical habitat. NOAA Fisheries Service may consider whether to designate the newly available habitat as critical habitat as part of its 5-year status review or as a separate reconsideration of the critical habitat designation for the species (J. Simondet, NOAA Fisheries Service, pers. comm., 2011). ~~Removal of the Four Facilities would allow~~The Proposed Action would restore access for upper Klamath River Population coho salmon ~~access~~ to ~~at least 68 miles of additional~~the Hydroelectric Reach, expanding their distribution to include historical habitat ~~and possibly up to as much as 82 miles (Administrative Law Judge 2006), including approximately 38 miles in~~ along the mainstem ~~and at least 30 miles in~~Klamath River and all tributaries ~~such as Fall,~~ upstream at least as far as Spencer Creek; including in Jenny, Shovel, and ~~Spencer~~Fall Creeks~~, and others. These tributaries are thought to provide~~ (Hamilton et al. 2005), including around 76 miles of potential habitat ~~suitable for coho salmon.~~within the Hydroelectric Reach, In addition, coho salmon could find suitable temperatures for holding in pockets within the J.C. Boyle Bypass Reach, although the average and maximum temperatures in this reach are expected to exceed optimal temperatures for coho salmon. Access to this habitat would increase the availability of spawning sites, result in additional food resources, and provide access to areas of better water quality. Water quality conditions would also improve within the mainstem downstream ~~of~~from the J.C. Boyle Powerhouse. ~~Removal of~~ As discussed in detail above, the thermal lag formerly caused by water storage in reservoirs and the ~~Four Facilities would result in lower~~ associated increased thermal mass would be eliminated in the Lower Klamath River. This elimination would cause water temperatures ~~during the fall months, but would increase~~ to have more natural diel variation, and would become more in sync with historical migration and spawning periods for Klamath River. Overall, these changes would result in water ~~temperatures slightly~~temperature more favorable for salmonids in

the ~~spring months,~~ mainstem. Removal of the Four Facilities would also increase dissolved oxygen concentrations, and eliminate reservoir habitat that creates the conditions necessary for the growth of blue green algae and other phytoplankton. These changes would be beneficial for coho salmon critical habitat. **Based on reductions in habitat quality during reservoir drawdowns that would be detrimental to PCEs, the Proposed Action would have a significant effect on coho salmon critical habitat in the short term. Based on benefits to the PCEs, the Proposed Action would have a beneficial effect on critical habitat for coho salmon in the long term.**

Bull Trout Based on the restricted distribution of bull trout, implementation of the Proposed Action would not affect the physical or chemical components of critical habitat. However, the Proposed Action would allow Chinook salmon and steelhead to access areas they have not been able to access since the completion of the Copco 1 Development in 1918. These species would potentially compete with and prey upon bull trout fry and juveniles; however, bull trout would also be expected to consume the eggs and fry of Chinook salmon and steelhead. These species co-evolved in the watershed together, and it is anticipated that they would be able to co-exist in the future. **The Proposed Action would have a less-than-significant impact on critical habitat for bull trout in the short and long term.**

Southern Resident Killer Whale The Klamath River contributes to critical habitat for Southern Resident Killer Whales through its contribution of Chinook salmon to their food supply. The Proposed Action would not affect the geographic extent of critical habitat for this species, as it is located in the ~~state~~State of Washington. The Proposed Action is expected to increase wild populations of anadromous salmonids, which could increase food supply for Southern Resident Killer Whales. In a compilation of potential adult production from habitats upstream of Iron Gate Dam, estimates ranged from 9,180 to 21,245 (Hamilton et al. 2011). Klamath River salmon are anticipated to provide less than 1 percent of the diet of Southern Resident Killer Whales in most months. The Proposed Action would not be likely to materially affect the food supply of Southern Resident Killer Whales. **Based on small influence of the Klamath River on PCEs of Southern Resident Killer Whale, the Proposed Action would have a less-than-significant impact on critical habitat for Southern Resident Killer Whales in the short and long term.**

Eulachon Under the Proposed Action, PCEs of critical habitat supporting eulachon would be degraded in the short term, including short-term adverse effects of suspended sediment on spawning and egg incubation habitat, and adult and larval migration habitat for southern DPS eulachon. Under the Proposed Action it is anticipated that water quality will improve throughout the Klamath River, including the estuary (WQST 2011) and that habitat restoration effort under KBRA will improve estuary habitat. Critical habitat for the Southern DPS eulachon includes approximately 539 miles of riverine and estuarine habitat in California, Oregon, and Washington, of which the Klamath River Estuary is a small proportion (<2%). **Although the Proposed Action would result in short-term reductions in habitat quality detrimental to PCEs, a very small**

proportion (< 2%) of eulachon critical habitat would be effected for a short duration, and the Proposed Action would have a less-than significant effect on

eulachon critical habitat in the short term. Based on benefits to the PCEs, the Proposed Action would have a beneficial effect on critical habitat for eulachon in the long term.

Essential Fish Habitat

As described below, ~~lowering the water surface elevation of the reservoirs~~ reservoir drawdown associated with dam removal under the Proposed Action could alter the quality of ~~Essential Fish Habitat (~~EFH~~)~~. In addition, the removal of dams and reservoirs could alter the availability and quality of EFH.

Chinook and Coho Salmon EFH The short-term release of sediment from the dams under the Proposed Action would be detrimental to Chinook and coho salmon EFH during the months when SSC concentrations are elevated. In the long term, the Proposed Action would increase habitat for Chinook and coho salmon (upstream of currently designated EFH) by providing access to habitats upstream of Iron Gate Dam. EFH quality would be affected by improved water quality, and decreased prevalence of disease, as described above for coho salmon critical habitat. Improved access to habitats (upstream of designated EFH), improved water quality, increased sediment transport, and decreased prevalence of disease, would provide a benefit to EFH for Chinook and coho salmon. **Based on a substantial reduction in EFH quality during reservoir drawdown, the Proposed Action would have a significant effect on EFH for Chinook and coho salmon in the short term. Based on benefits to quality, the Proposed Action would have a beneficial effect on EFH for Chinook and coho salmon in the long term.**

Groundfish EFH ~~Under the Proposed Action,~~ EFH for Pacific Coast groundfish includes all waters and substrate within areas with a depth less than or equal to 3,500 m (1,914 fm) shoreward to the mean higher high water level or the upriver extent of saltwater intrusion. Under the Proposed Action, impacts to the nearshore environment are not anticipated to be distinguishable from existing conditions, based on a relatively small magnitude of SSCs released to the nearshore environment, an anticipated rapid dilution of the sediment plume as it expands in the ~~estuary~~ ocean, and a relatively low rate of deposition of sediments to the marine nearshore bottom substrates (subsection of Section 3.3.4.3.2). EFH in the Klamath River Estuary could be affected by elevated ~~turbidity~~suspended sediment from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream ~~of~~ from Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see ubsection of Section 3.~~2.~~3.4.3.2~~.2).~~). However, the area of EFH for groundfish affected by the Proposed Action within the Klamath River Estuary is a very small proportion (<1%) of the total EFH designated for groundfish along the Pacific Coast.

In the long term, SSCs would be similar to that under existing conditions. Natural bedload transport processes would resume, as the dams would no longer trap sediments upstream of Iron Gate Dam. Bedload in the estuary and ocean would not be appreciably affected, because of the small contribution of the area above Iron Gate Dam to the total bedload in the system. With the exception of algal toxins, water quality benefits resulting from dam removal would largely have dissipated upstream of the estuary, and therefore, water quality in the estuary would be expected to remain similar to existing conditions. **Based on small proportion of groundfish EFH affected, and short duration of poor water quality during reservoir drawdown in the ~~estuary, the Proposed Action would have a less-than-significant effect on EFH for groundfish in the short and long term.~~**

~~**Pelagic Fish EFH** The effects of the Proposed Action on pelagic fish EFH would be the same as those described for groundfish EFH, with substantial short-term increases in SSCs. These increases would subside after about 3 months. After this time SSCs would be expected to be similar to those under existing conditions. **Based on short duration of poor water quality during reservoir drawdown in the** ~~**near-shore environment and estuary, the Proposed Action would have a less-than-significant effect on EFH for ~~pelagic~~ ground~~**fish in the short and long term.**

~~Species-Specific Impacts~~

Pelagic Fish EFH EFH for coastal pelagic species occurs from the shorelines of California, Oregon, and Washington westward to the exclusive economic zone and above the thermocline where sea surface temperatures range from 10 to 26 ºC. The effects of the Proposed Action on pelagic fish EFH would be the same as those described for groundfish EFH in the estuary and near-shore environment. As described ~~*below, lowering the water surface elevation of the reservoirs*~~for groundfish, the area for EFH for pelagic fish affected by the Proposed Action within the Klamath River Estuary and near-shore environment is a very small proportion proportion (<1%) of the total EFH designated for pelagic species along the Pacific Coast. **Based on small proportion of Pelagic fish EFH affected, and short duration of poor water quality during reservoir drawdown in the near-shore environment and estuary, the Proposed Action would have a less-than-significant effect on EFH for pelagic fish EFH in the short and long term.**

Species-Specific Impacts

As described below, reservoir drawdown associated with dam removal under the Proposed Action could affect aquatic species. In addition, the removal of dams and reservoirs could alter the availability and quality of habitat, resulting in effects on aquatic species.

Species-specific impacts are based upon effects on key ecological attributes summarized above.

Fall-Run Chinook Salmon ~~To help determine if the Proposed Action will advance restoration of the salmonid fisheries of the Klamath Basin, a Chinook Salmon Expert Panel was convened to attempt to answer specific questions that had been formulated by~~

~~the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011). The Panel concluded that the Proposed Action appears to be a major step forward in conserving target fish populations in the Klamath Basin. The Panel predicted that, based on the information provided to them, it was possible that the Proposed Action would provide a substantial increase in the abundance of naturally spawned Klamath River Chinook salmon above that expected under existing conditions in the reach between Iron Gate Dam and Keno Dam. While the Panel agreed that there was also evidence for dramatic increases in abundance associated with the Proposed Action upstream of Keno Dam, they cautioned that achieving substantial gains in Chinook salmon abundance and distribution in the Klamath Basin is contingent upon successfully resolving key factors (discussed in this report in detail) that will continue to affect population, such as water quality, disease, and instream flows. In addition, they stated the concern that successful implementation of KBRA would be required, and would need appropriate scientific leadership.~~ Quantitative modeling of fall-run Chinook salmon populations ~~further substantiates the conclusions of the Expert Panel~~suggests that the Proposed Action would increase population abundance. Modeling ~~under both the Proposed Action and existing conditions~~of dam removal and existing conditions by Oosterhout (2005) suggests that dam removal would substantially increase numbers of spawners over a 50-year period ~~(Oosterhout 2005)~~relative to other management scenarios. Additional ~~production~~ population capacity and modeling efforts support this conclusion (Huntington 2006, Dunsmoor and Huntington 2006, Hendrix 2011, Lindley and Davis 2011). Of these, the Hendrix (2011) approach is considered the most intensive and robust conducted to date, because it addressed the Proposed Action, used stock-recruitment data from the Klamath River; explicitly incorporated variability in watershed, ~~climate,~~ and ocean conditions; and presented variance estimates of uncertainty. ~~Nobel~~ Hendrix (2011) applied a life-cycle model (EDRRA) to forecast the abundance of Chinook salmon (~~fall-run and spring-run combined~~Type I and Type II life history strategies) for both the Proposed Action and continuation of existing conditions (No Action/No Project Alternative) for the years 2012 to 2061. The EDRRA model includes hatchery releases of Chinook salmon from both Iron Gate and Trinity River hatcheries. All returning hatchery origin Chinook salmon are assumed to return to the hatchery and therefore, do not contribute to naturally spawning populations. Production benefits of Chinook salmon releases from Iron Gate hatchery are assumed to end in 2032, four years following the anticipated end of current mitigation releases (Trinity River Hatchery releases will continue). In addition, the model assumes reintroduction efforts described in the KBRA would fully seed available fry habitats upstream of Iron Gate Dam, including the Upper Klamath Basin upstream of Upper Klamath Lake prior to dam removal. The EDRRA model was not developed to be tributary specific; thus Chinook salmon populations originating from tributary streams cannot be separated from the mainstem, the Upper Klamath Basin or other tributaries.

The EDRRA Chinook salmon life cycle model developed by Hendrix (2011) addressed fisheries management of Klamath River Chinook salmon. The Pacific Fishery Management Council (PFMC) was established by the Magnuson Fishery Conservation and Management Act of 1976 and has regulatory jurisdiction over salmon fishing within

the 317,690 square mile exclusive economic zone from 3 miles to 200 miles off the coast of Washington, Oregon and California. Jurisdiction over commercial and recreational salmon fishing regulations in nearshore areas, within 3 miles of shore, lies with the respective states. However, the states generally adopt regulations consistent with those established by the PFMC. The Salmon Fishery Management Plan developed by the PFMC describes the goals and methods for salmon management. Management tools such as season length, quotas, and bag limits vary depending on how many salmon are present. There are two central parts of the Plan: Conservation objectives, which are annual goals for the number of spawners of the major salmon stocks ("spawner escapement goals"), and allocation provisions of the harvest among different groups of fishers (commercial, recreational, tribal, various ports, ocean, and inland). The PFMC must also comply with laws such as the ESA. Since the management of salmon considers many factors that can fluctuate greatly from year to year (population abundance and environmental conditions) it is impossible to predict how future management decisions regarding the specific harvest of Klamath Basin salmon might change as a result of the Proposed Action.

Given these uncertainties in management, the EDRRA Chinook salmon life cycle model assumes that current management rules (fishery control rule) established by the PFMC for management of Klamath River Chinook salmon would remain in place throughout the fifty year period of analysis. As stated in Hendrix (2011) "this rule is based on an optimal (i.e., escapement that produces maximum sustainable yield) escapement target after harvest of 40,700 (PFMC 2005)." The analysis uses the same escapement target for both alternatives (40,700) despite the fact that Basin spawning distribution will be extended by hundreds of miles under the Proposed Action (as described below). Therefore, in the EDRRA model, the population is being managed optimally under the No Action/No Project Alternative, whereas it is being managed sub-optimally under the Proposed Action. The management of natural production could be improved by using a Fishery Control Rule that was tailored to the production potential available under the Proposed Action. Such a management change would likely increase EDRRA model predictions of catches and escapement under the Proposed Action.

Hendrix (2011) results indicated substantial uncertainty in Chinook salmon stock recruitment dynamics, resulting in uncertain escapement and harvest abundance forecasts. Despite the uncertainty, modeling results indicate that the Proposed Action would result in higher relative abundance of Chinook salmon. Median escapements to the Klamath Basin are predicted to be higher with the Proposed Action than under existing conditions. Median values were used because the distributions that describe the uncertainty were not symmetric. As a result, the median was a better metric for describing the central portion of the distribution than the mean value. Harvest is also predicted to be greater with the Proposed Action, and the probability of low escapement leading to fishery closures was less under the Proposed Action. Finally, simulations predicted that there is an approximately 75 percent probability that there would be higher escapement with the Proposed Action, and an approximately 70 percent probability of higher annual harvest.

The high degree of overlap in the 95 percent intervals indicate that the statistical properties of the distributions are similar; that is, the range of predicted values are similar due to the large range of uncertainty in stock production values. Conditions that caused model runs to be lower in the Proposed Action relative to the No Action/No Project Alternative are related to fisheries management and the stock production curves used in Lower and Upper Basins. Due to the Fishery Control Rule, productivity of the stock is optimal in almost all years. This occurs because the fishery management ensures that the spawning stock that produces maximum sustainable yield returns to spawn whenever the escapement in the absence of fishing is greater than maximum sustainable yield. This statement of optimal productivity is not true for the Proposed Action for two reasons: 1) Maximum sustainable yield is greater for the Proposed Action due to additional habitat, which is not incorporated into fishery management; and 2) the target escapement by the fishery is combined for the Lower and Upper Klamath Basin; the escapement is too low for the Lower Klamath Basin and too high for the Upper Basin (or vice versa). Thus there are some years and some model iterations when the combined (suboptimal) production from the Lower Klamath Basin and Upper Klamath Basin is less than the optimal production under the No Action/No Project Alternative. In addition to the quantitative modeling results, FERC (2007) and Hamilton et al. (2011) in synthesizing all available information both concluded that increased habitat access following dam removal would result in an increase in the abundance of fall-run Chinook salmon population in the Klamath River Watershed.

To help determine if the Proposed Action will advance restoration of the salmonid fisheries of the Klamath Basin, a Chinook Salmon Expert Panel was convened to attempt to answer specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011). The Panel concluded that the Proposed Action appears to be a major step forward in conserving target fish populations in the Klamath Basin. The Panel predicted that, based on the information provided to them, it was possible that the Proposed Action would provide a substantial increase in the abundance of naturally spawned Klamath River Chinook salmon above that expected under existing conditions in the reach between Iron Gate Dam and Keno Dam. In addition, the Panel concluded that the Proposed Action offers greater potential than the current conditions for Chinook salmon to tolerate climate change and changes in marine survival (Goodman et al. 2011). While the Panel agreed that there was also evidence for dramatic increases in abundance associated with the Proposed Action upstream of Keno Dam, they cautioned that achieving substantial gains in Chinook salmon abundance and distribution in the Klamath Basin is contingent upon successfully resolving key factors (discussed in this report in detail) that will continue to affect population, such as water quality, disease, and instream flows. In addition, they stated the concern that successful implementation of KBRA would be required, and would need appropriate scientific leadership.

The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Proposed Action, removal of the Four Facilities would allow fall-run Chinook salmon to

regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River, upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising ~~420~~ hundreds of miles of additional potentially productive habitat upstream of Iron Gate Dam (DOI 2007), including access to groundwater areas resistant to climate change (Hamilton et al. 2011).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might ~~prevent~~ impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, ~~evidence~~available information indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Summer poor water quality conditions, may necessitate seasonal trap and haul around Keno Impoundment/Lake Ewauna for some life stages of primarily fall-run Chinook salmon until KBRA and TMDL implementation improve water quality. This is consistent with the fishway prescriptions of DOI and U.S~~-~~. Department of Commerce (DOC) (DOI 2007; NOAA Fisheries Service 2007). For adult fall-run Chinook salmon, seasonal collection and transport mortality when water quality is poor is likely to be minor compared to mortality associated with unaided passage through areas of poor water quality at this time of year. Overall, dam removal and associated KBRA actions would accelerate water quality improvements (Dunne et al. 2011) ~~and TMDL water quality benefits to~~ related to implementation of TMDLs and that would help meet beneficial uses such as anadromous fish (~~Water Quality Subgroup~~WQST 2011).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Proposed Action would restore fall-run Chinook salmon access to the Hydroelectric Reach~~.~~), including around 76 miles of potential habitat within the Hydroelectric Reach, as described in the No Action/No Project Alternative analysis above. Historically Chinook salmon (both fall- and spring-run) spawned and were abundant in tributaries within the Hydroelectric Reach, including Jenny, Fall, and Shovel Creeks (Administrative Law Judge 2006).

Adults could first access this reach in fall 2020 after dam removal. Because of this they would not be exposed to the elevated SSCs that would occur during dam removal. By fall 2020, elevated SSCs from dam removal would have subsided. Most of the sediment stored within the removed reservoirs would likely be eroded within the first ~~5~~six months after dam removal, and, at most, cause minor (less than 0.5 foot) deposition in river reaches between reservoirs, settling into pool and other low-velocity habitats as water velocities decrease.

River ~~channels~~channel habitat within the reservoir reaches would be low gradient habitat of critical importance for spawning and rearing for salmon, steelhead, redband trout, and Pacific lamprey. The upstream half of the J.C. Boyle Reservoir is shallow and considered low gradient (FERC 2007, p 3-185). FERC also considered the Copco No. 2 bypassed reach and reaches inundated by Iron Gate and Copco reservoirs to be low

gradient. For these reaches, they estimated that the density of Chinook salmon spawners per mile for mainstem habitat was twice that of high gradient habitat (FERC 2007). These river channels would likely excavate to their pre-dam elevations within ~~a few~~six months, and revert to and maintain ~~a~~ pool-riffle morphology due to restoration of riverine processes, ~~likely~~ creating holding and rearing habitat for anadromous salmonids.

Modeling ~~data~~ (Reclamation 2011) indicate that after dam removal, spawning gravel in all sections of the Hydroelectric Reach would be within the range usable for fall-run Chinook salmon, but the amount of sand within the bed within former reservoir sections could initially inhibit spawning success. The bed material within the reservoirs and between Iron Gate to Cottonwood Creek is expected to have a high content (30 to ~~50 %~~50 percent) of sand immediately following reservoir drawdown until a flushing flow moves the sand sized material out of the reach (Reclamation ~~2011~~2012). The flushing flow is expected to be at least 6,000 cfs and of several days to weeks to return the bed to a bed dominated by cobble and gravel with a sand content less than 20~~%~~ percent. After the flushing flow, the bed is expected to maintain fractions of sand, gravel, and cobble which would be expected under natural conditions. Based on the historical record a sufficient flushing flow would likely occur within 5 years following dam removal. Riverine sections between reservoirs would be expected to provide the preferred substrate size range for fall-run Chinook salmon, with very little sand, suggesting that high-quality spawning habitat would be created.

Habitat exposed following dam removal is anticipated to be used during the first spawning migration after dam removal (fall 2020). At two dam removal sites in southern Oregon on the Rogue River, fall-run Chinook salmon quickly used spawning habitat that was formerly inaccessible under reservoirs, benefiting from conversion to riverine habitat and associated bedload/gravel movement. At Savage Rapids in 2010 (the first full fall after dam removal), 91 redds from within the bounds of the former reservoir were documented where no redds had existed previously, and more the following year. At the Gold Ray impoundment in 2010 (the fall after dam removal), 37 redds were documented from within the bounds of the former reservoir, with over twice that many the following year (ODFW 2011).

The Proposed Action would establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). ~~The removal of the four dams would likely reduce habitat availability for the polychaete host for *C. shasta* and *P. minibicornis*. Drawing down the reservoirs would reduce the amount of lentic habitat available, and increased flow variability would reduce the stability of pools, eddies, and low-velocity habitats. These changes~~ As described in detail in the subsection of Section 3.3.4.3.2, risk of fish disease and parasites for fall-run Chinook salmon will decrease. These changes and removal of the reservoirs would result in more favorable water

temperature for salmonids, as well as improve water quality and reduce the incidence of disease and algal toxins.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

The Proposed Action would decrease dissolved oxygen and release dam-stored sediment downstream to the ~~lower~~Lower Klamath River in the short term, and restore a flow regime that more closely mimics natural conditions the long term. Suspended sediment effects on fall-run Chinook salmon under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario, no effect from suspended sediment relative to existing conditions is anticipated for all adult fall-run Chinook salmon migrating or spawning within tributaries to the Klamath River during fall 2019 (around 92 percent of the population), or for juveniles rearing within tributaries (~~Table 3~~Table 3.3-5). Suspended sediment is anticipated to have sublethal effects on Type I and Type II outmigrants (Table 3.3-5). Effects would be distributed over three year-classes, rather than a single year-class. Therefore, Type-II and Type-III progeny of adults that successfully spawn in tributaries during 2020 will produce smolts that outmigrate to the ocean a year after the spring pulse of suspended sediment in 2020 and should not be noticeably affected by the Proposed Action. Direct ~~morality~~mortality from suspended sediment is anticipated to include the following:

- Under the most-likely-to-occur or worst-case scenario ~~predicted~~ complete loss of ~~the~~ eggs ~~of~~from the 2019 brood year deposited in the mainstem in fall 2019 is predicted. Based on redd surveys from ~~2001 through 2009 (CDFG, unpublished data~~1999 through 2009 (Magneson and Wright 2010), an average of around ~~4,600~~1,700 redds could be affected~~, or~~. Based on escapement estimates in the Klamath Basin from 2001 through 2009 (CDFG 2010, unpublished data) this would be around 8 percent of all anticipated redds in the ~~basin~~Basin in 2019.
- Type III juvenile fall-run Chinook salmon from the 2019 cohort (hatched from eggs laid in 2018) outmigrating to the ocean during spring 2020 would be exposed to high SSCs. However, based on outmigrant trapping in the mainstem Klamath River at Big Bar (Scheiff et al. 2001), Type III age 1 spring outmigrants are very rare, and only 31 were observed at Big Bar in four years of trapping, or around 0.1 percent of trap captures. Under a most-likely-to-occur scenario 0 to ~~20~~ 20 percent mortality is predicted, or around 0 to 189 smolts (around 0.02 percent ~~of the total fall-run Chinook salmon smolt production). Under a worst-case scenario mortality rates of up 71 percent are predicted for the Proposed Action, equating to 669 smolts, or around 0.07 percent of the total fall-run Chinook salmon smolt production. Type I and Type II juvenile outmigrants are expected to experience sublethal effects.~~

~~The Proposed Action would also result in the release of bedload sediment, as described in detail in Appendix F. Effects associated with release of coarse sediment are expected to impact the same individuals as described for suspended sediment above. For example, bedload sediment is predicted to bury redds constructed in fall 2019, which are the same redds expected to suffer from suspended sediment. In addition, bedload sediment could result in the deposition that could aggrade pools or overwhelm other habitat features that~~

~~Chinook salmon use for adult holding or juvenile rearing. However, the effect on habitat is anticipated to be short term, and pools would likely return to their pre-sediment release depth within one year (Stillwater Sciences 2008). In the long term, the river is predicted to revert to and maintain a pool-riffle morphology.~~

Table 3.3-5. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Fall-run Chinook Salmon.

Scenario	Life History Stage: Fall-run Chinook Salmon			
	Adult migration (July 15–Oct 31 2020)	**Spawning through fry emergence (Oct 15 2019–Feb 28 2020)**	**Age 0+ rearing (March 1–March 31 2020)**	**Outmigration (Type I April 1–August 31 2020) (Type II Sept 1–Nov 30 2020) (Type III Feb 1–April 15 2020)**
Most-likely	**Normal Existing Conditions (50% exceedance probabilities)**			
	No effects	No effects.	Moderate stress for age 0 in upper mainstem.	**Type I:** Major stress for Type I fry (about 60% of production)
				Type II: No effects
				Type III: Major stress for about 2 weeks for Type III outmigrants (<1% of production)
	Proposed Action			
	Same as existing conditions	Up to 100% mortality of the progeny of mainstem spawners (approximately ~~4,600~~1,700 redds, or around 8% of production).	No juvenile progeny anticipated rearing in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	**Type I:** Major stress and reduced growth
				Type II: Same as existing conditions
				Type III: Major stress, reduced growth, and up to 20% mortality (0 to 189 smolts, or less than 1% of production)
Worst-case	**Extreme Existing Conditions (10% exceedance probabilities)**			
	No effect	A few days of suspended sediment may reduce size at emergence for progeny from mainstem spawning (about 8% of escapement).	Major stress for age 0 in upper mainstem.	**Type I:** Major stress and reduced growth for the about 60% of fry entering mainstem in April–May
				Type II: Moderate stress for the about 40% of Type II juveniles entering mainstem in Sept–Nov
				Type III: Major stress for the less than 1% of juveniles entering mainstem in Feb–April
	Proposed Action			
	Major stress and impaired homing	Up to 100% mortality of the progeny of mainstem spawners (approximately ~~4,600~~1,700 redds, or around 8% of production).	No juvenile progeny anticipated in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	**Type I:** Same as existing conditions **Type II:** Moderate (1 day) to major (about 1 wk) stress **Type III:** Major stress, reduced growth, and up to 71% mortality (Up to 669 smolts, or less than 1% of production)

of the total fall-run Chinook salmon smolt production). Under a worst-case scenario mortality rates of up 71 percent are predicted for the Proposed Action, equating to 669 smolts, or around 0.07 percent of the total fall-run Chinook salmon smolt production. Type I and Type II juvenile outmigrants are expected to experience sublethal effects.

As described in detail in Appendix F, the 2021 cohorts could also be affected by sediment deposits with high levels of sand that would likely remain through fall 2020. In the long term, increased supply of gravel from upstream sources is predicted to increase the amount of fall-run Chinook salmon spawning habitat by decreasing the median substrate size to 40 to 60 mm (Reclamation ~~2011~~2012), within the observed range for Chinook salmon spawning (16 to 70 mm [Kondolf and Wolman 1993]). However, in the short term, high sand composition, may ~~be as high as 30 percent, reducing~~reduce the quality of spawning habitat. These levels of sand may continue to affect the 2020 brood year (2021 cohort) as these levels of sand that could remain through fall 2020 unless it is flushed from the substrate during winter flows. Changes in bedload would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of 8 miles, or 4 percent of the channel length of the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam. The most severe effects would also be limited to a small proportion of the total channel length (0.5 miles, or less than 1 percent of the channel downstream ~~of~~ from Iron Gate Dam), as sediment deposition would lessen downstream ~~of~~ from Bogus Creek to Cottonwood Creek. At most, around 8 percent of fall-run Chinook salmon in the Klamath Basin are expected to spawn in the mainstem, with an even smaller percentage expected to spawn within the 8-mile affected reach (~~Appendix~~ Appendix E).

In the long term, decreased substrate size is anticipated to improve spawning gravel quality in the mainstem downstream from Iron Gate Dam. Bedload sediment movement and transport are vital to create and maintain functional aquatic habitat. The river would eventually exhibit enhanced habitat complexity due to a more natural flow and reconnected bedload transport regime that will mean the restoration of spawning gravels and early rearing habitat downstream from Iron Gate Dam. Pools would likely return to their pre-sediment release depth within one year (Reclamation 2012), and the river is predicted to revert to and maintain a pool-riffle morphology providing suitable habitat for fall-run Chinook salmon.

Short-term (< 2 months) reductions in dissolved oxygen are anticipated to occur as a result of high SSCs following dam removal, as described in detail in Section X.X. While predicted short-term increases in oxygen demand under the Proposed Action generally result in dissolved oxygen concentrations above the minimum acceptable level (5 mg/L) for salmonids, exceptions to this would occur four to eight weeks following drawdown of J.C. Boyle and Iron Gate reservoirs (i.e., in February 2020), when dissolved oxygen would remain below 5 mg/L from Iron Gate Dam to near the confluence with the Shasta River (RM 176.7), or for a distance approximately 20–25 km downstream from the dam. Any incubating fall-Chinook salmon eggs in the river during this time are assumed to be already suffering 100% mortality caused by increased SSC during this time, and thus the

decrease in dissolved oxygen is not anticipated to have an additional effect. No other life-stages are anticipated to occur in the mainstem Klamath River during this time, and thus will not be affected.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the ~~lower~~Lower Klamath River. Flows under the Proposed Action are intended to benefit fall-run Chinook salmon~~. Hetrick's analysis of KBRA type[7] flows showed the greatest benefits would be in years when production was low (Hetrick et al. 2009). Implementing either the KBRA type flows or the Hardy et al. (Hardy et al. 2006) Phase II flow recommendations was predicted to decrease the occurrence of poor production years in the future by two-thirds. This would have significant~~, and are anticipated to have positive consequences for Chinook salmon given their life cycle in the Klamath River~~ (Hetrick et al. 2009). Dam removal would~~.

As discussed in detail above in the subsection of Section 3.3.4.3.2, dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and ~~to~~ have diurnal variations more ~~in sync~~synchronized with historical migration and spawning periods (Hamilton et al. 2011). ~~These~~Under the Proposed Action, warmer springtime temperatures would result in fall-run Chinook salmon fry emerging earlier (Sykes et al. 2009), encountering favorable temperatures for growth sooner than under existing conditions (Figure 3.3-19), which could support higher growth rates and encourage earlier emigration downstream, thereby reducing stress and disease (Bartholow et al. 2005; FERC 2007). A predicted earlier outmigration in response to elevated water temperatures in the spring is also supported by a vast body of literature relating to increased growth rates and thermal response of outmigrating salmonids (Hoar 1988). In addition, fall-run Chinook salmon spawning in the mainstem during fall would no longer be delayed (reducing prespawn mortality) (Figure 3.3-18), and adult migration would occur in more favorable water temperatures than under existing conditions (Figure 3.3-19). Overall, these changes would result in water ~~temperature~~temperatures more favorable for ~~salmonids~~fall-run Chinook salmon in the mainstem~~.~~ Klamath River downstream from Iron Gate Dam.

Incidence of disease are expected to be reduced by enhancing the scour capabilities of flow by uninterrupted sediment transport, a flow regime that more closely mimics natural conditions, thereby disturbing the habitat of the polychaete worm that hosts *C. shasta* (FERC 2007). Reducing polychaete habitat will likely increase abundance of smolts by increasing outmigration survival, particularly for Type I and Type III life-histories (FERC 2007).

Estuary ~~The~~

~~[7] This analysis assumed that low flows in water years 2012 to 2020 would resemble low flows in water years 1961 to 2000. The Hetrick et al. (2009) analysis was based on a period of record 1961-2000; thus we refer to these as 'KBRA type' flows.~~

Under the Proposed Action, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see the subsection of Section 3.2.4.3.2). However, the Proposed Action would not substantially change or affect estuarine habitat used by fall-run Chinook salmon. Short- and long-term improvements to water quality and reductions in algal toxins would be expected with the establishment of a flow regime that more closely mimics natural conditions, and would benefit fall-run Chinook salmon. ~~Sediment,~~ In addition, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Fall-Run Chinook Salmon

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect fall-run Chinook salmon. Fall-run Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. ~~Overall,~~ Direct mortality is predicted for fall-run Chinook salmon redds and some smolts. However, the effect of SSC from the Proposed Action on the fall-run Chinook salmon population, under both most-likely and worst-case scenarios, is expected to be relatively minor because of variable life histories, the large majority of age 0 juveniles that remain in tributaries until later in the spring and summer, and because many of the fry that outmigrate to the mainstem come from tributaries in the mid- or ~~lower~~Lower Klamath River, where ~~suspended sediment concentrations~~ SSCs resulting from the Proposed Action are expected to be lower due to dilution from tributaries ~~in between. Effects would be distributed over three year-classes, rather than a single year-class. Therefore, Type-II and Type-III progeny of adults that successfully spawn in tributaries during 2020 will produce smolts that outmigrate to the ocean a year after the spring pulse of suspended sediment in 2020 and should not be noticeably affected by the Proposed Action. However, direct mortality is predicted for 4,600 redds (around 8 percent of total redds in the basin), and for around 669 Type III smolts (< 1 percent of production). In addition, sublethal effects on Type I and Type II outmigrants are predicted~~. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for fall-run Chinook salmon in the short term.**

Mitigation Measures AR-1 through AR-4 (see Section 3.3.4.4) could be implemented to reduce the short-term effects of SSCs on fall-run Chinook salmon incubating eggs and smolts. There would still be short-term effects for fall-run Chinook salmon, including some direct mortality, but no one year class would suffer a substantial decrease in abundance. **Based on minimal reduction in the abundance of a year class in the short term, the Proposed Action would be a less-than-significant effect on fall-run Chinook salmon after mitigation.**

Under the Proposed Action, removal of dams could alter habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins, all of which could affect fall-run Chinook salmon in the long term. As stated above, dam removal would also restore connectivity to ~~420~~ hundreds of miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach. ~~Almost any type of fish passage structure would be less efficient as a migration corridor for fish than removing the obstacle to passage itself. For example, fish ladders may cause delays in adult upstream migration or may become blocked by debris, and juvenile fish may have to navigate through impoundments with poor water quality or non-native predatory fish. Any of these potential factors has a chance of affecting fitness, survival, or reproductive success (Buchanan et al. 2011a).~~ By providing an unimpeded migration corridor, the Proposed Action would provide the greatest possible benefit related to fish passage, hence, the highest survival and reproductive success. It is anticipated that the Proposed Action would increase the abundance, productivity, population spatial structure, and genetic diversity of fall-run Chinook salmon in the Klamath River watershed. In general, free flowing conditions as per the Proposed Action, would likely provide optimal efficiency, decrease outmigrant delay, and increase concomitant adult escapement (Buchanan et al. ~~2011a)~~2011b). As discussed in detail above, dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. In addition, under the Proposed Action diminished disease conditions and improved water quality in the mainstem Klamath River will likely improve the survival of smolts outmigrating from tributaries downstream from Iron Gate Dam (e.g., Scott and Shasta rivers), thus increasing the likelihood of successful restoration actions in those watersheds. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for fall-run Chinook salmon in the long term**.

Spring-Run Chinook Salmon As discussed above for fall-run Chinook salmon, a Chinook Salmon Expert Panel was convened to attempt to answer specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011). While noting uncertainties based on existing data, the panel concluded that the prospects for the Proposed Action to provide a substantial positive effect for spring Chinook salmon is more remote than for fall-run Chinook salmon. The primary concern of the panel was that low abundance and productivity (return per spawner) of spring Chinook salmon would limit recolonization of habitats upstream of Iron Gate Dam. However, as described below in this section, this concern would be addressed in that the KBRA includes a reintroduction component to establish populations in the new habitats~~, at least initially~~. KBRA implementation would reintroduce spring-run Chinook salmon upstream of Upper Klamath Lake in Phase 1. The adaptive management approach to reintroduction will include spring-run and fall-run Chinook salmon (Hooton and Smith 2008). Even without supplementation, it is likely that spring-run Chinook salmon recolonization would occur as it did for Chinook salmon following barrier removal at

Landsburg Dam in Washington (Kiffney et al. 2009). In addition, KBRA actions would be implemented that are anticipated to improve productivity of existing and potentially newly accessible habitats. The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Under the Proposed Action, dam removal would allow spring-run Chinook salmon to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir (FERC 2007). The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River and upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to ~~49~~ 49 significant tributaries in the Upper Klamath Basin, comprising ~~420~~ hundreds of miles of additional potentially productive habitat (DOI 2007), including access to important thermal refugia within areas influenced by groundwater exchange that are more resistant to climate change (Hamilton et al. 2011). Some of these areas, such as the lower Williamson River, have habitat that would provide substantial holding areas for spring-run Chinook salmon (Hamilton et al. 2010). Other holding areas with suitable temperatures upstream of J.C. Boyle Reservoir include groundwater influenced areas on the west side of Upper Klamath Lake, and the Wood River (Gannett et al. 2007). Warmer winter water temperatures associated with groundwater would also be conducive to the growth of salmonids (Hamilton et al. 2011).

The Proposed Action would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins ~~and disease~~in this reach. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25 °C, high pH) in the reach from Keno Dam to Link Dam might ~~prevent~~impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, ~~evidence~~available information indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Historically, adult spring-run Chinook salmon migrated upstream of the current location of Iron Gate Dam perhaps as early as February and March (Fortune et al. 1966) and likely held over in large holding pools in the mainstem in tributaries fed by cool water, and in refugia habitat upstream of Upper Klamath Lake (CDFG 1990c; Moyle 2002; Snyder 1931). One benefit of such early migration would be the avoidance of periods of poor water quality. The restored water temperature regime under the Proposed Action may restore upstream migration timing of adult spring-run Chinook salmon because of the shift in water temperatures downstream from Iron Gate dam (Bartholow et al. 2005).

Summer poor water quality conditions, may necessitate seasonal trap and haul around Keno Impoundment/ Lake Ewauna for some life stages of ~~Chinook~~Chinook salmon (primarily fall-run) until KBRA and TMDL implementation improve water quality. This is consistent with the fishway prescriptions of DOI and DOC (DOI 2007; NOAA

Fisheries Service 2007). Overall, dam removal and associated KBRA actions would accelerate water quality improvements (Dunne et al. 2011) and TMDL water quality benefits to anadromous fish (~~USDI Secretarial Determination Water Quality Subgroup In Review~~WQST 2011).

Huntington (2006) reasoned that spring-run Chinook salmon likely accounted for the majority of the Upper Klamath Basin's actual salmon production under historical conditions. Huntington (2006) cautioned that while access to the Upper Klamath Basin provides considerable promise of increasing spring-run abundance, the existing potential for Chinook salmon production within the Basin upstream of Upper Klamath Lake is clearly much lower than his estimate of historical potential. However, Huntington (2006) did not fully account for the historical (and unknown) production potential of Upper Klamath Lake itself, which could have been considerable, as suggested by a recent experimental reintroduction into Upper Klamath Lake (Maule et al. 2009).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
The Proposed Action would restore spring-run Chinook salmon access to the Hydroelectric Reach), including around 76 miles of potential habitat within the Hydroelectric Reach, as described in the No Action/No Project Alternative analysis above. Chinook salmon (both fall- and spring-run) historically spawned and were abundant in tributaries within the Hydroelectric Reach, including Jenny, Fall, and Shovel creeks (Administrative Law Judge 2006). Adults could first access this reach in spring 2021 after dam removal; thus, short-term gains in flow-related habitat or habitat expansion would be limited to later cohorts. Elevated SSCs and bedload movement from dam removal would have dissipated by this time (see ~~Figure 3.3-5, Figure 3.3-6, and Figure 3.3-7~~Figure 3.3-5, Figure 3.3-6, and Figure 3.3-7), returning to background levels similar to those under existing conditions and would not be expected to affect spring-run Chinook salmon using this area.

The Proposed Action would eliminate the Four Facilities and would establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The removal of the reservoirs would ~~allow~~ allow Fall, Shovel, and Spencer Creeks to flow directly into the mainstem Klamath River, along with Big Springs in the J.C. Boyle Bypass Reach and additional springs, which would provide fish with patches of cooler water as refugia ~~(Hamilton et al. 2011). The removal of the four dams would likely reduce habitat availability for the polychaete host for *C. shasta* and *P. minibicornis*. Removal of the reservoirs would reduce the amount of lentic habitat available, and increased flow variability would reduce the stability of pools, eddies, and low-velocity habitats. These changes would result in more favorable water temperature for salmonids~~during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). As described in detail in the subsection of Section 3.3.4.3.1, risk of fish disease and parasites for spring-run Chinook salmon will decrease. These changes and removal of the reservoirs would result in more favorable water temperature for salmonids, as well as improve water quality and reduce ~~instances~~the incidence of disease and algal toxins.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the ~~lower~~Lower Klamath River Reach in the short term, and would establish a flow regime that more closely mimics natural conditions in the long term. Adult spring-run Chinook salmon do not currently occur upstream of the Salmon River, and would not be expected to be able to use the mainstem Klamath River upstream of Iron Gate Dam until conditions in the Hydroelectric Reach are suitable.

Suspended sediment effects on spring-run Chinook salmon under the Proposed Action are described in detail in Appendix E, and summarized here. The distribution of spring-run Chinook salmon in the Salmon River and tributaries downstream limits their exposure to mostly lower concentrations of suspended sediment. Under the most-likely-to-occur scenario or worst-case scenario, no effect from suspended sediment relative to existing conditions is anticipated for all spring-run Chinook salmon spawning and rearing, which occurs primarily within tributaries (Table 3.3-6). Suspended sediment is anticipated to have sublethal effects on adult migration, primarily for those adult returning to the Salmon River (around 5 percent of all spring-run migrants), and sublethal effects on Type I and Type II outmigrants (Table 3.3-6). Direct ~~morality~~mortality from suspended sediment is anticipated to include the following:

- Type III juvenile spring-run Chinook salmon from the 2019 cohort (hatched from eggs laid in 2018) outmigrating to the ocean from the Salmon River during spring 2020 would be exposed to high SSCs. However, based on outmigrant trapping in the Salmon River~~ (Karuk Tribe, unpublished data)~~, Type III age 1 spring outmigrants are very rare, and only 30 were observed in five years of trapping. Assuming a larger number of Type III smolts outmigrate from the Salmon River and are undetected (assume an average of around 78 Type III smolts per year), under a most-likely-to-occur scenario 0 to 20 percent mortality is predicted or 16 smolts at most (less than 1 percent of the total spring-run Chinook salmon smolt production). Under a worst-case scenario mortality rates of 20 to 36 percent are predicted, or around 28 smolts at worst (<~~1~~ 1 percent of all production). Type I and Type II juvenile outmigrants are expected to experience sublethal effects.

~~Adults could first access the reach upstream of the Iron Gate Dam in Spring 2021 if dam removal is completed by April of that year. As described in detail in Appendix F, short- and long-term changes in bedload would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of 8 miles, or 4 percent of the mainstem Klamath River channel downstream of Iron Gate Dam (Appendix F). The most severe effects would also be limited to a small proportion of the total channel length (0.5 miles, or less than 1 percent of the channel downstream of Iron Gate Dam), as sediment deposition would lessen downstream of Bogus Creek to Cottonwood Creek and, thus, would not affect the area currently used by spring-run Chinook salmon. By spring 2021, suspended sediment concentrations would have returned to background levels and the channel would likely have reverted back to its previous pool-riffle morphology (Stillwater Sciences 2008).~~

~~The Proposed Action would create a flow regime that more closely mimics natural conditions in the lower Klamath River by increasing spring flow and by incorporating more variability in daily flows. Dam removal would cause water temperatures to warm earlier in the spring and early summer and cool earlier in the late summer and fall, and to have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. Migrating adults and juveniles rearing or migrating in the mainstem in spring 2020 would be exposed to poor water quality due to the Proposed Action. Because most spawning occurs in the Salmon and Trinity Rivers, magnitude of exposure would be limited by dilution from tributaries entering downstream of Iron Gate Dam.~~

Table 3.3-6. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Spring-run Chinook Salmon~~.~~

Scenario	Life History Stage: Spring-run Chinook Salmon			
	Adult migration (Apr 1–Jun 30, 2020)	**Spawning through fry emergence (Sept 1 2019–Feb 28, 2020)**	**Fry and juvenile rearing (year-round)**	**Outmigration (Type I: April 1–August 31 2020) (Type II: Sept 1–Nov 30 2020) (Type III: Feb 1–April 15 2020)**
Most likely	**Existing Conditions (normal)**			
	Spring Migration: Moderate stress and Impaired homing for adults returning to Salmon River (average 5% of total run, up to 35% of natural run) **Summer Migration:** No effects	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	**Type I:** Major stress for Type I fry from Salmon River (about 80% of Salmon River production) **Type II:** No effects (about 20% of Salmon R. production) **Type III:** Major stress for Type III juveniles from Salmon River (< 1% of Salmon River production)
	Proposed Action			
	Spring Migration: Major stress and impaired homing **Summer Migration:** Same as existing conditions	Same as existing conditions	Same as existing conditions	**Type I:** Same as existing conditions **Type II:** Same as existing conditions **Type III:** Major stress, reduced growth, and up to 20% mortality. (around 16 smolts, less than 1% of the total smolt population from the Salmon River)
Worst-case	**Existing conditions (extreme)**			
	Spring Migration: Major stress and impaired homing **Summer Migration:** Moderate stress	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	**Type I:** Major stress for Type I fry from Salmon River (about 80% of Salmon River production) **Type II:** Moderate stress for Type II juveniles from Salmon River (about 20% of Salmon River production) **Type III:** Major stress for Type III juveniles from Salmon River (<1% of Salmon River production)
	Proposed Action			
	Spring Migration: Same as existing conditions **Summer Migration:** Impaired homing	Same as existing conditions	Same as existing conditions	**Type I:** Same as existing conditions **Type II:** Same as existing conditions **Type III:** Major stress, reduced or no growth, and up to 36% mortality (up to 28 smolts, less than 1% of the total smolt population from the Salmon River)

Adults could first access the reach upstream of the Iron Gate Dam in Spring 2021 if dam removal is completed by April of that year. As described in detail in Appendix F, short- and long-term changes in bedload would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of 8 miles, or 4 percent of the mainstem Klamath River channel downstream from Iron Gate Dam (Appendix F). The most severe effects would also be limited to a small proportion of the total channel length (0.5 miles, or less than 1 percent of the channel downstream from Iron Gate Dam), as sediment deposition would lessen downstream from Bogus Creek to Cottonwood Creek and, thus, would not affect the area currently used by spring-run Chinook salmon. Within one year (i.e., by spring 2021), SSCs would have returned to background levels and the channel would likely have reverted back to its previous pool-riffle morphology (Stillwater Sciences 2008).

The Proposed Action would create a flow regime that more closely mimics natural conditions in the Lower Klamath River by increasing spring flow and by incorporating more variability in daily flows. As discussed in detail above, dam removal would cause water temperatures to warm earlier in the spring and early summer and cool earlier in the late summer and fall, and have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. Migrating adults and juveniles rearing or migrating in the mainstem in spring 2020 would be exposed to poor water quality due to the Proposed Action. Because most spawning occurs in the Salmon and Trinity Rivers, magnitude of exposure would be limited by dilution from tributaries entering downstream from Iron Gate Dam.

Incidence of disease are expected to be reduced by enhancing the scour capabilities of flow by uninterrupted sediment transport, a flow regime that more closely mimics natural conditions, thereby disturbing the habitat of the polychaete worm that hosts *C. shasta*. Reducing polychaete habitat would likely increase abundance of smolts by increasing outmigration survival, particularly for Type I and Type III life-histories.

Estuary~~ The~~
Under the Proposed Action, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see the subsection of Section 3.2.4.3.2). However, the Proposed Action is not expected to substantially change or affect spring-run Chinook salmon estuarine habitat. Short- and long-term improvements to water quality and reductions in algal toxins would be expected with the establishment of a flow regime that more closely mimics natural conditions. This would benefit spring-run Chinook salmon. ~~Sediment, flow,~~Flow and water temperature effects would likely not extend downstream to the estuary.

Summary: Spring-Run Chinook Salmon

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect spring-run Chinook salmon. The overall effect of suspended sediment from the Proposed Action on the spring-run Chinook salmon population is not anticipated to differ much from existing conditions and the No Action/No Project Alternative. There is very little difference from existing conditions and the No Action/No Project Alternative for adult migrants, all of which is predicted to be sublethal, and no effects are anticipated for the spawning, incubation, and fry stages because they do not spawn in the mainstem. Type I and II outmigrants are expected to experience very similar conditions under the Proposed Action as under existing conditions and the No Action/No Project Alternative. However, direct mortality is predicted for ~~around 16 to 28~~ some Type III smolts (< 1 percent of production). ~~In addition, sublethal effects on adult migrants and Type I and Type II outmigrants are predicted.~~ **Based on minimal reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be less-than-significant for spring-run Chinook salmon in the short term.**

Implementation of Mitigation Measures AR-2 (see Section 3.3.4.4) could reduce the short-term effects of SSCs on spring-run Chinook salmon Type III smolts. With implementation of mitigation measures, there would still be short-term effects for spring-run Chinook salmon including some potential direct mortality, but there would not be a substantial reduction in the abundance of a year class. **Based on minimal reduction in the abundance of a year class in the short term, the Proposed Action would be a less-than-significant effect on spring-run Chinook salmon after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, temperature variation, ~~and~~ fish disease incidence, and algal toxins which could affect spring-run Chinook salmon in the long term. Dam removal would restore connectivity to ~~420~~hundreds of miles of potentially usable habitat in the Upper Klamath Basin, including additional habitat within the Hydroelectric Reach. Access to additional habitat would provide a long-term benefit to spring-run Chinook salmon populations. ~~Almost any type of fish passage structure would be less efficient as a migration corridor for fish than removing the obstacle to passage itself. For example, fish ladders may cause delays in adult upstream migration or may become blocked by debris, and juvenile fish may have to navigate through impoundments with poor water quality or non-native predatory fish. Any of these potential factors has a chance of affecting fitness, survival, or reproductive success (Buchanan et al. 2011a).~~ The expansion of habitat opportunities would allow maximum expression of life-history variation and the restoration of an additional population of spring-run Chinook salmon population to strengthen resiliency in the Klamath Basin, particularly because passage upstream of Iron Gate Dam would provide access to groundwater thermal refugia during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). By providing an unimpeded migration corridor, the Proposed Action would provide the greatest possible benefit related to fish passage, hence, the highest survival and reproductive success

(Buchanan et al. 2011b). As discussed in detail above, dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. In addition, with large scale hydraulic mining operations now outlawed, spring-run Chinook salmon would no longer be subject to one of their most significant threats in the Klamath River (as discussed above in the subsection of Section 3.3.3.1.1.). Current improved fisheries management also minimizes overharvest. It is anticipated that as a result of the Proposed Action the spring-run Chinook salmon population within the Klamath River watershed would have an increase in abundance, productivity, population spatial structure, and genetic diversity. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for spring-run Chinook salmon in the long term.**

Coho Salmon A Coho Salmon and Steelhead Expert Panel was convened and charged with answering specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action on coho salmon and steelhead (Dunne et al. 2011). While noting the constraints of the Panel to arrive at conclusions within a short time period and without adequate quantitative or synthesized information, the conclusion of the Panel was that~~ the Proposed Action would result in a modest increase in the~~ : "Although Current Conditions will likely continue to be detrimental to coho~~ salmon population compared with existing conditions. The Panel indicated that a relatively modest increase in coho population would result from dam removal due to the following factors:~~

- ~~Only modest increases in suitable coho salmon habitat would result from dam removal;~~
- ~~Coho salmon use more tributary streams and rely less on the mainstem Klamath River habitats primarily affected by dam removal;~~
- ~~Anticipated positive but unquantifiable~~, the difference between the Proposed Action and Current Conditions is expected to be small, especially in the short term (0-10 years after dam removal). Larger (moderate) responses are possible under the Proposed Action if the KBRA is fully and effectively implemented and mortality caused by the pathogen *C. shasta* is reduced. The more likely small response will result from modest increases in habitat area usable by coho with dam removal, small changes in conditions in the mainstem, positive but un-quantified changes in tributary habitats where most coho spawn and rear~~ due to KBRA implementation; and,~~
- ~~Potential~~, and the potential risk for disease and low ocean survival to offset gains in production~~.~~

in the new habitat."

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

There is no historical evidence that coho salmon occurred upstream of J.C. Boyle Reservoir~~, primarily because most people at the time did not distinguish between the various anadromous salmonid species~~. However, in historical interviews Snyder (1931) noted that ~~they occurred in large numbers in the Klamath River. He stated that "Nothing definite was learned about them from inquiry because most people are unable to distinguish them," but also that~~while, "silver salmon are said to migrate to the headwaters of the Klamath to spawn~~." Beginning in 1910-1911, adult coho salmon~~, the interviews were ~~trapped at the "Klamathon Racks" near the town of Klamathon, which is~~ not conclusive since most people at the time did not distinguish between the various anadromous salmonid species. Overall, historical evidence ~~that they migrated upstream of Iron Gate and Copco Dams.~~

of coho salmon occurrence upstream of Spencer Creek and J.C. Boyle reservoir is uncertain.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

The Proposed Action would restore access for upper Klamath River Population coho salmon to the Hydroelectric Reach, expanding their distribution to include historical habitat along the mainstem Klamath River and all tributaries upstream at least as far as Spencer Creek; including in Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005~~).~~), including around 76 miles of potential habitat within the Hydroelectric Reach, as described in the No Action/No Project Alternative analysis above. Coho salmon downstream from Iron Gate Dam belonging to the Upper Klamath River Population Unit would migrate above the dam if access was provided by fishways (Administrative Law Judge 2006). Over time, access to habitat above Iron Gate Dam would benefit the Upper Klamath River Population Unit by: a) extending the range and distribution of the species thereby increasing the coho salmon's reproductive potential; b) increase genetic diversity in the coho stocks; c) reduce the species vulnerability to the impacts of degradation; and d) increase the abundance of the coho salmon population (Administrative Law Judge 2006). The NRC of the National Academy of Science reviewed causes of decline and strategies for recovery of endangered and threatened fishes of the Klamath Basin. The NRC concluded that "removal of Iron Gate Dam... could open new habitat, especially by making available tributaries that are now completely blocked to coho" (NRC 2004). In a recent evaluation of recolonization after access was provided, juvenile coho salmon established a population and outnumbered resident salmonid species by 40 percent within 5 years of colonization (Pess et al. 2011).

Adults could first access this reach in fall 2020 after dam removal. By this time, elevated SSCs from dam removal would likely have dissipated, returning to background levels similar to those of existing conditions. Most sediment released from the reservoirs would likely be eroded within the first ~~five~~six months after dam removal (by May 2020), returning sections of river currently inundated by the Four Facilities and riverine sections between reservoirs to pool-riffle morphology. Within this reach, coho salmon generally spawn in tributaries and not within the mainstem Klamath River, but might rear and migrate through the Hydroelectric Reach. Dam removal would result in the provision of suitable rearing habitat for juveniles and spawning habitat for the few individuals that might spawn in the mainstem Klamath River. Access to the cooler waters associated

with spring inputs in the Hydroelectric Reach would benefit coho salmon rearing in the mainstem (Hamilton et al. 2011).

The Proposed Action would also eliminate the Four Facilities and would establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish ~~(Hamilton et al. 2011). The removal of the four dams would also likely reduce habitat availability for the polychaete host for *C. shasta and P. minibicornis*. Removal~~during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). As described in detail in the subsection of Section 3.3.4.3.2, risk of fish disease and parasites for coho salmon will decrease. These changes and removal of the reservoirs would ~~reduce the amount of lentic habitat available, and increased flow variability would reduce the stability of pools, eddies, and low-velocity habitats. These changes would~~ result in more favorable water temperature for salmonids, ~~and would~~as well as improve water quality and reduce ~~instances~~the incidence of disease and algal toxins. All of these changes would benefit coho salmon produced in the Hydroelectric Reach in 2020 and thereafter.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the ~~lower~~Lower Klamath River Reach in the short term and would establish a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on coho salmon under the Proposed Action are described in detail in Appendix E, and summarized here. There are nine coho salmon population units in the Klamath River watershed (see the subsection of Section 3.3.3.1.4). Only negligible effects from suspended sediment would be expected on the three population units in the Trinity River, and on the ~~lower~~Lower Klamath River Population Unit relative to existing conditions. Effects on the Salmon River Population Unit are anticipated to remain sublethal even under a worst-case scenario (Table 3.3-7). Effects on the upper Klamath River, mid-Klamath ~~River, Shasta, and Scott population units under the most-likely-to-occur or worst-case scenario are anticipated to be sublethal on most life-stages (Table 3.3-7), with the following exceptions:~~

~~Under the most-likely-to-occur or worst-case scenario coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, as well as their progeny, would suffer up to 100 percent mortality; however, even under existing conditions and the No Action/No Project Alternative, 80–100 percent mortality is expected due to the effects of suspended sediment on these life stages (in addition to other sources of mortality). Based on spawning surveys conducted from 2001 to 2005 (Magneson and Gough 2006), from 6 to 13 redds could be affected in 2019 during the Proposed Action, many of which are thought to be hatchery~~

Table 3.3-7. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10~~%~~ % Exceedance Probabilities) for Coho Salmon~~.~~

Scenario	Life History Stage: Coho Salmon				
	Adult migration (Sept 1, 2019–Jan 1, 2020)	**Spawning through fry emergence (Nov 1, 2019–Mar 14, 2020)**	**Age 0+ rearing during summer (Mar 15–Nov 14, 2020)**	**Age 1+ rearing during winter (Nov 15, 2019–Feb 14, 2020)**	**Outmigration Early spring outmigration: (Feb 15–March 31, 2020) Late spring outmigration: (April 1– June 30, 2020)**
Most Likely	**Existing Conditions (normal)**				
	Stressful SSCs for about 5 days; deleterious ~~affects~~effects on adults unlikely	Low survival (<20%)	**Age 0+ summer:** Major stress for age 0+ from 2020 cohort in mainstem (<50% of fry)	**Age 1+ winter:** Moderate stress for age 1+ juveniles from 2019 cohort in mainstem (assume <1% of juveniles)	**Early spring outmigration:** Major stress mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of run outmigrate in early spring) **Late spring outmigration:** Major stress for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during late spring (approximately 56% of run)
	Proposed Action				
	Major stress and impaired homing	Up to 100% mortality of progeny of mainstem spawners (about 13 redds, or 0.7–26% of Upper Klamath River Population Unit natural escapement)	**Age 0+ summer:** Reduced growth	**Age 1+ winter:** Major stress, reduced growth, and up to 20% mortality	**Early spring outmigration:** Major stress, reduced growth, and up to 20% mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (~44 percent of run outmigrate in early spring). (2,668 smolts, 3% of total production in basin) **Late spring outmigration:** Major stress and reduced growth

Table 3.3-7. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10~~%~~ % Exceedance Probabilities) for Coho Salmon~~.~~

Scenario	Life History Stage: Coho Salmon				
	Adult migration (Sept 1, 2019–Jan 1, 2020)	**Spawning through fry emergence (Nov 1, 2019–Mar 14, 2020)**	**Age 0+ rearing during summer (Mar 15–Nov 14, 2020)**	**Age 1+ rearing during winter (Nov 15, 2019–Feb 14, 2020)**	**Outmigration Early spring outmigration: (Feb 15–March 31, 2020) Late spring outmigration: (April 1– June 30, 2020)**
Worst-case	**Existing Conditions (extreme)**				
	Major stress and impaired homing	Up to 100% mortality of progeny of mainstem spawners (about13 redds, or 0.7–26% of Upper Klamath River Population Unit natural escapement)	**Age 0+ summer:** Major stress and reduced growth for fish rearing in mainstem (< 50% of fry)	**Age 1+ winter:** Major stress and reduced growth for fish rearing in mainstem (assume <1% of juveniles)	**Early spring outmigration:** Major stress and reduced growth for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of run outmigrate in early spring) **Late spring outmigration:** Major stress for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during late spring (approximately 56% of run)
	Proposed Action				
	Same as existing conditions	Same as existing conditions	**Age 0+ summer:** No growth	**Age 1+ winter:** Major stress, reduced growth and up to 52% mortality	**Early spring outmigration:** Major stress, reduced growth, and up to 49% mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of run outmigrate in early spring) (6,536 smolts, 8% of total production in basin) **Late spring outmigration:** Major stress and reduced growth

River, Shasta, and Scott population units under the most-likely-to-occur or worst-case scenario are anticipated to be sublethal on most life-stages (Table 3.3-7), with the following exceptions:

- Under the most-likely-to-occur or worst-case scenario, coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, as well as their progeny, would suffer up to 100 percent mortality; however, even under existing conditions and the No Action/No Project Alternative, 80–100 percent mortality is expected due to the effects of suspended sediment on these life stages (in addition to other sources of mortality). Based on spawning surveys conducted from 2001 to 2005 (Magneson and Gough 2006), from 6 to 13 redds could be affected in 2019 during the Proposed Action, many of which are thought to be hatchery returning fish (NOAA Fisheries Service 2010a). Based on the range of escapement estimates of Ackerman et al. (2006), 13 redds (the highest number observed) could represent anywhere from 0.7 to 26 percent of the naturally returning spawning in the Upper Klamath River Population Unit, and much less than 1 percent of the natural and hatchery returns combined.
- Coho salmon smolts outmigrating from tributaries in the Upper or Mid-Klamath River, Shasta, or Scott populations during early spring (around 46 percent of outmigrating smolts compared to those that outmigrate in late spring) are predicted to experience 20 percent mortality under a most-likely-to-occur scenario, or around 49 percent mortality under a worst-case scenario. Anticipated total mortality varies by population, and is detailed in ~~Appendix~~ Appendix E.

All population units would be expected to recover from these losses within one or two generations, given the benefits to the population. Although no single year-class is expected to be completely lost, mortality of a portion of the smolt outmigration from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units may affect the strength of the 2018 year class, requiring two or three generations to recover from losses.

The Proposed Action would also result in the release of bedload sediment, as described in detail in Appendix F. Effects associated with release of coarse sediment are expected to affect the same individuals described for suspended sediment above. For example, bedload sediment is predicted to bury redds constructed in fall 2019, which are the same redds expected to suffer from suspended sediment (~13 redds, or 0.7–26 percent of Upper Klamath River Population unit natural escapement). In addition, bedload sediment could result in the deposition that could aggrade pools or overwhelm other habitat features that coho salmon use for adult holding or juvenile rearing. However, the effect on habitat is anticipated to be short term, and pools would likely return to their pre-sediment release depth within one year (~~Stillwater Sciences 2008~~Reclamation 2012). If the magnitude and duration of flows in spring 2020 are sufficiently high to effectively mobilize the bed, coho salmon spawning

habitat in the mainstem downstream ~~of~~ from Iron Gate Dam could improve over existing conditions. ~~In the long term,~~Within six months the river is predicted to revert to and maintain a pool-riffle morphology~~.~~, providing a benefit to coho salmon.

~~The described~~As discussed in detail above in the subsection of Section 3.3.4.3.2, dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. Cooler water temperatures during fall would benefit upstream migrant adults and juveniles during fall upstream migration and juvenile redistribution to overwintering habitats by providing a broader window of suitable habitat. Spring outmigrants may also move out earlier, potentially reducing their susceptibility to parasites. As with SSCs, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to poor water quality due to the Proposed Action, but these effects would be short term.

Incidence of disease are expected to be reduced by enhancing the scour capabilities of flow by uninterrupted sediment transport, a flow regime that more closely mimics natural conditions, thereby disturbing the habitat of the polychaete worm that hosts *C. shasta*. Reducing polychaete habitat would likely increase abundance of smolts by increasing outmigration survival.

Estuary ~~The~~
Under the Proposed Action, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see the subsection of Section 3.2.4.3.2). However, the Proposed Action is not expected to substantially change or affect coho salmon estuarine habitat. ~~Sediment, flow,~~Flow and water temperature effects would likely not extend downstream to the estuary.

Summary: Coho Salmon
Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect coho salmon. In general, the wide distribution and use of tributaries by both juvenile and adult coho salmon will likely protect the population from the worst effects of the Proposed Action. However, direct mortality is anticipated for ~~around 13~~ redds~~, or 0.7–26 percent of Upper Klamath River Population unit natural escapement. Direct mortality is also anticipated for 2,668~~ and smolts ~~under the most-likely to occur scenario, or 6,536 smolts under a worst-case scenario. This equates to no mortality~~from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units. No mortality is anticipated for the

Salmon River, Trinity River, and ~~lower~~Lower Klamath River populations under the most likely or worst-case scenarios~~, and 9 percent of the production from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units, or 22 percent under a worst-case scenario. Sublethal effects are anticipated for all other life-stages~~. All population units would be expected to recover from these losses within one or two generations, given the~~ long-term~~ benefits described below. ~~Although no single year-class is expected to be completely lost, mortality of a portion of the smolt outmigration from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units may affect the strength of the 2018 year class, requiring two or three generations to recover from losses.~~ **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units in the short term. Based on no reduction in the abundance of a year class, the effect of the Proposed Action would be less-than-significant for the coho salmon from the three Trinity River population units, Salmon River and the Lower Klamath River Population Unit in the short term.**

Implementation of Mitigation Measures AR-1 through AR-4 (see Section 3.3.4.4) could reduce the short-term effects of SSCs on coho salmon adults, incubating eggs, and smolts. With implementation of mitigation measures there would still be short term effects for coho salmon including direct mortality to as high as 18 percent of the smolts from some population units under a worst-case scenario (see Section 3.3.4.4). **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would have a significant effect on coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units after mitigation in the short term.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, temperature variation, ~~and~~ fish disease incidence, and algal toxins which could affect coho salmon in the long term. Substantial declines in abundance resulting from effects of the Proposed Action are not anticipated for more than one year class (i.e. one generation), although complete recovery of that year class may require two to three generations. Dam removal would restore connectivity to habitat on the mainstem Klamath River up to and including Spencer Creek and would create additional habitat within the Hydroelectric Reach. As discussed in detail above, dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. It is anticipated that as a result of the Proposed Action, the ~~upper~~Upper Klamath River, ~~mid~~Mid-Klamath River, Shasta River, Scott River, Salmon River, and ~~lower~~Lower Klamath River coho salmon population units would have an increase in abundance, productivity, population spatial structure, and genetic diversity. In general, free flowing conditions as per the Proposed Action, would likely provide optimal efficiency, decrease outmigrant delay, and increase concomitant adult escapement (Buchanan et al. ~~2011a~~2011b). It is anticipated that as a result of the Proposed Action,

the three Trinity River population units would have increased productivity. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for the coho salmon from the Upper Klamath River, Mid-Klamath River, Lower Klamath River, Shasta River, Scott River, and Salmon River population units in the long term**. **Based on improved habitat quality, the effect of the Proposed Action on coho salmon from the three Trinity River population units would be less-than-significant for the long term.**

Steelhead A Coho Salmon and Steelhead Expert Panel was convened and charged with answering specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action on coho salmon and steelhead (Dunne et al. 2011). The conclusion of the Panel was that the Proposed Action ~~would~~ could result in increased spatial distribution and abundance of steelhead. This assessment is based on the observations that steelhead would be able to access a substantial extent of new habitat, steelhead are relatively tolerant to warmer water (compared to coho salmon), they are similar to other species (resident redband/rainbow trout) that are currently thriving in upstream habitats, and that while steelhead are currently at lower abundances than historical values, they are not yet rare. The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Under the Proposed Action, dam removal would allow steelhead to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. This would expand the population's distribution to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). ~~Steelhead are known to use intermittent~~This would be a potential increase in access to 49 significant tributaries ~~for spawning; Huntington (2006), counting only perennial stream~~in the Upper Klamath Basin, comprising 360 miles~~, estimated that potential new~~ of additional potentially productive habitat ~~could reach 500 miles. Current distribution of redband trout within areas that would be accessible to steelhead has been estimated at 496 miles by ODFW (W. Tinniswood, pers. comm., 2011). Because redband trout have habitat requirements similar to those of steelhead, this can be used as a rough estimate of habitat that may also be available to steelhead.~~ (Huntington 2006; DOI 2007; NOAA Fisheries Service 2007).

The Proposed Action would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease in the Upper Klamath River. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
The Proposed Action would restore steelhead access to the Hydroelectric Reach, including an estimated 80 miles of habitat within the Hydroelectric Reach, as described in the No Action/No Project Alternative analysis above. Adults could first access this reach in fall 2020 (winter steelhead) or winter 2021 (summer steelhead) after dam removal (summer steelhead spawning typically does not begin until December). Elevated ~~suspended sediment concentrations~~SSCs resulting from dam removal would likely have

returned to background levels similar to existing conditions. Steelhead could use this reach as a migration corridor, as most sediment released from the reservoirs would likely be eroded within the first ~~5~~6 months after dam removal (by May 2020) and would not impede upstream movement. Reaches currently inundated by reservoirs and reaches between reservoirs would likely return to a pool-riffle morphology, which would benefit rearing steelhead.

The Proposed Action would also eliminate the reservoirs and establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). The action would also be likely to nearly eliminate blue-green algae blooms and their associated toxins, improving water quality. These changes would benefit steelhead.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the ~~lower~~Lower Klamath River in the short term, and restore a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on steelhead under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario, no effect from suspended sediment relative to existing conditions is anticipated for the half-pounder life history, all spawning (which occurs primarily in tributaries), and age 0 rearing (Table 3.3-8). Sublethal effects are anticipated for all other life stages (Table 3.3-8), with the following exceptions:

- Under the most-likely-to-occur scenario, up to 36 percent mortality is predicted for the winter run steelhead (up to 1,008 adults, or up to 14 percent of the total winter run escapement). On average around 20 percent of winter steelhead migrate prior to initiation of reservoir drawdown on December 15th. In addition, steelhead are highly mobile species that have been known to stray to avoid habitat degradation (Bisson et al. 2005), and regularly occur in environments with high SSC, and therefore the predictions described here are likely more dire than would occur. It is likely that at least some would enter tributaries if conditions within the mainstem were adverse.
- Under the most-likely-to-occur scenario, up to 52 percent mortality is predicted for age 1 juveniles in the mainstem (up to 8,200 juveniles or around 14 percent of total basin-wide age 1 production).
- Under the most-likely-to-occur scenario, up to 52 percent mortality is predicted for age 2 juveniles in the mainstem (up to 6,893 juveniles or around 13 percent of total basin-wide age 2 production).

- Under the worst-case scenario, 0 to 20 percent mortality is predicted for the summer run steelhead (from 0 to 130 adults, or from 0 to 9 percent of the basin-wide escapement).
- Under the worst-case scenario, 71 percent mortality is predicted for the winter run steelhead (up to 1,988 adults, or up to 28 percent of the basin-wide escapement). On average around 20 percent of winter steelhead migrate prior to initiation of reservoir drawdown on December 15th. In addition, steelhead are highly migratory species that stray to avoid habitat degradation (Bisson et al. 2005), and regularly occur in environments with high SSC, and therefore the predictions described here are likely more dire than would occur.
- Under the worst-case scenario, up to 71 percent mortality is predicted for age 1 juveniles in the mainstem (up to 11,207 juveniles or around 19 percent of total basin-wide age 1 production).
- Under the worst-case scenario, up to 71 percent mortality is predicted for age 2 juveniles in the mainstem (up to 9,412 juveniles or around 18 percent of total basin-wide age 2 production).

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead~~.~~

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
	Existing Conditions (normal)					
Most likely	**Summer run:** Major stress, possibly impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 45% of escapement) **Winter run:** Major stress, possibly impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 80% of escapement)	**Adult runbacks:** Major stress depending on time spent in mainstem **Half-pounder residency:** Many will have returned to the ocean or estuary; those remaining may experience major stress in the mainstem, but may avoid suspended sediment by entering nearby tributaries	Most spawning takes place in tributaries; no effects predicted	Major stress for age 0+ juveniles in mainstem (about 60% of juveniles)	**Age 1+ rearing:** Major stress for juveniles in mainstem (about 60% of juveniles) **Age 2+ rearing:** Major stress for juveniles in mainstem (about 60% of juveniles)	Major stress during outmigration, depending on time spent in mainstem; about 57% outmigrate from Trinity River and will have less exposure

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead.

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
	Proposed Action					
Most likely	**Summer run:** Same as existing conditions **Winter run:** Major stress, impaired homing, and up to 36% mortality (Up to 1,008 adults, or up to 14% of the total escapement)	**Adult runbacks:** Same as existing conditions **Half-pounder residency:** Same as existing conditions	Same as existing conditions	Major stress resulting in reduced growth	**Age 1+ rearing:** Major stress, reduced growth, and up to 52% mortality. (Up to 8,200 juveniles or around 14% of total age 1 production) **Age 2+ rearing:** Reduced growth and up to 52% mortality (Up to 6,893 juveniles or around 13% of total age 2 production)	Major stress and reduced growth

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead~~.~~

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
Worst-case	**Existing conditions (extreme)**					
	Summer run: Major stress, impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 53% of run) **Winter run:** Major stress and potential for impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 80% of run)	**Adult runbacks:** Major stress; exposure dependant on time it takes runbacks to return to sea **Half-pounder residency:** Major stress and reduced growth for any in mainstem, but most assumed to remain in tributaries or to have returned to the ocean or estuary. Those remaining may experience major stress and reduced growth in the mainstem, but may avoid suspended sediment by entering nearby tributaries.	Most spawning takes place in tributaries; no effects predicted	Major stress and reduced growth for age 0+ juveniles in mainstem (about 60% of juveniles)	**Age 1+ rearing:** Stress, reduced growth, and up to 20% mortality for juveniles in mainstem (about 60% of juveniles) **Age 2+ rearing:** Major stress and reduced growth for juveniles in mainstem for juveniles in mainstem (about 60% of juveniles)	Major stress resulting in reduced growth, about 57% outmigrate from Trinity River and will have less exposure

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead.

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
	Proposed Action					
Worst-case	**Summer run:** Major stress, impaired homing, and up to 20% mortality (from 0 to 130 adults, or from 0 to 9% of the basin-wide escapement) **Winter run:** Major stress, impaired homing, and up to 71% mortality. The proportion migrating prior to January would not be affected. (Up to 1,988 adults, or up to 28% of the basin-wide escapement).	**Adult runbacks:** Major stress **Half-pounder residency:** Same as existing conditions	Same as existing conditions	Same as existing conditions	**Age 1+ rearing:** Stress, reduced growth, and up to 71% mortality Up to 11,207 juveniles or around 19% of total age 1 production) **Age 2+ rearing:** Stress, reduced growth and up to 71% mortality (Up to 9,412 juveniles or around 18% of total age 2 production).	Same as existing conditions

- ~~Under the worst-case scenario, 71 percent mortality is predicted for the winter run steelhead (up to 1,988 adults, or up to 28 percent of the basin-wide escapement). On average around 20 percent of winter steelhead migrate prior to initiation of reservoir drawdown on December 15th. In addition, steelhead are highly migratory species that stray to avoid habitat degradation (Bisson et al. 2005), and regularly occur in environments with high SSC, and therefore the predictions described here are likely more dire than would occur.~~
- ~~Under the worst-case scenario, up to 71 percent mortality is predicted for age 1 juveniles in the mainstem (up to 11,207 juveniles or around 19 percent of total basin-wide age 1 production).~~
- ~~Under the worst-case scenario, up to 71 percent mortality is predicted for age 2 juveniles in the mainstem (up to 9,412 juveniles or around 18 percent of total basin-wide age 2 production).~~

As described in detail in Appendix F, dam-released sediment associated with the Proposed Action might aggrade pools or overwhelm other habitat features used for adult holding or juvenile rearing above Cottonwood Creek. The effect would be short term (< one years), as pools would likely return to their pre-sediment release depth ~~relatively quickly (Stillwater Sciences 2008). In the long term,~~ (Reclamation 2012). Within six months the river would revert to and maintain a pool-riffle morphology. In the long term, under this alternative bedload sediment transport would restore vital aquatic habitat.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the ~~lower~~Lower Klamath River. ~~Dam~~As discussed in detail above, dam removal would cause water temperatures to warm earlier in the spring and early summer and cool earlier in the late summer and fall, and ~~to~~ have diurnal variations more in sync with historical migration and spawning periods. These changes would result in water temperature more favorable for salmonids occurring in the mainstem. Migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to low dissolved oxygen due to the Proposed Action, but these effects would be short term. ~~Restoring flow variability and natural sediment transport processes would likely reduce habitat conditions for the polychaete host for salmonid parasites, although this would benefit Chinook and coho salmon to a greater degree because steelhead are generally resistant to infection.~~ All of these long-term changes would benefit steelhead using the ~~lower~~Lower Klamath River Reach.

Estuary~~ The~~
Under the Proposed Action, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see the subsection of Section 3.2.4.3.2). However, the Proposed Action is not expected to substantially change or affect steelhead estuarine habitat. ~~Sediment,~~

~~flow,~~Flow and water temperature effects would likely not extend downstream to the estuary.

Summary: Steelhead

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect steelhead. In general, the effects of suspended sediment resulting from the Proposed Action on steelhead are likely to be much higher than under existing conditions and the No Action/No Project Alternative, particularly for the portion of the population that spawns in tributaries upstream of the Trinity River. For that portion of the population, effects are anticipated ~~for at least six year-classes, including~~ on adults, run-backs, half-pounders, any juveniles rearing in the mainstem, and outmigrating smolts. However, the broad spatial distribution of steelhead in the Klamath Basin and their flexible life history suggests that some will avoid the most serious effects of the Proposed Action by (1) remaining in tributaries for extended rearing, (2) rearing farther downstream where SSC should be lower due to dilution (e.g., the progeny of the adults that spawn in the Trinity River Basin or tributaries downstream ~~of~~ from the Trinity River), and/or (3) moving out of the mainstem into tributaries and off-channel habitats during winter. In addition, the life-history variability observed in steelhead means that, although numerous year classes will be affected, not all individuals in any given year class will be exposed to the effects of the Proposed Action. In addition, some portion of the progeny of those adults that spawn successfully would rear in tributaries long enough to not only avoid the most serious impacts of the Proposed Action in 2020, but may also not return to spawn for up to two years, when any suspended sediment resulting from the Proposed Action should be greatly reduced. The high incidence of repeat spawning among summer-run steelhead (ranging from 40 to 64 percent, Hopelain 1998) should also increase that population's resilience (including ~~of~~ all year classes) to effects of the Proposed Action. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for summer and winter steelhead in the short term.**

Implementation of Mitigation Measures AR-2 and AR-3 (see Section 3.3.4.4.2 and 3.3.4.4.3) could be implemented to reduce the short-term effects of SSCs on steelhead adults and outmigrating juveniles. With implementation of mitigation measures there would still be short-term effects on summer and winter steelhead, including sublethal and lethal effects. **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would be a significant effect on summer and winter steelhead in the short term after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, temperature variation, and algal toxins which could affect steelhead in the long term. Dam removal would restore connectivity to ~~496~~ hundreds of miles of historical habitat in the Upper Klamath Basin and would create additional habitat within the Hydroelectric Reach ~~(W. Tinniswood, pers. comm., 2011). It is anticipated that as a result of the Proposed Action the summer and winter steelhead within the Klamath River watershed would have an increase in abundance, productivity,~~

population spatial structure, and genetic diversity. In general, . FERC (FERC 2007) concluded that implementing fish passage would help to reduce adverse effects to steelhead associated with lost access to upstream spawning habitats. Hamilton et al. (2011) also concluded that access to additional habitat in the upper Klamath River watershed would benefit steelhead runs. In general, dam removal with KBRA would likely result in the restoration of more reproducing populations, increased abundance, higher genetic diversity, and the opportunity for variable life histories and use of new habitats (Hamilton et al. 2011). In general, free flowing conditions as per the Proposed Action, would likely provide optimal efficiency, decrease outmigrant delay, and increase concomitant adult escapement (Buchanan et al. 2011a). Almost any type of fish passage structure would be less efficient as a migration corridor for fish than removing the obstacle to passage itself. For example, fish ladders may cause delays in adult upstream migration or may become blocked by debris, and juvenile fish may have to navigate through impoundments with poor water quality or non-native predatory fish. Any of these potential factors has a chance of affecting fitness, survival, or reproductive success (Buchanan et al. 2011a2011b). By providing an unimpeded migration corridor, the Proposed Action would provide the greatest possible benefit related to fish passage, hence, the highest survival and reproductive success (Buchanan et al. 2011b). As discussed in detail above, dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for summer and winter steelhead in the long term**.

Pacific Lamprey Access to habitat would benefit Pacific lamprey by increasing their viability through: a) extending the range and distribution of the species; b) providing additional spawning and rearing habitat; c) increasing the generic diversity of the species; and d) increasing the abundance of the Pacific lamprey population (Administrative Law Judge 2006). The FERC (2007) concluded that "Removal of Iron Gate dam provides the greatest potential to expand the range of Pacific lamprey, a species of cultural importance to the tribes, to potential habitat upstream of Iron Gate dam." A Lamprey Expert Panel (Panel) was convened to compare the potential and charged with answering specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action and existing conditions on lamprey (Close et al. 2010). The conclusion was that the Proposed Action could increase Pacific lamprey production habitat by up to 14 percent. . The increase could potentially be more if habitat in the Upper Klamath Basin is accessible and suitable. The panel also concluded there might be a total increase of production of outmigrant lamprey (and hence harvest potential) in the range of 1 to 10 percent relative to the No Action Alternative. The Panel expects that adult Pacific lamprey would recolonize newly accessible habitat after dam removal, but natural colonization of all habitat available to them may take decades. Larval rearing capacity downstream of from Iron Gate Dam is expected to increase after dam removal because a large amount of fine sediment—a major component of larval rearing habitat—would be released through dam removal. The available burrowing habitat for larvae

would subsequently decrease over time, but would likely remain higher than under current conditions because sediment input and transport processes would be restored and KBRA measures would increase sediment transport -(Close et al. 2010). In addition, the return to a temperature regime and flows that more closely mimic natural patterns would likely benefit Pacific lamprey, which evolved under those conditions. The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Pacific lamprey did notoccurred historically occur upstream of J.C. Boyle Reservoir (Hamilton et al. 2005) and are not anticipated to occupy this reach after implementation of this alternativeat least to Spencer Creek (Hamilton et al. 2005), although there is some uncertainty in this regard (Administrative Law Judge (2006). It is anticipated that Pacific lamprey below Iron Gate dam would migrate above the dam if access was provided (Administrative Law Judge (2006).

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
The Proposed Action would provide Pacific lamprey with access to the Hydroelectric Reach and to the mainstem Klamath River and its tributaries upstream at least as far as Spencer Creek, including Jenny, Shovel, and Fall creeks (Hamilton et al. 2011). Most sediment released from the reservoirs would likely be eroded within the first fivesix months after dam removal (by May 2020), returning sections of river currently inundated by reservoirs and riverine sections between reservoirs to a pool-riffle morphology. After erosion of dam-stored sediment, the Hydroelectric Reach would likely contain gravel suitable for lamprey spawning and rearing.

The Proposed Action would also eliminate the reservoirs and establish a flow regime that more closely mimics natural conditions. Drawing down the reservoirs would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). These changes would result in more favorable water temperatures for native fishes, and improved water quality. These changes would provide a long-term benefit to Pacific lamprey produced that occur within the Hydroelectric Reach.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

The Proposed Action would release dam-stored sediment and reduce dissolved oxygen downstream to the ~~lower~~Lower Klamath River in the short term, and restore a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on Pacific lamprey under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario, sublethal effects from suspended sediment relative to existing conditions is anticipated for outmigrants, and for Pacific lamprey migrating to or from the Trinity River or tributaries further downstream (Table 3.3-9). High rates of mortality are predicted for adults and ~~ammocoestes~~ammocoetes in the mainstem Klamath River during winter and spring 2020. However, there is little to no literature on the effects of suspended sediment on lamprey. This analysis used the effects of suspended sediment on salmonids to predict effects on lamprey, with the assumption that effects on lamprey are equivalent or less severe than on salmonids. In general, most life stages of Pacific lamprey appear more resilient to poor water quality conditions (such as suspended sediment) than salmonids (Zaroban et al. ~~-~~1999), so this is likely a conservative assessment of potential effects.

The Proposed Action would affect spawning and incubation in the area between Iron Gate Dam and Cottonwood Creek by burying gravel in dam-released sediment and increasing the proportion of sand in the bed, thereby decreasing ammocoete survival. The ~~river would be~~ bed material within the reservoirs and between Iron Gate to Cottonwood Creek is expected to ~~return to its existing bedform after~~have a high content (30 to 50 percent) of sand immediately following reservoir drawdown until a ~~few~~flushing flow moves the sand sized material out of the reach (Reclamation 2012). The flushing flow is expected to be at least 6,000 cfs and of several days to weeks to return the bed to a bed dominated by cobble and gravel with a sand content less than 20 percent. After the flushing flow, the bed is expected to maintain fractions of sand, gravel, and cobble which would be expected under natural conditions, and suitable for Pacific lamprey. Based on the historical record a sufficient flushing flow would likely occur within 5 years following dam removal.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the ~~lower~~Lower Klamath River Reach. Dam removal would cause water temperatures to have natural diurnal variations. These changes would result in water temperatures that are more similar to those that Pacific lamprey evolved with and would improve water quality. These long-term changes would likely provide a benefit to Pacific lamprey using the ~~lower~~Lower Klamath River.

Estuary ~~The Proposed Action is not expected to substantially change or affect Pacific lamprey estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.~~

Under the Proposed Action, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less

than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be

Table 3.3-9. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Pacific Lamprey.

Scenario	Life History Stage: Pacific Lamprey		
	Adult Migration and Spawning (all of 2020)	**Ammocoete Rearing (all of 2020)**	**Outmigration Spring (May 1–June 30, 2020) Fall/winter (Sept 1–Dec 31, 2020)**
Most Likely	**Existing Conditions (normal)**		
	Major stress and impaired homing; later-returning adults and those returning to lower tributaries would have less exposure	**Ammocoete rearing:** Major stress of ammocoetes in mainstem for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would have lower exposure	**Spring outmigration:** Major stress
			Fall and winter outmigration: Moderate stress and reduced feeding
	Proposed Action		
	Major stress and up to 36% mortality; later-returning adults and those returning to lower tributaries would have less exposure	**Ammocoete rearing:** Major stress, reduced growth, and up to 52% mortality	**Spring outmigration:** Same as existing conditions
			Fall and winter outmigration: Same as existing conditions
Worst-case	**Existing Conditions (extreme)**		
	Major stress and impaired homing; later-returning adults and those returning to lower tributaries would have less exposure	**Ammocoete rearing:** Major stress and reduced growth	**Spring outmigration:** Moderate to major stress and reduced growth
			Fall and winter outmigration: Major stress
	Proposed Action		
	Major stress, reduced growth, and up to 71% mortality	**Ammocoete rearing:** Major stress, reduced growth, and up to 71% mortality for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would not suffer mortality	**Spring outmigration:** Same as existing conditions
			Fall and winter outmigration: Same as existing conditions

higher than the extreme values estimated by the sediment transport model for existing conditions (see the subsection of Section 3.2.4.3.2). However, the Proposed Action is not expected to substantially change or affect Pacific lamprey estuarine habitat. Flow and water temperature effects would likely not extend downstream to the estuary.

Summary: Pacific Lamprey

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect Pacific lamprey. The Proposed Action would have short-term effects related to SSCs, bedload sediment transport and deposition, and water quality (particularly dissolved oxygen). Overall, because multiple year classes of lamprey rear in the mainstem Klamath River at any given time, and since adults will migrate upstream over the entire year, including January 2020 when effects from the Proposed Action will be most pronounced, effects on Pacific lamprey adults and ammocoetes could be much higher in the mainstem Klamath River than under existing conditions and the No Action/No Project Alternative. However, because of their wide spatial distribution and varied life history, most of the population would likely avoid the most severe suspended sediment pulses resulting from the Proposed Action. In addition, Pacific lamprey are considered to have low fidelity to their natal streams (FERC 2006), and may not enter the mainstem Klamath River if environmental conditions are unfavorable in 2020. Migration into the Trinity River and other ~~lower~~Lower Klamath River tributaries may also increase during 2020 because of poor water quality. Low fidelity also increases the potential that lamprey can recolonize mainstem habitat if ammocoetes rearing there suffer high mortality. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for Pacific lamprey in the short term.**

Implementation of Mitigation Measures AR-2 and AR-5 (see ~~Section~~Sections 3.3.~~4.~~4.4.2 and 3.3.4.4.5) could be implemented to reduce the short-term effects of dissolved oxygen and SSCs on lamprey ammocoetes. With implementation of mitigation measures there could still be short-term effects for lamprey including sublethal and lethal effects. **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would be a significant effect on Pacific lamprey in the short term after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, and temperature variation which could affect Pacific lamprey in the long term. The Proposed Action would provide access to habitat ~~in the Hydroelectric Reach and tributaries to this reach~~upstream of Iron Gate Dam at least as far as Spencer Creek. It is anticipated that as a result of the Proposed Action the Pacific lamprey population within the Klamath River watershed would have an increase in abundance, productivity, population spatial structure, and genetic diversity. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for Pacific lamprey in the long term**.

Green Sturgeon -Listed Southern Green Sturgeon may enter the Klamath River estuary to forage during the summer months. They would not be present when the most severe

effects of dam removal are occurring, and are not expected to be affected by the Proposed Action. The remainder of this section focuses on the effects of the Proposed Action on the Northern Green Sturgeon DPS. Northern Green Sturgeon do not occur upstream of Ishi Pishi Falls and would not be affected by Proposed Action effects that do not extend downstream past these falls.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the ~~lower~~Lower Klamath River in the short term, and restore a flow regime that more closely mimics natural seasonal flow patterns in the long term. Suspended sediment effects on green sturgeon under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario no effect relative to existing conditions is predicted for adults (Table 3.3-10), mostly because green sturgeon distribution within the mainstem Klamath River is primarily limited to areas downstream ~~of~~ from Orleans, where the effects of SSC resulting from the Proposed Action are more diluted from tributary accretion. Up to 100 percent mortality is predicted for incubating eggs and larval life stages, and up to 20 percent mortality is predicted for rearing juveniles under a most-likely-to-occur scenario, or up to 40 percent mortality of juveniles under a worst-case scenario. However, around 30 percent of juveniles rear in the Trinity River and would not be exposed to SSC from the Proposed Action.

Bedload sediment effects related to dam-released sediment would not extend as far downstream to Ishi Pishi Falls and would not affect green sturgeon.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the ~~lower~~Lower Klamath River and would improve water quality and reduce instances of algal toxins. These long-term effects would benefit green sturgeon using the ~~lower~~Lower Klamath River reach.

Estuary~~ The~~

Under the Proposed Action, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see Section 3.2.4.3.2.2). However, the Proposed Action is not expected to substantially change or affect estuarine habitat. ~~Sediment, flow,~~Flow and water temperature effects resulting from the Proposed Action would likely not extend downstream to the estuary.

~~*Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and affect green sturgeon.* Overall the effects of the Proposed Action are most likely to include physiological stress, inhibited growth, and high mortality for some~~

~~portion of the age-0 2020 cohort and age 1 2019 cohort. However, effects on salmonids likely overestimate those on sturgeon. To summarize, green sturgeon in the Klamath Basin have the following traits likely to enhance the species' resilience to impacts of the Proposed Action:~~

- ~~Most of the population (subadult and adult) would be in the ocean during the year of the Proposed Action (2020) and would be unaffected (Appendix E).~~
- ~~The approximately 30 percent of the population that spawn and rear in the Trinity River would be unaffected.~~
- ~~Much of the spawning and rearing of green sturgeon occurs downstream of the Trinity River, where sediment concentrations would be similar to existing conditions and the No Action/No Project Alternative.~~
- ~~Green sturgeon are long-lived (>40 years) and are able to spawn multiple times (~8 times) (Klimley et al. 2007), so effects on two year classes may have little influence on the population as a whole.~~

Table 3.3-10. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Green Sturgeon. Based on salmonid literature; effects likely overestimated.

Scenario	Life History Stage: Green Sturgeon			
	Adult migration	**Post-spawning holding**	**Spawning through hatching/larvae**	**Juvenile Rearing (year-round) and Outmigration**
Most Likely	**Existing conditions (normal)**			
	Moderate to major stress; 75% of adults not expected to migrate in 2020	No effects	Up to 68% mortality; about 30% that spawn in Trinity River would be unaffected (based on salmonid literature; effects likely overestimated)	Major stress; about 30% of juveniles rear in Trinity River and would be unaffected (based on salmonid literature; effects likely overestimated)
	Proposed Action			
	Major stress	Same as existing conditions	76% mortality for all mainstem production	Reduced growth and up to 20% mortality
Worst-case	**Existing conditions (extreme)**			
	Major stress	Short period (<1 week) of relatively low SSCs, not expected to result in deleterious effects	84% mortality for all mainstem production	Major stress and reduced or no growth (based on salmonid literature; effects likely overestimated)
	Proposed Action			
	Same as existing conditions; about 25% of adults expected to be exposed in 2020	Same as existing conditions; about 75% of adults hold in mainstem after spawning; remainder return to ocean	95% mortality for all mainstem production ; about 30% that spawn in Trinity River would be unaffected	Reduced growth and up to 36% mortality; about 30% of juveniles rear in Trinity River and would be unaffected

Summary: Green Sturgeon
Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and affect green sturgeon. Overall the effects of the Proposed Action are most likely to include physiological stress, inhibited growth, and high mortality for some portion of the age-0 2020 cohort and age 1 2019 cohort. To summarize, green sturgeon in the Klamath Basin have the following traits likely to enhance the species' resilience to impacts of the Proposed Action:

- Most of the population (subadult and adult) would be in the ocean during the year of the Proposed Action (2020) and would be unaffected (Appendix E).
- The approximately 30 percent of the population that spawn and rear in the Trinity River would be unaffected.
- Much of the spawning and rearing of green sturgeon occurs downstream from the Trinity River, where sediment concentrations would be similar to existing conditions and the No Action/No Project Alternative.

Green sturgeon are long-lived (>40 years) and are able to spawn multiple times (~8 times) (Klimley et al. 2007), so effects on two year classes may have little influence on the population as a whole.

Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for green sturgeon in the short term.

Implementation of Mitigation Measure AR-3 (see Section 3.3.4.4.3) could be implemented to reduce the short-term effects of SSCs on green sturgeon adults post-spawning. With implementation of mitigation measures there would still be short-term effects for green sturgeon including sublethal and sublethal effects. **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would be a significant effect on green sturgeon in the short term after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in flow regime, water quality, temperature variation, and algal toxins which could affect green sturgeon in the long term. It is anticipated that as a result of the Proposed Action, the green sturgeon population within the Klamath River watershed would have an increased productivity. **Based on improvements in habitat quality within part of their range, the effect of the Proposed Action would be less-than-significant for green sturgeon in the long term.**

Lost River and Shortnose Sucker A Resident Fish Expert Panel (Panel) was convened to compare the potential effects of the Proposed Action and existing conditions on resident fish, including sucker populations (Buchanan et al. 2011a). The Panel concluded that under the Proposed Action, specifically with implementation of KBRA, restoration strategies used to recover suckers including lake level management, water quality improvement, and habitat restoration (wetlands and spawning and rearing habitat) are

expected to increase spawning success, and larval, juvenile, and adult survival leading to larger populations and more frequent recruitment.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Under the Proposed Action, water elevations in Upper Klamath Lake would be higher, which would benefit Lost River and shortnose suckers, but the difference in habitat value would not be substantive. The KBRA is expected to provide benefits to sucker populations through the following measures: nutrient reduction, reconnecting former wetlands to Agency Lake, reconstructing quality rearing habitat for early life stages, and restoring shoreline spring spawning habitat restoration, among others.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Lost River and shortnose suckers are found within reservoirs in Hydroelectric Reach. The Proposed Action would eliminate reservoir habitat, and as dams within the Hydroelectric Reach were removed, sediment would move downstream. Under the Proposed Action adult Lost River and shortnose suckers in reservoirs downstream ~~of~~from Keno Dam would be captured and relocated to Upper Klamath Lake (Buchanan et al. 2011a). Those not relocated to the Upper Klamath Basin would likely be lost; however, since little or no reproduction occurs downstream ~~of~~from Keno Dam (Buettner et al. 2006), there is no potential for interaction with upstream populations, and they are not considered to substantially contribute to the achievement of conservation goals or recovery (Hamilton et al. 2011). Lost River and shortnose suckers are listed as fully protected species under California Fish and Game code; thus, any take of these species is prohibited. ~~-~~However, if there is an Affirmative Determination by the Secretary, and a ~~component~~concurrence by the State of ~~the Proposed Action includes~~California, CDFG will provide draft legislation to ~~permit the~~the other KHSA/KBRA parties which would authorize limited take of ~~some individuals during implementation.~~ these fully protected species.

Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Generally, with the exception of *F. columnaris* and Ich, pathogens associated with anadromous fish do not impact non-salmonids (e.g. suckers) (Administrative Law Judge 2006). In the most recent review of effects of interactions between reintroduced anadromous fish and federally listed suckers, the USFWS concludes that indirect effects of removal of the lower four dams is "not likely to adversely affect" listed fish because the effects are insignificant (Roninger 2012).

Summary: Lost River and Shortnose Suckers
Reservoir removal associated with dam removal under the Proposed Action could alter habitat availability and affect ~~lost river~~Lost River and shortnose suckers. **Based on reduction in abundance within reservoirs, the effect of the Proposed Action would be significant for Lost River and shortnose sucker populations in the short term.**

Implementation of Mitigation Measure AR-6 (see Section 3.3.4.4.6) could be implemented to reduce the impact to individuals within reservoirs by rescuing fish prior to reservoir drawdown. **Based on small numbers of individuals affected after**

mitigation, and on anticipated legislation allowing take, the effect of the Proposed Action would be less-than-significant for Lost River and shortnose sucker populations in the short term after mitigation.

Restoration action associated with KBRA implementation under the Proposed Action could alter habitat availability and suitability and affect ~~lost river~~Lost River and shortnose suckers. In the long term, restoration actions under KBRA are anticipated to improve conditions for sucker populations within Klamath Lake. **Based on improved habitat quality, the effect of the Proposed Action would be beneficial for Lost River and shortnose sucker populations in the long term.**

Redband Trout A Resident Fish Expert Panel (Panel) was convened to compare the potential effects of the Proposed Action and existing conditions on resident fish, including redband trout (Buchanan et al. 2011a). The Panel concluded that the habitat improvements associated with KBRA implementation, including water quality and quantity and riparian corridor improvements and protection, are anticipated to increase trout productivity in headwater and lower tributary areas of the Upper Klamath Lake Basin. The Panel predicted that following the Proposed Action, the abundance of redband trout in the free-flowing reach between Keno Dam and Iron Gate Dam could increase significantly. In addition, they expect the existing trout and colonizing anadromous steelhead to co-exist, as they do in other watersheds, although there may be shifts in abundance related to competition for space and food. The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Under the Proposed Action, redband trout would be able to migrate more successfully from the Hydroelectric Reach to the Upper Klamath Basin (Hamilton et al. 2011) than

under existing conditions. Establishment of a flow regime that more closely mimics natural conditions downstream ~~of~~ from Keno Dam would eliminate the stranding of redband trout caused by flow reductions at Klamath Hydroelectric Project facilities~~, and would create stable stream habitat between J.C. Boyle Reservoir and the California state line.~~

.

Redband trout could be affected by increased predation from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Hamilton et al. 2011). ~~Adult salmon moving into the Upper Basin would likely bring with them genotypes of *C. shasta* that had previously been restricted to the lower river. However, facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). While the effects of these introductions are uncertain, at least some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, might not be susceptible to the new genotypes. Additionally, the changes in habitat that could result from dam removal (fewer areas of slow-flowing,~~

~~stable habitat) would likely reduce the density of polychaete populations, resulting in reduced disease exposure for fish. The close similarities between~~Furthermore, anadromous steelhead trout and resident rainbow/redband trout ~~suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species~~ co-existed and intermingled prior to the construction of Copco 1 Dam in 1917. There are many examples from nearby river systems in the Pacific Northwest showing that wild anadromous salmon and resident rainbow/redband trout can co-exist and maintain abundant populations without negative consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006).

Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Under existing conditions, redband trout are found within the Hydroelectric Reach, but are impaired from migrating between tributaries and the reservoirs to complete their life cycle because of poorly functioning fishways at J.C. Boyle Dam (DOI 2007; NOAA Fisheries Service 2007). Under the Proposed Action, redband trout would be able to migrate more successfully than under existing conditions (Hamilton et al. 2011). In addition, approximately 4 mi (6.4 km) of habitat has been adversely affected by the dewatered (100 cfs) flows in the bypass reach, and 17 mi (27.4 km) of habitat has been adversely affected by the daily fluctuating flows in the peaking reach (Administrative Law Judge 2006). In addition, the Administrative Law Judge (2006) finding regarding project flow operations stated, "Current Project operations, particularly sediment blockage at the J.C. Boyle Dam, the flow regime, and peaking operations, negatively affect the redband trout fishery."

Under this alternative, the establishment of a flow regime that more closely mimics natural conditions and eliminates peaking and associated negative aquatic impacts would benefit the redband trout populations downstream from J.C. Boyle. Redband trout throughout this reach of the mainstem, except upstream of J.C. Boyle Reservoir, would be affected by high ~~suspended sediment concentrations~~SSCs for a period of three to four months during reservoir drawdown associated with the Proposed Action. Redband trout in riverine reaches between the reservoirs in the Hydroelectric Reach would be vulnerable to sublethal and lethal effects of sediment released during dam removal and bedload deposition (Newcombe and Jensen 1996, Buchanan et al. 2011a); however, a large proportion of the adult population should be already spawning in Spencer or Shovel creeks during the dam removal. Juvenile redband trout outmigrating from Spencer Creek would be expected to recolonize the mainstem by late spring or summer when water conditions become suitable. Those in the affected area could move to tributaries for refuge.

The Proposed Action would eliminate reservoir habitat, returning sections of river currently inundated by reservoirs and riverine sections between reservoirs to a pool-riffle

morphology. Modeling data indicate that after dam removal, spawning gravel in all sections of the Hydroelectric Reach would be within the range usable for salmonids, but the amount of sand within the bed within former reservoir sections might inhibit spawning success. Riverine sections between reservoirs would be expected to provide the gravel with very little sand, suggesting high-quality spawning habitat. The initial movement of coarse and fine sediment after drawdown would likely create unfavorable conditions for redband trout within the mainstem Klamath River, but these conditions would be short term. Buchanan et al. (2011a) estimate that 43 miles of additional riverine habitat would be available to resident redband trout as a result of the Proposed Action. The adfluvial life-history strategy would no longer be possible within this reach. Migratory opportunities would increase for these fish, allowing them to access areas with suitable habitat when conditions become unfavorable in one area of their range. The Proposed Action would also increase the number of thermal refugia available to redband trout as they would have access to more tributaries, as well as to the cool areas near the mouths of tributaries and the many springs in this reach.

Summary: Redband Trout

The Proposed Action would have short~~-~~-term effects related to SSCs and bedload movement that could affect redband trout. **Based on a small proportion of the population with a potential to be exposed to short-term effects, the effect of the Proposed Action would be less-than-significant for redband trout in the short term.**

Dam removal would ~~increase~~ restore connectivity ~~between Upper~~among the Lower Klamath Basin~~ and~~, the Hydroelectric Reach and its tributaries, and the Upper Klamath Basin, and would ~~create additional~~ rehabilitate and increase availability of riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for redband trout in the long term.**

Bull Trout

Upper Klamath River Upstream of the Influence of J.C. Boyle Reservoir

To evaluate the effects of the Proposed Action on bull trout, a four member expert panel (Buchanan et al. 2011a) was convened and tasked with reviewing all available information on bull trout in the upper Klamath River, and information on potential effects of the Proposed Action. The panel concluded that the Proposed Action provides promise for preventing extinction of bull trout and for increasing overall population abundance and distribution (Buchanan et al. 2011a).

Buchanan et al. (2011a) observed that the proposed KBRA actions would enhance resident populations of headwater bull trout, and implementation of KBRA could have a significant contribution toward recovery of these populations. Passage from Sun Creek to the Wood River may be improved by KBRA actions allowing for fluvial life history forms of bull trout in the Wood River system. The cold waters of the Wood River may successfully provide habitat for reintroductions of anadromous salmon and steelhead.

Rearing anadromous juveniles could provide an increased prey base for fluvial bull trout and produce predator/prey interactions ecologically similar to historical conditions (Buchanan et al. 1997).

Summary: Bull Trout

Dam removal associated with the Proposed Action could alter habitat availability for anadromous fish, which could affect bull trout. **Based on the restricted distribution of bull trout, the Proposed Action would have a less-than-significant impact on bull trout in the short and long term**.

Eulachon

~~Lower Klamath River: Downstream of Iron Gate Dam~~ ~~The Proposed Action would release dam-stored sediment downstream to the lower Klamath River. Adult eulachon entering the Klamath River after January 2020 might be exposed to elevated SSCs for a portion of their migration period. However, these SSCs are expected to be similar to those encountered about one in ten years under existing conditions. Because eulachon generally occur within 8 miles of the coast and dam-release-related SSCs would decrease in the downstream direction from Iron Gate Dam due to dilution from tributaries, the magnitude of the effect would likely be low. Short-term decreases in water quality associated with the Proposed Action might affect adults and larvae in the mainstem Klamath River. As with SSCs, these effects might be muted by tributary inputs.~~

~~Estuary~~ ~~The Proposed Action is not expected to substantially change or affect estuarine habitat. SSCs are likely to be elevated above those occurring normally under existing conditions, but would be similar to those observed under extreme existing conditions. In the long term, sediment, flow, and water temperature effects resulting from the Proposed Action would likely not extend downstream to the estuary.~~

~~*The Proposed Action would have short term effects related to SSCs and bedload movement*. **Based on short duration of poor water quality during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on eulachon in the short and long term.**~~

~~**Longfin Smelt**~~ ~~Impacts to longfin smelt would be the same as those described for eulachon.~~

~~**Based on short duration of poor water quality during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on longfin smelt in the short and long term.**~~

Lower Klamath River: Downstream from Iron Gate Dam and Estuary

The Proposed Action would release dam-stored sediment downstream to the Lower Klamath River and estuary. Adults entering the Klamath River in the winter and spring of 2020 may be exposed to high SSC for a portion of their migration period. Although no analysis of the effects of SCC on eulachon is available, based on application of the Newcombe and Jensen (1996) approach using studies of the effects on other estuary

species, it is predicted that under a most-likely or worst-case scenario mortality would be higher under the Proposed Action than under existing conditions. Mortality is also predicted to be higher for spawning, incubation, and larval life stages under the Proposed Action than under existing condition. However, there are two key factors that reduce the likelihood that substantial numbers of individuals would be exposed. First, eulachon are in very low abundance in the Klamath River, and thus there is a very low probability that many individuals will be in the Klamath River during implementation of the Proposed Action. Second, eulachon have a relatively long period of the year when they could potentially spawn in the Klamath River (January through April; Larson and Belchik 1998), and a relatively short duration of occurrence within freshwater (around one month), increasing the probability that most of the population would migrate and spawn either before or after the largest pulses of SCC (predicted to be over 1,000 mg/L for the month of January under a worst case scenario; Figure 3.3-10).

Summary: Eulachon
The Proposed Action would have short-term effects related to SSCs and bedload movement. **Based on no substantial reduction in the abundance of a year class, the Proposed Action would be a less-than-significant effect on eulachon in the short term. Based on short duration of poor water quality in the estuary during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on eulachon in the long term.**

Longfin Smelt The Proposed Action would release dam-stored sediment downstream to the Klamath River Estuary. Longfin smelt entering the Klamath River in the winter and spring of 2020 may be exposed to high SSC for a portion of their migration period. Although no analysis of the effects of SCC on longfin smelt is available, based on application of the Newcombe and Jensen (1996) approach using studies of the effects on other estuary species, it is predicted that under a most-likely or worst-case scenario mortality would be higher under the Proposed Action than under existing conditions. However, as described for eulachon above, the protracted migration season for longfin smelt (throughout the year), and relatively short duration of occurrence in the estuary (<2 months), increase the probability that most of the population would migrate and spawn either before or after the largest pulses of SCC (predicted to be two weeks in duration or less).

The Proposed Action would have short-term effects related to SSCs and bedload movement. **Based on no substantial reduction in the abundance of a year class, the Proposed Action would be a less-than-significant effect on longfin smelt in the short term. Based on short duration of poor water quality during reservoir drawdown, the Proposed Action would have a less-than-significant effect on longfin smelt in the long term.**

Introduced Resident Species
Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Introduced resident species occur in Lake Ewauna and Upper Klamath Lake, but the Proposed Action would not affect populations in this area.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
The Proposed Action would eliminate reservoir habitat upstream of Iron Gate Dam, and thus the abundance of these species would decline substantially or be reduced to nothing, as their preferred reservoir habitat would be eliminated (Buchanan et al. 2011a).

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam
A few introduced resident species occur in the ~~lower~~Lower Klamath River, but habitat conditions there are generally not suitable for these species. Under the Proposed Action, conditions would be expected to become less suitable.

Summary: Introduced Resident Species
The Proposed Action would eliminate habitat for introduced resident species in the Hydroelectric Reach. **Because these species were introduced and they occur in other nearby water bodies, their loss would not be considered significant from a biological perspective, and would benefit native species. Their loss would, however, decrease opportunities for recreational fishing for these species, as discussed in Section 3.20, Recreation.**

Interactions Among Species The Proposed Action would restore access for anadromous salmon and steelhead to habitat upstream of Iron Gate Dam, as described in detail above. Restoration of access would result in anadromous salmon and steelhead potentially interacting with resident redband trout and bull trout. These species evolved together in the Upper Klamath Basin of the Klamath River, and co-existed prior to the construction of dams (Goodman et al. 2011).

Bull trout currently exist with redband trout in the upper basin and Proposed Action habitat benefits that would result in redband population increases would also benefit bull trout populations. In the 2007 USFWS Biological Opinion (USFWS 2007c) on relicensing of the Hydropower Project, the Service issued take for bull trout and determined that the level of anticipated take associated with reintroduction of anadromous salmonids is not likely to result in jeopardy to bull trout destruction or adverse modification of critical habitat for bull trout. In the most recent review of effects of interactions between reintroduced anadromous fish and federally listed bull trout, the USFWS concludes that indirect effects of removal of the lower four dams is "not likely to adversely affect" listed fish because the effects are insignificant (Roninger 2012).

Anadromous salmonids currently co-exist with resident rainbow trout and resident cutthroat trout downstream from Iron Gate Dam, without any obvious ecosystem detriment. While there is little information on the nature of any competitive interactions between steelhead and resident trout in the Klamath Basin, research does suggest that in some circumstances, resident trout may have a competitive edge over steelhead trout (Administrative Law Judge 2006). Conversely, a recent study showed that hatchery salmon supplementation negatively impacted resident trout abundance and salmonid biomass in a Washington watershed (Pearsons and Temple 2010). However, competition between steelhead and currently present indigenous species such as redband trout are not assumed to be a major limiting factor since these species historically co-evolved (Hooton

and Smith 2008). There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous steelhead trout and resident rainbow/redband trout can co-exist and maintain abundant populations without adverse consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006). As noted by Buchanan et al. (2011a), existing trout and colonizing anadromous steelhead are expected to co-exist, as they do in other watersheds, although there may be shifts in abundance related to competition for space and food.

Freshwater ~~mussels~~
Mussels

Suspended Sediment Concentrations

Due to the limited data available regarding overall abundance, distribution, life history, and population recruitment of freshwater mussels within the mainstem Klamath River, the overall effects that would be associated with predicted short- and long-term exposure to elevated SSCs on freshwater mussel populations as a result of the Proposed Action are difficult to determine.

Under the Proposed Action, SSCs would be expected to be higher than under existing conditions and would likely exceed 600 mg/L, the minimum SSCs level that would be considered detrimental to freshwater mussels, for 2 to 4 months after facility removal, depending on hydrologic conditions and location on the river. The SSCs in excess of ~~600~~ 600 mg/L for 2 to 3 months would occur as far downstream as Klamath Station (at RM 5.0; see Figure 3.3-~~10~~14); however, the highest levels, well in excess of 1,000 mg/L, would occur between Seiad Valley and Iron Gate Dam. Over time, as sediment stored behind the dams was diminished, the expected increase in SSCs over background levels would also diminish. Under existing conditions, SSCs could spike to levels exceeding ~~600~~ 600 mg/L upstream of Orleans, although these spikes generally occur for a few days as opposed to several months, which is what would be expected under the Proposed Action. SSCs in excess of 600 mg/L for more than 4- to 5-day periods within the mainstem Klamath River would cause major physiological stress to freshwater mussels and might result in substantial mortality. The most significant impacts would occur downstream ~~of~~ from Iron Gate Reservoir, especially to those individual freshwater mussels or freshwater mussel beds upstream of Orleans and closest to Iron Gate Dam.

Because freshwater mussels found within the Klamath River are so long lived (from 10 to more than 100 years, depending on the species) and sexual maturity might not be reached until 4 years of age or more, even relatively short term (e.g., for more than 5 consecutive days) SSCs in excess of 600 mg/L, would be expected to be detrimental for freshwater mussel populations within the mainstem Klamath River. However, it is anticipated that mainstem Klamath freshwater mussel populations would rebound, recolonizing through the transport of larvae (glochidia) by host fish from downstream populations less affected by excessive SSCs or from populations within tributaries, such as the Salmon or Scott Rivers, or from populations on the Klamath River upstream of Iron Gate Reservoir. This process is expected to take many years, however.

Changes in Bed Elevation

Silt and fine material make up the largest proportion of the volume of sediment stored behind the dams and would be transported downstream primarily as suspended sediment. Courser material (larger than 0.063 mm) would also be transported downstream and would likely be deposited in the river channel, changing riverbed elevations from the existing condition 8 miles between Iron Gate Dam and Cottonwood Creek. The 182 miles of mainstem downstream ~~of~~ from Cottonwood Creek are not predicted to have any substantial aggradation.

Of the freshwater mussel species found on the mainstem Klamath River, the western ~~ridge freshwater~~ridged mussel (*G. angulata*) seems to be the most abundant and is widely distributed between Iron Gate Dam and the confluence of the Trinity River (Westover 2010). The Klamath River differs from other Pacific Northwest rivers in that this species dominates its mussel community (Westover 2010). *G. angulata* populations are currently sparsely distributed and it has been extirpated from a portion of its range; it is believed to have had a much wider distribution historically (Westover 2010). The floater species (*Anodonta spp*.) are less abundant, with the largest single bed found immediately ~~below~~downstream from Iron Gate Dam (Westover 2010). The western pearlshell (*Margaritifera falcata*) is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found ~~below~~ downstream from the confluence of the Salmon River (Westover 2010). It is not known how well any of these species could tolerate deposition of sediment and whether they could move upward through deposited material to the surface to breathe and feed. It seems reasonable to presume that some percentage of Klamath River freshwater mussels buried under 0.5 to 3.0 feet of new sediment would not survive. Because of the relatively small area affected, these changes in bed elevation are not expected to substantially affect the overall population of freshwater mussels. It is anticipated that Klamath freshwater mussel populations would rebound eventually, recolonizing through the transport of larvae (*glochidia*) by host fish from downstream populations less affected by bed elevation changes or from populations within tributaries, such as the Trinity, Salmon or Scott Rivers, or from populations on the Klamath River upstream of Iron Gate Reservoir. However, due to the extended time it takes for freshwater mussels to reach sexual maturity (4 years or more, depending on the species), the reestablishment of freshwater mussel populations within affected reaches might be slow and might not be readily noticeable for some time, possibly a decade or more. The seven to eight species of fingernail clams and peaclams, including the montane peaclam, found in the Hydroelectric Reach and from Iron Gate Dam to Shasta River, are expected to be similarly affected.

Changes in Bed Substrate

Draining the Four Facilities under the Proposed Action would result in the erosion of accumulated sediments, changing substrate characteristics within the Klamath River, especially within the current reservoir reaches. The reformation of river channels in the reservoir reaches is expected to occur within ~~5~~6 months (see ~~Figure 3.3-9~~Figure 3.3-9). The reformation of river channels between Iron Gate Dam and the upstream reaches of J.C~~.~~. Boyle Reservoir would benefit freshwater mussels by providing more

suitable substrates (i.e., large gravel, cobble, and boulder) than currently exists, especially within the current reservoir reaches. In addition, the Proposed Action would also open access to river reaches upstream of Iron Gate Dam to migratory fish species, which might serve as host fish for parasitic freshwater mussel larvae (glochidia). As a result, suitable habitats upstream of Iron Gate Dam might be ~~opened to additional,~~colonized or ~~more rapid, colonization of~~ recolonized by freshwater mussel species, transported as glochidia from downstream reaches by migratory fish species, which are currently blocked by Iron Gate Dam. An increased distribution of anadromous salmonids resulting from dam removal would be expected to benefit *M. falcata* by increasing its distribution as well. However, due to the long time it might take for freshwater mussels to reach sexual maturity, the recolonization and/or growth of existing freshwater mussel populations upstream of Iron Gate Dam might be slow and might not readily noticeable for some time.

Summary: Freshwater Mussels

The Proposed Action would have short~~-~~-term effects related to SSCs and bedload movement. **Based on substantial reduction in the abundance of multiple year classes in the short term and the slow recovery time of freshwater mussels, the effect of the Proposed Action would be significant for mussels in the short term.**

Implementation of Mitigation Measure AR-7 (see Section 3.3.4.4.7) could be implemented to reduce the short- and long-term impacts of the Proposed Action on freshwater mussels. With implementation of mitigation measures there would still be impacts to a portion of the freshwater mussel population, and there could still be a substantial reduction in the abundance of at least one year class. **Based on substantial reduction in year classes, the Proposed Action would have a significant effect on freshwater mussels after mitigation in the short term.**

Dam removal would ~~increase~~restore connectivity ~~between Upper~~among the Lower Klamath Basin~~ and~~, the Hydroelectric Reach and ~~would create additional~~ its tributaries, and the Upper Klamath Basin, and would rehabilitate and increase availability of riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and habitat quality in the long term, the effect of the Proposed Action would be beneficial for mussels in the long term.**

Benthic Macroinvertebrates

Peaking Effects

Under the Proposed Action, Klamath Hydroelectric Project peaking operations would no longer kill, through stranding, large numbers of young fish and aquatic invertebrates that are the primary prey food for resident trout (Administrative Law Judge 2006).

Suspended Sediment Concentrations

Under the Proposed Action, increased SSCs would be expected to affect filter-feeding benthic macroinvertebrates (BMIs) in much the same fashion as described for freshwater mussels. Excessive levels of SSCs for durations longer than normally occur under existing conditions are expected to cause physiological stress, reduced growth, and

potential mortality to filter-feeding BMIs. The scraper-grazers feeding guild among the BMIs are also expected to be deleteriously affected, but due to their increased mobility, would be affected less than the filter-feeders. This could affect BMI as far downstream as the Orleans. The high concentrations of suspended sediment released during winter are not predicted to have a severe effect on macroinvertebrates during their winter dormancy period. During spring and summer SSC will be lower, but would be expected to impact macroinvertebrates during the peak of their feeding and reproductive period. Recolonization of affected BMI populations would occur relatively quickly due to the shortened life cycle of BMIs and rapid dispersal through drift and/or the flying stages of many BMI adults. In addition, recolonization is expected to occur rapidly through drift or dispersal of adult life stages from established BMI populations within the many tributary rivers and streams of the Klamath River.

Changes in Bed Elevation

Under the Proposed Action, changes in bed elevation would affect BMIs in much the same fashion as described for freshwater mussels. Higher levels of sediment deposition than would normally occur under existing conditions would be expected to cause physiological stress, reduced growth, and potentially mortality to BMIs. As with the freshwater mussels, the most substantial impacts on BMIs would occur between Cottonwood Creek and Iron Gate Dam (approximately 8 ~~river miles~~RMs), with the greatest impacts occurring between Willow Creek and Iron Gate Dam. Recolonization of affected BMI populations would occur relatively quickly due to the shortened life cycle and greater dispersal capabilities of BMIs compared to freshwater mussels.

Changes in Bed Substrate

The reformation of river channels in the reservoir reaches upstream of Iron Gate Dam under the Proposed Action would benefit BMIs by providing more suitable substrates than currently exist. As a result, suitable habitats formed upstream of Iron Gate Dam might be opened to additional colonization by BMIs through rapid dispersal by drift from upstream populations within current riverine reaches and/or dispersion of adult life stages. In addition, recolonization would occur rapidly from established BMI populations within the many tributary rivers and streams of the Klamath River.

Summary: Benthic Macroinvertebrates

The Proposed Action would have short-term effects related to SSCs and bedload movement. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for macroinvertebrates downstream from Iron Gate Dam in the short term.**

While a large proportion of macroinvertebrate populations in the Hydroelectric Reach and in the mainstem Klamath River downstream ~~of~~from Iron Gate Dam would be affected in the short term by the Proposed Action, their populations would be expected to recover quickly because of the many sources for recolonization and their rapid dispersion through drift or aerial movement of adults. Habitat quality would also be improved in the Hydroelectric Reach by the ending of deleterious Klamath Hydroelectric Project peaking operations (Administrative Law Judge 2006).

Dam removal would ~~increase~~ restore connectivity ~~between~~among the Lower Klamath Basin, the Hydroelectric Reach and its tributaries, and the Upper Klamath Basin~~ and the Hydroelectric Reach and would create additional~~, and would rehabilitate and increase availability of riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action on macroinvertebrates would be beneficial in the long term.**

Deconstruction

As described below, disturbance to the river channel during construction could affect aquatic species.

The Proposed Action would require relocation of the City of Yreka's water supply pipeline in Iron Gate Reservoir, demolition of the dams and their associated structures, power generation facilities, transmission lines, installation of cofferdams, road upgrading, hauling, reservoir restoration, and other activities (as described in Section 2.4.3.1). These actions would include the use of heavy equipment, and blasting as necessary, and as such, have the potential to disturb aquatic species. Activities at the J.C. Boyle, Copco 1, and Copco 2 Dams would affect the riverine and introduced resident species in the Hydroelectric Reach.

At Iron Gate Dam, anadromous species could also be affected. These effects could include shockwaves associated with breaking down the dam structure using explosives or heavy equipment, potential crushing of aquatic species from operation of heavy equipment in the river, sedimentation, and release of oil, gasoline, or other toxic substances from construction sites. Demolition of the dams and their associated structures, power generation facilities, installation of cofferdams, and other activities are scheduled to occur at Iron Gate Dam between January 10 and June 26, with cofferdam installation scheduled to occur between 2 January 2020 and 6 February 2020. Therefore, this activity would occur during the first month of reservoir drawdown and the peak of SSC associated with reservoir drawdown. As discussed above, any aquatic species within the vicinity of Iron Gate Dam tailrace during this time would also be subject to SSC during the reservoir drawdown that are estimated to range from 80 to >10,000 mg/L during the January 10 through June 26, 2020, period. These SSCs corresponds to Newcombe and Jensen (1996) severity ratings of from 8 to 12, which equate to sub-lethal and lethal effects aquatic species. It is anticipated that this release of sediment would result in the displacement of any individuals that are rearing in the mainstem into tributaries or further downstream prior to deconstruction or cofferdam activities. Therefore, impacts associated with deconstruction would generally be of small magnitude, short duration, and low intensity when compared to those that would occur as a result of the changes in habitat structure and release of sediments stored behind the dams if they were removed.

To minimize these potential construction impacts, construction areas would be isolated from the active river where possible, and water would be routed around the construction area, allowing the flow to move down the other portion of the river, while the isolated portion of the dam is removed. After a work area is isolated, fish rescues to remove any

native fish trapped in the work area would be conducted. Fish would be relocated to an area of suitable habitat within the Klamath River. Implementation of soil erosion and sedimentation control and stormwater pollution prevention would minimize soil erosion and water quality effects on anadromous fish downstream ~~of~~from the work area, during and after construction. **Because best management practices for construction incorporated into the Proposed Action will prevent substantial effects, construction activities associated with the Proposed Action would be less–than-significant.**

Coastal Zone Consistency Determination

The following section provides an analysis of the effects of the Proposed Action on each of the relevant policies of the California Coastal Management Program as outlined in the California Coastal Act of 1976. The deconstruction activities of the Proposed Action would begin approximately 190 miles from the mouth of the Klamath River. Therefore, this analysis focuses on impacts that would be evident many ~~river miles~~RMs downstream in the estuary and near shore. The policies identified as applicable are Article 4 Marine Environment Section 30231 and Section 30236 (see *italicized* text below). Articles 2, Article 3, Article 5, Article 6, and Article 7 are not applicable due to the distance of deconstruction activities from the near shore environment and will not be further addressed in this analysis. Also this is a phased Coastal Zone Management Act (CZMA) analysis. Additional implementation specific analysis will be completed as needed if the Secretary makes an Affirmative Determination.

Section 30231 The biological productivity and the quality of coastal waters, streams, wetlands, estuaries and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface water flow; encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alterations of natural streams.

As described above, the Proposed Action would result in substantial short-term increases in suspended sediment during 2020 while the reservoirs are drawndown in preparation for facility removal. The effect of these short-term increases would be significant for some species within the Klamath River. However, as described above, aquatic species within the river would benefit from increased habitat availability and improved habitat suitability in the long term. In addition, under a worst-case scenario, ~~suspended sediment concentrations~~ SSCs resulting from the Proposed Action would be elevated within the estuary and nearshore environment for approximately three months (January, February, and March) in 2020. ~~As described~~SSCs in ~~Section 3.2.4.3.2, SSC levels within~~ the estuary ~~and near-shore environment~~ would ~~not~~ be ~~substantially~~ less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and would be higher than ~~under~~ the extreme values estimated by the sediment transport model for existing conditions~~, especially when compared with extreme winter~~ (see the subsection of Section 3.2.4.3.2.). After this time,

SSCs would return to levels similar to existing conditions. Based on the short duration of poor water quality during reservoir drawdown in the estuary and near-shore environment, the Proposed Action would not be deleterious in the short- term, and would not likely affect the estuary and near-shore environment in the long term.

For all species analyzed, when the short-term deleterious effects occurring during reservoir drawdown in 2020 are weighed against the long-term benefits to the Klamath River, the systemic restoration espoused in the Proposed Action improves biological productivity and the quality of waters, streams, wetlands, estuaries, and lakes. Therefore the Proposed Action is consistent with the California Coast Act Policy 30231.

Section 30236 Channelizations, dams or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible and be limited to (1) necessary water supply projects, (2) flood control projects where no other method for protecting existing structure in the flood plain is feasible and where such protections is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat

.

The primary function of the Proposed Action is to improve fish and wildlife habitat and water quality. For this reason, the Proposed Action deconstruction schedule was crafted with careful attention to the timing necessary to limit the impact of sediment release on aquatic resources and water quality. The timing in the Proposed Action is designed to limit the effects on water quality to one single large increase in suspended sediment and one single reduced dissolved oxygen event occurring within the winter and early spring of 2020. By limiting the duration of elevated suspended sediment and reduced dissolved oxygen, the Proposed Action avoids multiple years of effects to aquatic species and minimizes impacts to the sensitive juvenile rearing and smolt life stages of migratory fish. In addition to this built-in avoidance and minimization measure, the Proposed Action includes several required best management practices for the deconstruction activities including erosion and stormwater management, dust abatement, and hazardous spill prevention and response measures. To further address the alteration of rivers and streams and the effects of returning some of the natural processes to the Klamath River system, mitigation measures are being considered including AR 1: Protection of Mainstem Spawning, AR2: Protection of Outmigrating Juveniles, AR3: Fall Pulse Flows, AR-4: Hatchery Management, and AR-5 Pacific Lamprey Capture and Relocation.-

Given the careful crafting of the Proposed Action, the required Best Management Practices and mitigation measures, and the fact that the primary function of the project is improvement of fish and wildlife habitat, the Proposed Action is consistent with the California Coast Act Policy 30236.

~~*The Proposed Action could require the relocation of the City of Yreka water supply pipeline.* The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the dam to prevent damage from~~

~~deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would either be suspended from a pipe bridge across the river near its current location, or rerouted along the underside of the Lakeview Bridge just downstream of Iron Gate Dam. Standard construction Best Management Practices would reduce the likelihood and extent of aquatic impacts. **Therefore, the relocation of the Yreka pipeline would have less than significant impacts to aquatic resources.**~~

Interim Measures

The Proposed Action includes IMs to be implemented prior to the initiation of dam removal in 2020 (as described in Section 2.4.3). These IM's will cease to be implemented if the Secretary makes a Negative Determination, and would therefore have no long-term effect on aquatic resources. As described below, two of these have the potential to affect aquatic resources, including:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement, and
- IM 16: Water Diversions.

Implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement could result in alterations to habitat availability and habitat quality, and affect aquatic species.

Currently trout spawning gravel in the J.C. Boyle bypass reach is embedded with fine silt. In July 2006, the spawning gravel in the bypass reach below the emergency spillway was fifty ("50") percent embedded with silt and sand (ALJ Decision at 42 Finding of Fact number 14-7). Bedload mobilization is the natural geomorphic process whereby flow moves gravel for deposit on alluvial features and cleanses gravel of sediment. Diversion has reduced the capacity of flow to mobilize the bedload by an estimated eighty-three ("83") percent to ninety-six ("96") percent in the bypass reach (ALJ Decision at 40 Finding of Fact 11-2).

Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches following an Affirmative Determination and continuing through 2019. The first year would be before the Secretary makes a determination, and would therefore be included in the No Action/No Project Alternative. The following seven years would be part of the Proposed Action. This measure would use a passive approach to place gravel before high flow periods, or develop for other habitat enhancement that would provide equivalent fishery benefits in the Klamath River upstream of Copco Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. The additional gravel could also improve bed mobility in this reach following dam removal. Seasonal high flows, in combination with a gravel augmentation program, will likely create a more dynamic channel with a wider range of sediment deposits. This sediment will be deposited higher on the channel margin which will serve as an ecological benefit (ALJ Decision at 38 Finding of Fact 10-5). Also additional gravel may contribute to increased periphyton scour and less favorable habitat for the polychaete intermediate host of *C. shasta* and *P. minibicornis*. This could reduce the potential for infection of juvenile salmonids in the Hydroelectric Reach following dam removal (see also the subsection of Section 3.4.4.3.2, Algae). **Based on anticipated improvements in habitat availability and habitat quality, implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the Basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

Implementation of IM 16 (Water Diversions) could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under this IM, PacifiCorp would seek to eliminate three screened diversions (the Lower Shovel Creek Diversion [7.5 cfs], Upper Shovel Creek Diversion [2.5 cfs], and Negro Creek Diversion [5 cfs])

from Shovel and Negro Creeks and would seek to modify its water rights to move the points of diversion from Shovel and Negro creeks to the mainstem Klamath River. Based upon available information, the upstream most diversion on Shovel Creek is approximately one mile upstream of the confluence with the Klamath River. If this were successful the screened diversions would be removed prior to dam removal in 2020. The intent of this measure is to provide additional water to Shovel and Negro creeks, thus increasing the quality and amount of suitable habitat for aquatic species within these tributaries, while not diminishing PacifiCorp's water rights. These actions would provide improvements in the quality and amount of suitable habitat for resident and anadromous aquatic species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality with increased flow, implementation of IM 16 (Water Diversions) under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the Basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

Keno Transfer

Implementation of the Keno Transfer could cause adverse aquatic resource effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on aquatic resources compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and ~~West Side~~Westside Facilities – Programmatic Measure

Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse aquatic resource effects. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would ~~redirect~~no longer divert water flows ~~currently diverted~~ at Link River Dam into the two canals~~, back in to Link River.~~. Risk of entrainment into these facilities would also be eliminated. Following decommissioning of the facilities, there would be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. ~~Therefore, implementation~~ **Implementation of the East and ~~West Side~~Westside Facility Decommissioning action would ~~result in~~be beneficial for suckers and redband, and no change from existing conditions for other aquatic species.**

~~Interim Measures~~
~~The~~ City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The Proposed Action includes IMs to be implemented prior to the initiation of dam removal in 2020 (as described in Section 2.4.3). As described below, two of these have the potential to affect aquatic resources, including:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement, and
- IM 16: Water Diversions.

Implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches following an Affirmative Determination and continuing through 2019. The first year would be before the Secretary makes a determination, and would therefore be included in the No Action/No Project Alternative. The following seven years would be part of the Proposed Action. This measure would use a passive approach to place gravel before high flow periods, or develop for other habitat enhancement that would provide equivalent fishery benefits in the Klamath River upstream of Copco Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality, implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from** *require the relocation of th Yreka Water Supply Pipeline*. The existing **conditions.**

Implementation of IM 16 (Water Diversions) could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under this IM, PacifiCorp would seek to eliminate three screened diversions (the Lower Shovel Creek Diversion [7.5 cfs], Upper Shovel Creek Diversion [2.5 cfs], and Negro Creek Diversion [5 cfs]) from Shovel and Negro Creeks and would seek to modify its water rights to move the points of diversion from Shovel and Negro creeks to the mainstem Klamath River. If this were successful the screened diversions would be removed prior to dam removal in 2020. The intent of this measure is to provide additional water to Shovel and Negro creeks, thus increasing the quality and amount of suitable habitat for aquatic species within these tributaries, while not diminishing PacifiCorp's water rights. These actions would provide improvements in the quality and amount of suitable habitat for resident and anadromous aquatic species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality with** supply pipeline for tYreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the dam to prevent damage from deconstruction activities or increased **flow, implementation of IM 16 (**water velocities once the reservoir has been drawn down. The pipeline would be suspended from a pipe bridge across the river near its current location. Standard construction Best Management Practices would reduce the likelihood and extent of aquatic impacts. **Therefore, the relocation of the Yreka Water Diversions) under the**

~~**Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**~~**Supply Pipeline would have less-than-significant impacts to aquatic resources.**

KBRA – Programmatic Measures

The KBRA, which is a ~~component of~~connected action to the Proposed Action, encompasses several programs that could affect aquatic resources, including:

- Phases I and 2 Fisheries Restoration Plan
- Fisheries Monitoring Plan
- Fisheries Reintroduction and Management Plan - Phase I
- Water Diversion Limitations
- On-Project Plan
- Water Use Retirement Program
- Fish Entrainment Reduction
- Klamath ~~River~~ Tribes Interim Fishing Site
- Upper Klamath Lake and Keno Nutrient Reduction

With implementation of the KBRA, ongoing habitat restoration would be better funded, better coordinated and monitored to ensure effective implementation. The actions that would be taken under the KBRA would generally benefit aquatic resources by reducing the impacts of past and ongoing disturbance on aquatic habitats. Any undesirable impacts associated with the actions would be short~~-~~ term in nature and could be largely avoided by employing Best Management Practices for construction activities in and near water. Individual components of the KBRA are described below.

Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan

Implementation of Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan could result in alterations to water quantity, water quality, habitat availability and habitat quality, and affect aquatic species. The Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plans are designed to improve habitat for aquatic species and measure the efficacy of restoration actions. These plans prioritize restoration needs within the ~~basin~~Basin and establish a monitoring and adaptive management program to evaluate and optimize the success of restoration actions.

Measures that are ongoing in the ~~basin~~Basin or that have been identified for inclusion in the plans include floodplain rehabilitation, large woody debris emplacement, fish passage improvement, livestock exclusion fencing, riparian vegetation management, purchase of conservation easements, road decommissioning, and treatment of fine sediment sources. Restoration actions will occur within the mainstem Klamath River, as well as within critical tributaries known to support salmonid rearing, such as Scott and Shasta rivers.

These activities were chosen to benefit native fish populations as well as the health of the aquatic and riparian ecosystems of the Klamath Basin. Fish passage improvements would be designed to increase access to historical habitat. Many of these activities would be constructed to reduce fine sediment supply to streams within the project area, improving spawning habitat and productive macroinvertebrate habitat.

Purchase of conservation easements or land could provide long-term protection to areas beneficial to the riverine ecosystem as a whole or specific areas of importance to fish species such as endangered suckers. It could also protect areas where restoration actions have been used to improve or restore habitats.

Some restoration activities under the Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan could have short-term negative impacts, generally associated with construction and active management phases. Generally, these impacts would be localized and could be avoided through implementation of best management practices, such as control and containment of sediment and toxic discharge, isolation of work areas from the active channel of streams or rivers where possible, and rescuing fish where mortality may result from an action. The long-term water quality improvements generated by implementation of Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity, water quality, habitat availability and habitat quality, implementation of Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, benthic macroinvertebrates, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where they would be less-than-significant. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, and freshwater mussels would not change from existing conditions.**

Phase I Fisheries Reintroduction and Management Plan

Implementation of Phase I of the Fisheries Reintroduction and Management Plan could result in alterations to habitat availability (fish access), and could affect aquatic species. The Phase I Fisheries Reintroduction and Management Plan is intended to support the reintroduction and management of fish in the Upper Klamath Basin during and after implementation of the KHSA. ~~The~~ As specified in the KHSA, the plan would include provisions for the continued operation of a fish hatchery at Fall Creek or in the Iron Gate Dam area and the construction of fish collection facilities to support primarily the transport of fall-run Chinook salmon around ~~areas of poor water quality~~Keno Impoundment/ Lake Ewauna, when needed, on an interim seasonal basis.

The initial use of the hatchery facility at Iron Gate Dam or on Fall Creek would provide conservation of native salmon stocks during the impact period of dam removal. The development of guidelines for the use of the conservation hatchery at Iron Gate Dam or on Fall Creek outlined in the Phase I Fisheries Reintroduction and Management Plan

would be to support the establishment of naturally producing populations in the Klamath ~~River~~ Basin following implementation of the KHSA. Additionally, it is anticipated that a smaller production facility would be constructed in the Upper Klamath Basin to provide necessary research stock and locally reared fish for the reintroduction.

~~Volitional~~ As specified in the KHSA, volitional upstream and downstream passage facilities (screens and ladders) would be developed for passage around ~~areas of poor water quality~~Keno Impoundment/ Lake Ewauna and will provide for volitional passage during the majority of the year. In addition, the development of fish collection facilities upstream and downstream ~~of~~ from Keno Impoundment/Lake Ewauna would be required to provide effective migration for fall-run Chinook salmon when water quality is poor during the period from June 15 to November 15. During the limited period of use, fish collection and release facilities would be operated to minimize any delay and stress and provide for adequate acclimation. For adult fall-run Chinook salmon, fish transport would be an effective fish passage method because transport would be for a short distance on a seasonal, interim basis[8]. For adult fall-run Chinook salmon, seasonal collection and transport mortality when water quality is poor would be minor compared to mortality associated with unaided passage through areas of poor water quality at this time of year.

In some instances, the collection and transport of fall-run Chinook salmon around ~~areas of poor water quality~~Keno Impoundment/Lake Ewauna could result in limited, seasonal mortality as follows:

~~1.~~ Some juvenile federally listed suckers would likely be collected incidentally and may suffer related stress and mortality. However, regardless of any remediation at an upstream collection facility, nearly all these downstream migrant suckers would eventually die in the absence of lacustrine habitat below Keno Impoundment/Lake Ewauna. There is little to no evidence of recruitment of suckers in downstream reservoirs currently and this habitat does not contribute significantly to the recovery of the species. Suckers may be collected and returned to habitat above Keno Impoundment~~.~~

1. /Lake Ewauna.

~~2.~~ Some redband trout may be collected incidentally resulting in displacement and incidental collection-related stress and mortality. Redband trout may be collected and returned to habitat above Keno Impoundment~~.~~

2. /Lake Ewauna.
3. For fall-run Chinook salmon emigrants, the ~~seasonal~~seasonally poor quality conditions are not expected to overlap with the peak migration period, thus the

[8] This seasonal, transport on an interim basis is not to be confused with permanent, year round trap and haul, which does not provide equal benefits for the Klamath River when compared with the Services' fishway prescriptions (U.S. Department of the Interior (2007) The Department of the Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082). Sacramento, California: 650 p.; NOAA Fisheries Service (2007). NOAA Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis for the Klamath Hydroelectric Project (FERC Project No. 2082): 151 p.).

majority of juvenile Chinook salmon would not be affected. For those fall-run Chinook salmon emigrants collected and transported ~~when~~ during poor water quality conditions, transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.

4. For steelhead trout and spring-run Chinook salmon, migration would likely occur primarily when water quality was adequate, thus, collection and transport of these fish would not be necessary or minimal. However, all anadromous salmonids would be collected and transported when water quality is poor during the period from June 15 through November 15. Transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.

Limited, seasonal transport of fall-run Chinook salmon would provide a net benefit by allowing them migration to and from additional (historical) spawning habitat, by providing more effective migration, and by reducing the density of spawners below Keno Dam in certain poor water quality situations. The majority of fish transported would likely be fall-run Chinook salmon. However, the Phase I Fisheries Reintroduction and Management Plan may include seasonal, interim transport for a minor component of the spring-run Chinook, and steelhead migrants. Thus, these fish would also receive benefits from this program. Increased anadromous fish abundance, especially Chinook salmon, would result in more prey availability for Southern Resident Killer Whales when the whales are near the Oregon and California coasts.

Other reintroduction activities under the Phase I Fisheries Reintroduction and Management Plan could have short-term impacts, generally associated with construction and active management phases. Generally, these impacts would be localized and could be avoided or minimized through implementation of best management practices, such as control and containment of sediment and toxic discharge, isolation of work areas from the active channel of streams or rivers where possible, and rescuing fish where mortality may result from an action. The habitat improvements generated by implementation of the Phase I Fisheries Reintroduction and Management Plan would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on access to additional, historical habitat and the anticipated improvements in fish health, implementation of the Phase I Fisheries Reintroduction and Management Plan under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, Southern Resident Killer Whales, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon, except those Trinity River population units, through continued support from the fish hatchery. The Trinity River population units, would experience no change from existing conditions in the long- term. Effects on green sturgeon, bull trout, eulachon, and freshwater mussels would be no change from existing conditions. These actions would be less than significant for redband trout as well as for shortnose and Lost River suckers.**

Water Diversion Limitations

Implementation of Water Diversion Limitations could result in reducing uncertainties associated with maintaining adequate ecological flows for aquatic species and their habitats, especially in low-flow years, and could alter water quality, and water temperatures in certain seasons and affect aquatic species. *This component of the KBRA would establish limits on specific diversions within Reclamation's Klamath Project to protect flows in the mainstem and ensure that adequate water supply is available for allocation to the wildlife refuges.*

~~Reduced surface water deliveries associated with the diversion limitations could result in the increased use of groundwater for irrigation supply.~~

A plan would be developed for monitoring groundwater in order to restrict pumping to no more than 6 percent of ~~flows in~~ the ~~reach upstream~~output of ~~Copco 1 Dam that is fed predominantly by~~ springs listed in the KBRA Section 15.2.4.A.i. This measure would protect an important resource that provides ~~stable~~suitable habitat conditions that may be critical to the survival of some species. This reliable source of cool inflow from springs provides benefit to aquatic species by influencing temperature, dissolved oxygen, algal growth, and the dilution of contaminants or natural toxins, such as those produced by *M. aeruginosa*.

The long-term water quality and quantity improvements generated by implementation of diversion limitations would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity and water quality, implementation of Water Diversion Limitations under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where they would be no change from existing conditions. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and ~~benthic macroinvertebrates~~BMIs would be no change from existing conditions.**

On-Project Plan

Implementation of the On-Project Plan could result in alterations to water quantity and water quality and affect aquatic species. *The On-Project Plan would include a groundwater monitoring plan that limits pumping so that flows from springs in the watershed upstream of Copco 1 Dam would not be reduced by more than 6 percent, protecting these important habitats that provide ~~stable~~suitable habitat conditions and often support rare or unique species. It would also provide a plan to implement the water diversion limitations described above. This measure would help protect flows in the mainstem with the benefits described above. The long-term water quality and quantity improvements generated by implementation of the On-Project Plan would contribute to the long-term improvements anticipated from hydroelectric facility removal. Based on anticipated improvements in water quantity and water quality, implementation of Water Diversion Limitations under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and shortnose and Lost River suckers. These actions would also be beneficial for coho*

salmon, except those in the Trinity River population units, where they would be no change from existing conditions. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and ~~benthic macroinvertebrates~~BMIs would be no change from existing conditions.

Water Use Retirement Program

The Water Use Retirement Program could alter water quantity and water quality, and affect aquatic species. This component of the KBRA would increase inflow to Upper Klamath Lake by 30,000 acre-feet per year on average. A variety of mechanisms ~~would~~may be used to achieve this objective, including acquisition of water rights, forbearance agreements, water leasing, changes in agricultural cropping patterns, land fallowing, and juniper removal~~, and forest thinning~~. The additional water provided would increase flows in tributaries to Upper Klamath Lake improving habitat for redband trout, shortnose and Lost River suckers, and bull trout. Anadromous salmon and steelhead that would have access to these tributaries as a result of the Proposed Action would also be expected to benefit.

This additional water could be used for a variety of purposes downstream ~~of~~ from Upper Klamath Lake, including augmenting the base flow or high flow components of the annual hydrograph. Maintaining base flows, particularly during extreme droughts, is critical for fish spawning, rearing, passage, and preventing excessively warm water temperatures for all life stages. High flows are critical for shaping stream and river channels, creating diverse habitats, and connecting these habitats to riparian zones, terraces, and flood plains that provide nutrients to the riverine ecosystem and shelter for fish and other aquatic organisms when conditions in the river are unsuitable. Periodic springtime high flow events also have the potential of scouring the channel of fine-grained sediments and cladaphora which harbor intermediate hosts for organisms that produce high mortality in juvenile salmon. High flows mobilize the streambed, which removes fine sediments and organic material that can reduce spawning success and macroinvertebrate production, as well as reduce interstitial habitat used as cover by small fish. They are also important drivers of riparian ecosystem functions, such as dispersing and germinating seeds of riparian plants, and creating new areas for vegetation colonization through erosion. Riparian ecosystems are important for filtering fine sediment from hillslope runoff, buffering streams from contaminants, providing shade and temperature regulation, bank stability, and nutrients to the stream. Augmenting low flows in some years may be critical due to temperature, water quality, or disease concerns.

The additional water flows generated by implementation of the Water Use Retirement Program would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity, and water and stream channel quality, implementation of Water Use Retirement Program under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where there would be no change from**

existing conditions. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and ~~benthic macroinvertebrates~~BMIs would be no change from existing conditions.

Fish Entrainment Reduction

Implementation of the Fish Entrainment Reduction could result in alterations to potential alterations to mortality risk and affect aquatic species. This KBRA action would involve designing and installing fish screens at Project Diversions, including the Lost River Diversion Channel and associated diversion points, North Canal, Ady Canal, and other Reclamation and Reclamation contractor diversions. This action would reduce mortality caused by entrainment of fish at these diversions, to the benefit of endangered shortnose and Lost River suckers, as well as to redband trout. Steelhead and fall- and spring-run Chinook salmon would also benefit from this action once they recolonize areas upstream of Keno Dam. The reductions in entrainment mortality generated by implementation of the Water Use Retirement Program would contribute to the long-term improvements in anadromous species health anticipated from hydroelectric facility removal. **Based on anticipated reductions in entrainment mortality, implementation of Fish Entrainment Reduction under the Proposed Action would be beneficial for shortnose and Lost River suckers, redband trout, fall-run Chinook salmon, spring-run Chinook salmon, steelhead, and Pacific lamprey. These actions would also be beneficial for coho salmon from the Upper Klamath River population unit, and would be no change from existing conditions for all other coho salmon population units. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and ~~benthic macroinvertebrates~~BMIs would be no change from existing conditions.**

Klamath ~~*River*~~ Tribes Interim Fishing Site

Implementation of the Klamath ~~River~~ Tribes Interim Fishing Site could result in alterations to managed harvest mortality of fish species that are culturally important to the Klamath ~~River~~ Tribes, including Chinook and coho salmon, steelhead, and Pacific lamprey. The harvest, which would take place between Iron Gate Dam and Interstate 5, would be coordinated with harvest by other tribes and the commercial fishery to remain within the predicted sustainable limits for the fishery. The coordinated harvest at the Klamath ~~River~~ Tribes Interim Fishing Site would not be expected to contribute to any changes generated by the hydroelectric facility removal action. **Based on anticipated fisheries management coordination as part of the implementation of Klamath ~~River~~ Tribes Interim Fishing Site under the Proposed Action, this action would result in no change from existing conditions for aquatic species.**

Upper Klamath Lake and Keno Nutrient Reduction

Implementation of the Interim Flow and Lake Level Program could result in decreases in summer water temperature and nutrient inputs to Upper Klamath Lake. *KBRA (Appendix C-2, line 11) includes a program to study and reduce nutrient concentrations in the Keno Impoundment/Lake Ewauna and Upper Klamath Lake in order to reduce dissolved oxygen problems and algal problems in both water bodies. Restoration actions to control nutrients have not been developed, and there are many diverse possibilities*

that could require construction of treatment wetlands, construction of facilities, or chemical treatments of bottom sediment, among other possibilities. A nutrient reduction program in the Keno Impoundment/Lake Ewauna and Upper Klamath Lake would be designed to improve water quality (increasing dissolved oxygen and reducing algal concentration) and to provide fish passage through the Keno Impoundment/Lake Ewauna in summer and fall months; however, implementation of this nutrient reduction program will require future environmental compliance investigations and a determination on significance cannot be made at this time.

The specific locations in which some of these KBRA actions would be undertaken are unknown at this time, but they would be implemented at different locations and times than KHSA actions. Many of these actions would require additional environmental documentation and permitting before being implemented, and are covered programmatically in this document. Generally, the KBRA actions described above would be expected to result in a net benefit for fisheries resources and the aquatic environment. Any potential deleterious effects identified could be avoided or mitigated through careful planning and management.

3.3.4.3.3 Alternative 3: Partial Facilities Removal of Four Dams Alternative

The Partial Facilities Removal of Four Dams Alternative would include removal of enough of J.-C. Boyle, Copco 1, Copco 2, and Iron Gate Dams to allow free-flowing river conditions and volitional fish passage at all times. Under this alternative, portions of each dam would remain in place along with ancillary buildings and structures such as powerhouses, foundations, tunnels, and pipes, all of which would be outside of the ~~100~~ 100 year flood-prone width. Under this alternative, partial removal of the embankment/earth-filled dam and concrete dam structures would allow release of dam-stored sediment. The retention of these structures would not be expected to result in any difference in the physical or biological effects of dam removal from those described for the Proposed Action. This alternative would include the transfer of the Keno Facility to the DOI and implementation of the KBRA. Under this alternative, hatchery production would continue for eight years following the removal of Iron Gate Dam.

Key Ecological Attributes

Aquatic ecological attributes under the Partial Facilities Removal of Four Dams Alternative would have indistinguishable effects on aquatic species from the Proposed Action.

Species-Specific Impacts

~~*Lowering the water surface elevation of the reservoirs*~~*Reservoir drawdown associated with dam removal under this alternative could affect aquatic species. In addition, the removal of dams and reservoirs could alter the availability and quality of habitat, resulting in effects on aquatic species.* The impacts were considered for each of the following species and groups: fall-run Chinook salmon, spring-run Chinook salmon, coho salmon, steelhead, lamprey, green sturgeon, Lost River and shortnose suckers, redband trout, bull trout, eulachon, longfin smelt, introduced resident species, freshwater mussels and benthic macroinvertebrates. The effects of this Partial Facilities Removal of Four

Dams Alternative on aquatic species would be indistinguishable from those described for the Proposed Action.

~~*The Proposed Action*~~Interim Measures

Implementation of IMs 7 (J.C. Boyle Gravel Placement and/or Habitat Enhancement) and 16 (Water Diversions) could result in alterations to habitat availability and habitat quality, and affect aquatic species. These IM's will cease to be implemented if the Secretary makes a Negative Determination, and would ~~*require the relocation of the City of Yreka water supply pipeline*. Under the Partial Facilities Removal Alternative, the relocation of the Yreka water supply pipeline~~therefore have no long-term effect on aquatic resources. These IMs would ~~have the same impacts as~~increase spawning gravel or habitat upstream of Copco Reservoir and would increase flows in Shovel and Negro Creeks. As described under the Proposed Action~~.~~, these actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality, implementation of IMs 7 and 16 under the Partial Facilities Removal would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the Basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

Keno Transfer

Implementation of the Keno Transfer could cause adverse aquatic resource effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on aquatic resources compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and ~~West Side~~Westside Facilities – Programmatic Measure

Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse aquatic resource effects. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would ~~redirect~~no longer divert water flows ~~currently diverted~~ at Link River Dam into the two canals~~, back in to Link River.~~. Risk of entrainment into these facilities would also be eliminated. Following decommissioning of the facilities, there would be no change in outflow from Upper Klamath Lake or inflow into Keno Impoundment/Lake Ewauna. **~~Therefore, implementation~~ Implementation of the East and ~~West Side~~Westside Facility Decommissioning action would ~~result in~~ be beneficial for suckers and redband, and no change from existing conditions~~.~~**

Interim Measures
Implementation of IMs 7 (J.C. Boyle Gravel Placement and/or Habitat Enhancement) and 16 (Water Diversions) could result in alterations to habitat availability and habitat quality, and affect **for other aquatic species.** These IMs would increase spawning gravel or habitat upstream

City of Copco Reservoir and Yreka Water Supply Pipeline Relocation – Programmatic Measure
The Proposed Action would increase flows in Shovel and Negro Creeks. As described under the Proposed Action, these actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality, implementation***require the relocation of IMs 7 and 16 under the Yreka Water Supply Pipeline.* Under the Partial Facilities Removal **would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in**Alternative, the **basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

relocation of the Yreka Water Supply Pipeline would have the same impacts as under the Proposed Action.

KBRA – Programmatic Measures
The KBRA would be implemented under the Partial Facilities Removal of Four Dams Alternative and would have indistinguishable effects on aquatic species from those of the Proposed Action.

3.3.4.3.4 Alternative 4: Fish Passage at Four Dams Alternative
The Fish Passage at Four Dams Alternative would provide upstream and downstream fish passage at the Four Facilities, but would not include implementation of the KBRA. The ongoing restoration actions, described in the No Action/No Project Alternative, would continue. The alternative would incorporate the prescriptions from the Departments of InteriorDOI and CommerceDOC imposed during the FERC relicensing process, including fishway installation for both upstream and downstream migrations at all four facilities and barriers to prevent juvenile salmonid entrainment into turbines. In addition to the fishways, there are a series flow-related measures, including a condition that requires at least 40 percent of the inflow to the J.C. Boyle Reservoir to be released downstream. This alternative would limit generation of peaking power at J.C. Boyle Powerplant to one day per week as water supplies allow, and would include recreation flows one day a week.

Pursuant to the FERC's Licensing Regulations, the Department of the Interior filed its comments regarding the impacts of facilities and operations of the Klamath Hydroelectric Project (FERC No. 2082) on public resources and recommended various terms and conditions to be incorporated into any new license to address these impacts. In addition,

the Secretaries of Interior and Commerce filed fishway prescriptions under Section 18 of the Federal Power Act (FPA) to provide safe, timely, and effective fish passage, and, in doing so, specifically address the loss of fish habitat after the project was constructed.

Pursuant to the regulations of FERC (18 C~~.F.R.~~FR 385.604), many of the Parties to the FERC licensing proceeding undertook confidential settlement discussions to resolve disputed issues in the licensing proceeding, resulting in the KHSA. Section 3.2.1 of the KHSA provides that the Secretary of the Interior is to undertake ~~National Environmental Policy Act~~NEPA analysis and other appropriate actions to determine whether to proceed with Facilities Removal. Chapter 1 of this EIS/EIR states the purpose of the proposed ~~federal~~Federal action "is to advance restoration of the salmonid fisheries in the Klamath Basin that is in the public interest, and is consistent with the KHSA and KBRA and their objectives." Consistency with the KHSA and KBRA and their objectives thus underlies the alternatives and analyses presented in this document. ~~The reader should note, however, that the~~At time of document preparation, FERC has not taken final action on PacifiCorp's application for license. Therefore, the Department of the Interior's position in that proceeding~~,~~ has not changed, including the various impacts of PacifiCorp's dams on public resources and the need for and benefits of the fishways prescribed by the Secretaries. Fishways installed as part of fish passage alternatives ~~in~~ in this EIS/EIR would need to comply with the Section 18 prescriptions for the construction, operation, and maintenance of upstream and downstream passage (~~DOI~~ DOI 2007). General prescriptions cover anadromous (fall- and spring-run Chinook salmon, coho salmon, steelhead, and Pacific lamprey) and resident (rainbow and ~~redband~~ redband trout, shortnose and Lost River suckers) fish passage at all Klamath Hydroelectric Project dams, and include implementing operation and maintenance ~~plans~~ plans and prescribing attraction flows for upstream migrants (DOI 2007). Specific provisions apply to individual dams and include performance standards for upstream and downstream passage facilities.

DOI and NOAA Fisheries Service passage prescriptions for Keno Dam include the collection of adult Chinook salmon for transport past Lake Ewauna during summer months when water quality is poor (DOI 2007). If dissolved oxygen concentrations are less than 6 mg/L and water temperatures are higher than 20°C, as measured at Miller Island (RM 246), trap and haul would occur from June 15 through November 15 until restoration efforts improve water quality to conditions suitable for anadromous fish (DOI 2007). Conditions in the reach from Keno Dam to Link River Dam are expected to eventually improve through implementation of TMDL water quality measures and imposition of ~~state~~State water quality certification conditions to allow year-round volitional passage.

Under the Fish ~~passage at~~Passage at Four Dams Alternative, Iron Gate ~~Dam would provide fish with access to Scotch, Slide, Camp, Jenny, Fall, and Salt Creeks, and the Copco 2 Bypass Reach. Passage at Copco 1 Dam would provide access to 4.5 miles of reservoir habitat, 21 miles of mainstem habitat, and an additional 6 miles of tributary habitat. Passage would also allow access to cooler water in the J.C. Boyle Bypass Reach provided by springs (an estimated 200-250 cfs) (DOI 2007; FERC 2007). Passage at J.C.~~

Boyle Dam would provide access to 4.7 miles of mainstem habitat, to Spencer Creek. Overall, passage would provide access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive anadromous fish habitat upstream of Iron Gate Dam (DOI 2007), including access to groundwater discharge areas resistant to effects of climate change (Hamilton et al. 2011). There wouldHatchery will continue to be 22.4 miles of spawning and rearing habitat inundated by reservoirs (Cunanan 2009). operate to meet mitigation requirements.

Key Ecological Attributes

Suspended Sediment

Under the Fish Passage at Four Dams Alternative, SSCs would be the same as under existing conditions. Therefore, this alternative would have no effects associated with suspended sediment transport relative to existing conditions for any aquatic species.

Bedload Sediment

Under the Fish Passage at Four Dams Alternative, the dams would not be removed and sediment would continue to be stored behind Klamath Hydroelectric Project dams, similar to . As described for the No Action/No Project Alternative.

, the Klamath Hydroelectric Project dams would continue to trap fine and coarse sediment. These periodic inputs of bedload sediments are necessary for the long-term maintenance of aquatic habitats. As a result of the interception of sand, gravel and coarser sediment supply from sources upstream of Iron Gate Dam the channel downstream from Iron Gate Dam would continue to coarsen and decrease in mobility (Reclamation 2012), providing fewer components of habitat, in particular spawning habitat, and decreased quality habitat over time. This effect would gradually decrease in the downstream direction as coarse sediment is resupplied by tributary inputs (Hetrick et al. 2009), and would be substantially reduced at the Cottonwood Creek confluence (PacifiCorp 2004b). As occurs under existing conditions, the coarser bed material is mobilized at higher flows that occur less frequently, resulting in channel features that are unnaturally static and provide lower value aquatic habitat (Buer 1981).

Water Quality

Under the Fish Passage at Four Dams Alternative, water quality would be the same as under the No Action/No Project Alternative. Anadromous fish would be able to move through the Hydroelectric Reach and might be seasonally exposed to poor water quality during upstream and downstream migration. Dissolved oxygen concentrations within reservoirs can be seasonally stressful for anadromous fish from June to September (FERC 2007) and continued high rates of algal photosynthesis in the reservoirs would result in pH values that would not consistently meet applicable ODEQ and California Basin Plan water quality objectives (see Section 3.2.4.3). Implementation of water quality improvement measures under Oregon and California TMDLs (to address water quality impairments within the period of analysis) would improve conditions for migratory fish.

Water Temperature

Under the Fish Passage at Four Dams Alternative, the effects on water temperature are predicted to be similar to those that are predicted for the No Action/No Project Alternative. Under this Alternative, the expected overall higher flow releases would result in more reservoir water entering the J.C. Boyle Bypass Reach and correspondingly warmer water temperatures during summer and early fall, and cooler water temperatures in late fall and winter. These effects would be similar to those under the Proposed Action and would move this short reach away from consistently cooler water temperatures during summer and early fall months; however, as with the Proposed Action, areas adjacent to the coldwater springs in the Bypass Reach would continue to serve as thermal refugia for aquatic species because the springs themselves would not be affected by the Fish Passage at Four Dams Alternative. Anadromous fish would be able to move through the Hydroelectric Reach and might be seasonally exposed to high temperatures during upstream and downstream migration. Water temperature in the reservoirs can be ~~particularly~~ high from June to September (see Section 3.2.3.2) and ~~might~~surface layers may seasonally exceed thermal tolerances for ~~anadromous~~ salmonids or resident fish. However, these potential periods of high water temperature are outside of peak migration.

Since J.C. Boyle Reservoir, with its large thermal mass, would remain in place, effects on diel temperature variation in the Bypass Reach under the Fish Passage at Four Dams Alternative would be similar to those described for the No Action/No Project Alternative (i.e., reduced diel temperature variation). Maximum water temperatures in the Peaking Reach would be slightly cooler and temperatures would be less artificially variable compared to existing conditions, also due to higher overall flows and the lower frequency of peaking operations at the J.C. Boyle Powerhouse. Under existing conditions, there is a delay in the normal progression of water temperatures ~~below~~downstream from Iron Gate Dam (or Phase Shift from historical timing) (Bartholow et al. 2005). Under this alternative, the current phase shift and lack of temporal temperature diversity ~~would~~will persist, including current warm temperatures in late summer and fall~~. Current cooler temperatures in spring and early summer could benefit both adult and juvenile salmonids migrating during spring. However, juveniles~~ (Hamilton et al. 2011). Juveniles and adults migrating later in the year would continue to experience warm temperatures in late summer and fall that could be deleterious to health and survival, including increased risk of disease, and high rates of delayed spawning and prespawn mortality (Hetrick et al. 2009).

Fish Disease and Parasites

The incidence of fish disease in salmon ~~may~~ would be reduced under the Fish Passage at Four Dams Alternative~~, or may remain similar to the No Action/No Project Alternative because many of the primary factors affecting fish infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged (e.g., habitat conditions favorable for the invertebrate hosts, sediment transport, and temperature would remain similar to~~ relative to existing conditions~~). Fish passage upstream by anadromous salmonids would increase under this alternative, which could reduce the concentration of salmon using the~~

~~area immediately below Iron Gate Dam for spawning, potentially reducing the transfer of myxospores from fish to the polychaete hosts~~. FERC's (2007) analysis concluded that restoring access to reaches above Iron Gate Dam for anadromous fish would allow adult fall-run Chinook salmon to distribute over a greater length of the river, reducing crowding and the concentration of disease pathogens that currently occur in the reach between Iron Gate Dam and the Shasta River. However, concentrations of ~~adults~~post spawn salmon carcasses downstream ~~of~~ from Iron Gate Dam may still be ~~high while fish hold prior to ascending the fish ladder, and~~ elevated associated with the continued operation of Iron Gate Hatchery. ~~Overall, under this alternative, disease in salmon would be expected to continue because: (1) conditions promoting high densities of polychaetes and parasites would generally persist; (2) a small proportion of spawning salmon produce the bulk of the myxospores; and (3) infected salmon may be less likely to successfully utilize the ladders. Therefore, under this alternative, disease impacts would be reduced, but would continue to be detrimental to salmon.~~

Provision of fish passage would allow anadromous salmonid migration to move upstream in the mainstem Klamath River and tributaries. Evidence indicates that disease risks would be minimal (Administrative Law Judge 2006). Many pathogens are already present in the upper and Lower Klamath Basin (Administrative Law Judge 2006. Thus, establishing fish passage will not increase the risk of disease (Administrative Law Judge 2006). *C. shasta and P. minibicornis* exist throughout the Klamath River System in both the Upper and Lower Basins, so migration of wild anadromous fish upstream of downstream from Iron Gate Dam would not increase the risk of introducing pathogens to resident trout residing above Iron Gate Dam (Administrative Law Judge 2006). In addition, steelhead and resident redband trout are generally resistant to *C. shasta*. The remaining known pathogens do not impact non-salmonids, with the exception of *F. columnaris* and *Ich*.

Evidence also indicates that risks associated with dam removal to anadromous fish upstream of Iron Gate Dam are minimal. Steelhead within the Klamath River system are generally resistant to *C. shasta*, (Administrative Law Judge 2006). Since salmon and associated disease pathogens were present historically above Iron Gate Dam, C. shasta genotype movement would be a reintroduction of associated risk to these anadromous species.

While it is possible that the current infectious nidus (breeding place) for C. shasta and P. minibicornis may move upstream where salmon spawning congregations occur, the likelihood of this happening has uncertainty associated with it. However, any creation of an infectious zone (or zones) would be the result of the synergistic effect of numerous factors, such as those that occur within the current disease zone in the reach from the Shasta River downstream to Seiad Valley (factors noted by FERC (2007) and others). Reestablishment of a more natural flow and sediment transport rates to the river downstream from the current location of Iron Gate Dam would develop natural geomorphic channel forming processes to the river (Hetrick et al. 2009) which would make this synergy unlikely. The conditions that contribute to a current infectious nidus

below IGD or would contribute to the same zone above IGD would not exist with dam removal.

In the Williamson River there is currently an infectious area due to the continual introduction of non-resistant rainbow trout that become infected and die within a reasonably small reach of the river. However, reintroduced salmon that would become infected are likely to migrate through this reach; dispersing spores over a greater area and more of these spores will be lost to the system, resulting in low spore concentrations.

There have been recently discovered *C. shasta* genotypes in the Klamath River. In this regard, risk is related to host specificity, which appears to exist at least to some degree (Atkinson and Bartholomew 2010). As an example, redband trout are thought to be susceptible to Type 0, which already occurs in the upstream Basin and Chinook salmon are susceptible to Type I, which occurs in the Lower Klamath Basin. Type 0 genotype occurs in low densities and it is not very virulent (infection results in low or no mortality); if Type I genotype were to be reintroduced above Iron Gate Dam, it would affect only Chinook salmon. It is not expected that reintroduction of *C. shasta* genotypes upstream would be deleterious because fish in the upstream Basin have shown resistance to the downstream genotypes. Redband trout would presumably have been exposed to genotypes of *C. shasta* during the pre-dam period, and their populations were abundant. Because the salmonid species in the Klamath Basin already co-occur with the genotype of *C. shasta* to which they are susceptible, and the salmonid species are less susceptible to other genotypes of *C. shasta*, expanding the distribution of the different genotypes of *C. shasta* would be unlikely to be deleterious to salmonids. Recently discovered *C. shasta* genotypes and research findings in the past several years do not appear to contradict the finding that movement of anadromous salmonids into the Upper Klamath Basin presents a relatively low risk of introducing pathogens to resident fish (Administrative Law Judge 2006, USFWS/NOAA Fisheries Service Issue 2(B)).

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, high nutrient inputs supporting the growth of toxin-producing nuisance algal species such as *M. aeruginosa* in Upper Klamath Lake would remain similar to existing conditions for decades into the future. This would result in continued bioaccumulation of microcystin in suckers in Upper Klamath Lake and could be deleterious to fish health. For salmonids in Upper Klamath Lake, impacts would be similar to those currently observed downstream from Iron Gate Dam. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species in Upper Klamath Lake would likely decrease (see ~~Sections~~the subsection of Section 3.2.4.3.1, Chlorophyll-a and Algal Toxins – Upper Klamath Basin, and Section 3.4.4.3.1, Alternative 1: No Action/No Project Alternative –Phytoplankton, for additional detail regarding TMDLs and algal growth in Upper Klamath Lake). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in suckers in ~~the lake~~Upper Klamath Lake would occur.

Hydroelectric Reach: ~~f~~f rom Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Continued impoundment of water at the Four Facilities under the Fish Passage at Four Dams Alternative would support growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in Copco 1 and Iron Gate Reservoirs, resulting in high seasonal concentrations of algal toxins in the Hydroelectric Reach for decades into the future. This would result in continued bioaccumulation of microcystin in fish tissue for species in the Hydroelectric Reach and could be deleterious to fish health. For salmonids, impacts would be similar to those currently observed downstream from Iron Gate Dam. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would likely decrease in the Hydroelectric Reach (see ~~Sections~~the subsection of Section 3.2.4.3.1, Chlorophyll-a and Algal Toxins – Upper Klamath Basin, and Section 3.4.4.3.1, Alternative 1: No Action/No Project Alternative –Phytoplankton, for additional detail regarding TMDLs and algal growth in the Hydroelectric Reach). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Hydroelectric Reach would occur.~~–~~

Lower Klamath River~~:~~: Downstream ~~of~~ from Iron Gate Dam Continued impoundment of water at the Four Facilities under the Fish Passage at Four Dams Alternative would support the seasonal transport of toxin-producing nuisance algae and microcystin to the Klamath River downstream ~~of~~ from Iron Gate Dam. This would result in continued bioaccumulation of microcystin in fish and mussel tissue for species in the river and could be deleterious to fish health. For salmonids, impacts would be similar to those currently observed downstream from Iron Gate Dam. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would likely decrease in the Hydroelectric Reach (see ~~Sections~~(see the subsection of Section 3.2.4.3.1, Chlorophyll-a and Algal Toxins – Upper Klamath Basin, and Section 3.4.4.3.1, Alternative 1: No Action/No Project Alternative – Phytoplankton, for additional detail regarding TMDLs and algal growth in the Klamath River downstream from Iron Gate Dam). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish and mussels in the Klamath River downstream ~~of~~from Iron Gate Dam would occur.~~–~~

Aquatic Habitat

Under the Fish Passage at Four Dams Alternative~~, the hydrology~~ access to historical anadromous fish habitat would be restored (with the exception of habitat under the four reservoirs) as discussed in the Aquatic Habitat section for Alternative 2 (subsection of Section 3.3.4.3.2). Hydrology of the Klamath River from Iron Gate Dam to the Klamath River Estuary would generally remain the same as under existing conditions, subject to the influence of climate change (discussed under Section 3.10, Greenhouse Gases/Global Climate Change). Activities currently underway to recover salmonid and sucker populations within the Klamath Basin would continue at their current levels. Fish would be able to migrate past the dams and would regain access to substantial areas of additional habitat; however, access could be delayed at the ladders and seasonally may be impaired by ~~poor~~ water ~~quality conditions in the reservoirs.~~ temperatures.

~~In addition, juveniles and smolt traveling through the four hydroelectric reservoirs would be exposed to some level of predation by introduced resident fish including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~

Fish ~~traveling~~migrating through reservoirs would be protected from entrainment at the hydroelectric intake by fish collection and routing facilities as required under the Section 18 prescriptions for ~~the~~ FERC relicensing of the Klamath Hydroelectric Project (DOI 2007). Under this alternative, there would be substantial changes to hydroelectric operations. J.C. Boyle Powerhouse would no longer generate in peaking mode, and higher flow releases would be made through the J.C. Boyle Bypass Reach than under existing conditions. Higher base flows would also be provided in the Copco 2 Bypass Reach. Peaking operations would only occur one day a week to coincide with recreation flows, at least 40 percent of flow would go into the Bypass Reach (and not enter the powerhouse), and ramping rates would be slower than they are currently. Seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle Bypass Reach by increasing the sediment deposit within the channel and decreasing reed canary grass (Administrative Law Judge 2006). The more normative flow regime associated with this alternative would provide these seasonal high flows. These modifications would benefit fish in this reach, including redband trout and anadromous fish.

Aquatic Resources Effects

Critical Habitat

As described below, continued impoundment of water within reservoirs and access to additional habitat under the Fish Passage at Four Dams Alternative could alter currently designated critical habitat.

Coho Salmon Under the Fish Passage at Four Dams Alternative, coho salmon would be able to access habitat in the Hydroelectric Reach by ascending the fishways associated with each of the dams. The upstream boundary of critical habitat for coho salmon in the Klamath Basin is Iron Gate Dam; any newly accessible areas would be outside of their currently designated critical habitat. NOAA Fisheries Service may want to consider including the newly accessible reaches as critical habitat as part of their 5-year status review or in a separate decision (J. Simondet, NOAA Fisheries Service, pers. comm., 2011). Under this alternative, the KBRA would not be implemented. However, ongoing

restoration activities will continue. The areas inundated by the reservoirs would not provide suitable spawning or rearing habitat for coho salmon, but they would regain access to the riverine reaches on the mainstem and to the tributaries, although the downstream ends of most of the tributaries would be inundated by the reservoirs. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows.

Water temperatures would continue to be seasonally affected by the reservoirs. ~~They~~ Similar to existing conditions, they would be warmer in the summer and fall when adults are migrating upstream and ~~would continue to be deleterious~~may pose a degree of seasonal risk to adult migrants~~,~~ downstream ~~of~~ from Iron Gate Dam, upon entry into the reservoirs, and in bypass reaches. ~~Many~~The incidence of ~~the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and for *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. Fish passage upstream by anadromous salmonids would increase under this alternative, which could reduce the concentration of salmon using the area immediately below Iron Gate Dam for spawning, potentially reducing the transfer of myxospores from~~ fish ~~to~~ disease in salmon would be reduced under the ~~polychaete hosts~~Fish Passage at Four Dams Alternative relative to existing conditions. FERC's (2007) analysis concluded that restoring access to reaches above Iron Gate Dam for anadromous fish would allow salmon to distribute over a greater length of the river, reducing crowding and the concentration of disease pathogens that currently occur in the reach between Iron Gate Dam and the Shasta River. However, concentrations of ~~adults~~post spawn salmon carcasses downstream ~~of~~ from Iron Gate Dam may still be ~~high while fish hold prior to ascending the fish ladder, and~~ elevated associated with the continued operation of Iron Gate Hatchery.~~ Overall, under this alternative disease in salmon would be expected to continue because: (1) conditions promoting high densities of polychaetes and parasites would generally persist; (2) a small proportion of spawning salmon produce the bulk of the myxospores; and (3) infected salmon may be less likely to successfully utilize the ladders. Therefore, under this alternative, disease impacts would be reduced, but would continue to be detrimental to salmon.~~

In terms of ~~Primary Constituent Elements~~PCEs of coho salmon critical habitat, this alternative would provide access to additional spawning habitat upstream of currently designated critical habitat, including in Fall, Jenny, Shovel and Spencer Creeks, although the downstream ends of these streams would continue to be inundated by the reservoirs and would not provide suitable spawning or rearing habitat. The food resources in these tributaries would also become available to fry and juvenile coho salmon rearing in those streams. Water quality conditions in the Hydroelectric Reach and downstream ~~of~~ from Iron Gate Dam would be expected to improve over time with TMDL implementation, but would not improve as quickly or to the same extent as under the Proposed Action. **Based on the current designation of critical habitat, the effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for coho salmon critical habitat in the short and long term.**

Bull Trout -Under the Fish Passage at Four Dams Alternative, the physical and chemical components of critical habitat for bull trout would be improved by the Oregon TMDL processes, but the KBRA would not be implemented. However, ongoing restoration activities will continue to occur. Actions taken as part of the Fish Passage at Four Dams Alternative would not affect the physical or chemical components of critical habitat, but would allow Chinook salmon and steelhead to access areas they have not been able to access since the completion of the Copco 1 Development in 1918. These species could compete with and prey upon bull trout fry and juveniles. However, bull trout would also be expected to consume the eggs and fry of Chinook salmon and steelhead. Because these species co-evolved in the watershed together, it is anticipated that they would be able to co-exist in the future. **Based on the restricted distribution of bull trout, the Fish Passage at Four Dams Alternative would result in no change from existing conditions.**

Southern Resident Killer Whale Klamath River contributes to critical habitat for Southern Resident Killer Whales through its contribution of Chinook salmon to their food supply. ~~The Proposed Action would~~ Fish Passage at Four Dams Alternative would not affect critical habitat for this species. Implementation of ~~the Fish Passage at Four Dams Alternative,~~this alternative is expected to increase production of wild Chinook salmon by providing anadromous salmonids with access to habitat upstream of Iron Gate Dam~~, is expected to increase production of wild Chinook salmon~~. The Iron Gate Hatchery would continue to operate, ensuring ongoing production of hatchery Chinook salmon and contribution to ocean stocks. Klamath River Chinook salmon likely represent only a very small proportion of the diet of this killer whale population because most of their feeding is on Fraser River and Puget Sound~~s~~ stocks (Hanson et al. 2010); therefore, any increase in salmon production from ~~the Proposed Action~~this alternative would not substantially affect this species. **Based on small influence of the Klamath River on PCEs of Southern Resident Killer Whales, the Fish Passage at Four Dams Alternative would result in no change from existing conditions.**

Essential Fish Habitat

As described below, continued impoundment of water within reservoirs and access to additional habitat under the Fish Passage at Four Dams Alternative could alter the availability and suitability of ~~Essential Fish Habitat (~~EFH~~)~~.

Chinook and Coho Salmon EFH Implementation of the Fish Passage at Four Dams Alternative would increase habitat for Chinook and coho salmon (upstream of currently designated EFH) by providing access to habitat upstream of Iron Gate Dam. However, under this alternative, EFH for Chinook and coho salmon would be expected to remain similar to its current condition, as described for the No Action/No Project Alternative. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for Chinook and coho salmon EFH in the short and long term.**

Groundfish EFH Implementation of the Fish Passage at Four Dams Alternative would not affect groundfish EFH. SSCs and bedload would remain the same as under existing conditions, as would water quality. **The effect of the Fish Passage at Four Dams**

Alternative would be no change from existing conditions for groundfish EFH in the short and long term.

Pelagic Fish EFH Implementation of the Fish Passage at Four Dams Alternative would not affect pelagic fish EFH. SSCs and bedload would remain the same, as would water quality. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for pelagic fish EFH in the short and long term.**

Species-Specific Impacts

A described below, ~~fish ladders~~fishways at Four Dams could alter the availability of habitat resulting in effects on aquatic species.

Fall-Run Chinook Salmon

Upper Klamath Basin ~~upstream~~ Upstream of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, fish passage facilities installed at the four dams within the Hydroelectric Reach would allow fall-run Chinook salmon to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising ~~420~~ hundreds of miles of additional potentially productive habitat (DOI 2007), including access to groundwater discharge areas relatively resistant to effects of climate change (Hamilton et al. 2011). ~~There would continue to be 22.4 miles of spawning and rearing habitat inundated reservoirs (Cunanan 2009).~~ Implementation of the Fish Passage at Four Dams Alternative would not result in changes to the suspended sediments or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might ~~prevent~~ impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Poor water quality conditions from Link Dam to Keno Dam during the late summer and fall could be detrimental to fish in this area, particularly anadromous salmonids (FERC 2007). Therefore, the Fish Passage at Four Dams Alternative would include an interim seasonal trap and haul operation that would involve capturing and trucking both upstream and downstream migrant fish (primarily adult fall-run Chinook salmon) around this area when water quality conditions would be prohibitively stressful. This is consistent with the fishway prescriptions of DOI and U.S. Department of Commerce (DOC) (DOI 2007; NOAA Fisheries Service 2007). As adult fall-run Chinook salmon in the Klamath River migrate upstream from August through October, and juveniles migrate to the ocean from spring to early fall, stress-related

mortality associated with seasonal, interim trap and haul activities would affect this species to some degree.

Some degree of stress and mortality of adult and juvenile salmon may result from the interim seasonal trap and haul operations (Buchanan et al. 2011b), especially between Link Dam and Keno Dam, and during periods with high water temperatures or poor water quality. The distance that fish would be transported under this alternative would be limited however, and trap and haul would only be used when fish would otherwise be exposed to stressful conditions.

Hydroelectric Reach: from From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Implementation of the Fish Passage at Four Dams Alternative would restore fall-run Chinook salmon access to the Hydroelectric Reach. Passage through the reach would provide approximately 5254 miles of additional habitat along the mainstem and within accessible tributaries (DOI 2007). Riverine habitat under the existing reservoirs would continue to be inaccessible. , based on access to 58 miles of anadromous fish (steelhead) habitat (Administrative Law Judge 2006)[9], taking into account the restricted distribution of Chinook salmon (DOI 2007), habitat in the bypass reaches, and the continuation of around 22 miles of spawning and rearing habitat inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. Passage Under this Alternative, the expected overall higher flow releases would result in more reservoir water entering the J. C. Boyle Bypass Reach and correspondingly warmer water temperatures during summer and early fall, and cooler temperatures in late fall and winter. These effects would be similar to those under the Proposed Action and would move this short reach away from consistently cooler water temperatures during summer and early fall months; however, passage structures would provide access to thermal refugia created by 200 to 250 cfs of spring flow accretion in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007). Under this alternative, suspended and bedload sediment, water quality, water temperature, and the occurrence of fish disease and algal toxins would be the same as under existing conditions.

Similar to the No Action/No Project Alternative, Under this alternative fish migrating through reservoirs would continue to be be seasonally exposed to more some degree to stressful water quality conditions including high temperatures in reservoir surface layers with low dissolved oxygen in reservoir surface layers in the summer and fall, changes in dissolved oxygen, pH, and ammonia associated with algal blooms, and exposure to microcystin from *M. aeruginosa* blooms (Dunsmoor and Huntington 2006; FERC 2007). These conditions can become severely stressful in June through September, contributing to lower resistance to disease, and potentially causing direct mortality seasonally. Springs beneath the reservoirs would not provide thermal refugia, as they would discharge into layers of water with low DOdissolved oxygen that occur at the bottoms of the reservoirs. These

[9] This also takes into consideration slight differences in the Administrative Law Judge (2006) definition of the Project Reach from what is used in this report.

~~juveniles would also be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~ The combination and timing of effects (adults migrate from August through October, juveniles migrate from spring to early fall), could result in stress, migration delays, or mortality of fall-run Chinook salmon as they move through the Hydroelectric Reach.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project dams would continue to trap fine and coarse sediment~~ and reduce the storage capacity of the reservoirs~~. The channel directly downstream ~~of~~ from Iron Gate Dam would continue to be starved of fine sediment, but the effect would gradually decrease in the downstream direction as coarse sediment would be resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a). Coarsening of the bed could reduce spawning habitat for fall-run Chinook salmon ~~below~~ downstream from the dam over time, but this impact would be limited to the area upstream of Cottonwood Creek. Rearing habitat would be expected to remain similar to existing conditions.

Under the Fish Passage at Four Dams Alternative, the ~~lower~~Lower Klamath River downstream ~~of~~ from Iron Gate Dam reach would continue to have seasonally poor water quality because of the continued presence of the reservoirs with their increased hydraulic residence time and thermal mass (Bartholow 2005). The ~~delay in thermal signature would continue to delay the migration and spawning~~ continuation of warm water releases from Iron

Gate Dam will contribute to the delay in adult upstream migration of fall-run Chinook salmon ~~downstream of Iron Gate Dam, and~~ (Dunsmoor and Huntington 2006), and increase the risk of prespawn mortality ~~would remain high~~ (Hamilton et al. 2011). ~~Current cooler temperatures in spring and early summer could benefit rearing life history of anadromous species (Hamilton et al. 2011).~~

~~Many of the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and their parasites *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. Upstream fish passage would likely reduce salmon spawning density immediately downstream of Iron Gate Dam, which in turn is likely to reduce the transfer of myxospores from salmon to their polychaete hosts. However, concentrations of adults downstream of Iron Gate Dam may still be high while fish hold prior to accessing the fish ladder, and the continued operation of Iron Gate Hatchery. Therefore, under this alternative, disease impacts could be~~ As described above, the incidence of fish disease for fall-run Chinook salmon would be reduced~~, but continue to be detrimental to fall-run Chinook salmon.~~

under the Fish Passage at Four Dams Alternative relative to existing conditions. Dissolved oxygen concentrations during ~~July~~ August-October immediately downstream ~~of~~ from Iron Gate Dam would continue to be low (less than ~~8 mg/L).~~85 percent saturation during August-September and 90 percent saturation from October-November (see subsection of Section 3.2.4.3.1, Lower Klamath River). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream ~~of~~from Iron Gate Dam.

Estuary

The Fish Passage at Four Dams Alternative is not expected to substantially change or affect fall-run Chinook salmon estuarine habitat relative to existing conditions.

Summary: Fall-Run Chinook Salmon

Under this alternative, ~~fish ladders~~ fishways at Four Dams could result in alterations in habitat availability for fall-run Chinook salmon in the long term. Under the Fish Passage at Four Dams Alternative, fall-run Chinook salmon would regain access to mainstem and tributary habitat in the upper Klamath River and Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach, which would benefit the population. Some degree of stress and mortality of adult and juvenile salmon may result from the interim seasonal trap and haul operations (Buchanan et al. 2011b), especially between Link Dam and Keno Dam, and during periods with high water temperatures or poor water quality. Poor water quality, high water temperature, low dissolved oxygen, algal blooms and toxins~~, and predation~~ could ~~result in low~~ reduce survival of fall-run Chinook salmon passing through the four reservoirs. The distance that fish would be transported under this alternative would be limited however, and trap and haul only used when fish would otherwise be exposed to stressful conditions.

This alternative would result in continuation of ~~many~~some of the stresses that currently affect Chinook salmon populations. The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality, and high late summer and early fall water temperatures, allowing ~~many~~some conditions favorable for the transmission of fish disease to persist. These conditions would continue to have negative short- and long-term impacts on fall-run Chinook salmon populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities would continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the fall-run Chinook salmon population within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity. However, smolts produced from tributaries downstream ~~of~~from Iron Gate Dam would experience a continuation of existing deleterious effects. **Based on increased habitat availability, the effect of the Fish Passage at Four Dams Alternative would be beneficial for fall-run Chinook salmon in the short and long term.**

Spring-Run Chinook Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, fish passage facilities installed at the four dams within the Hydroelectric Reach would allow spring-run Chinook salmon to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005, Butler et al. 2010). ~~Passage at Keno Dam would provide~~Huntington (2006) reasoned that spring-run Chinook salmon likely accounted for the majority of the Upper Klamath Basin's actual salmon production under historical conditions. Huntington (2006) cautioned that while access to ~~20 miles of reservoir habitat and 1.2 miles~~the Upper Klamath Basin provides considerable promise of ~~riverine habitat between Keno and Link River Dams (FERC 2007).~~ increasing spring-run abundance, the existing potential for Chinook salmon production within the Basin upstream of Upper Klamath Lake is clearly much lower than his estimate of historical potential. However, Huntington (2006) did not fully account for the historical (and unknown) production potential of Upper Klamath Lake itself, which could have been considerable, as suggested by a recent experimental reintroduction into Upper Klamath Lake (Maule et al. 2009). Overall, the Fish Passage at Four Dams Alternative would provide access to 49 significant tributaries in the Upper Klamath Basin, comprising ~~420~~ hundreds of miles of additional potentially productive anadromous fish habitat upstream of Iron Gate Dam (DOI 2007), including access to important thermal refugia within areas influenced by groundwater ~~areas~~ exchange that are more resistant to climate change (Hamilton et al. 2011). ~~There would continue to be 22.4 miles of spawning and rearing habitat inundated by reservoirs (Cunanan 2009).~~ Some of these areas, such as the lower Williamson River, have habitat that would provide substantial holding areas for spring-run Chinook salmon (Hamilton et al. 2010). Other holding areas with suitable temperatures upstream of J.C. Boyle Reservoir include

groundwater influenced areas on the west side of Upper Klamath Lake, and the Wood River (Gannett et al. 2007).

The Fish Passage at Four Dams Alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25 °C, high pH) in the reach from Keno Dam to Link Dam might ~~prevent~~impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Poor water quality conditions, particularly in Lake Ewauna during the late summer and early fall, could be detrimental to fish in this area, particularly anadromous salmonids (FERC 2007). Therefore, an interim seasonal trap and haul operation would be implemented to capture and truck migrant fish around Lake Ewauna during stressful water quality conditions (from June 15~~th~~ to November 15~~th, see Section 3.3.2~~). As adult spring-run Chinook salmon in the Klamath River migrate upstream from April through June, and most juveniles migrate from April through May or October through November, trap and haul activities would be expected to have only minor effects on this run of Chinook salmon.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Fish Passage at Four Dams Alternative would include restoring spring-run Chinook salmon access to the Hydroelectric Reach. Passage through the ~~Reach~~reach would provide approximately ~~52~~54 miles of additional habitat along the mainstem and within accessible tributaries, based on access to 58 miles of anadromous fish (steelhead) habitat (Administrative Law Judge 2006),[10] taking into account the more limited distribution of Chinook salmon (DOI 2007), habitat in the bypass reaches, and the continuation of around 22 miles of spawning and rearing habitat inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. ~~Further,~~ Under this Alternative, the expected overall higher flow releases than under current conditions would result in more reservoir water entering the J.C. Boyle Bypass Reach and correspondingly warmer water temperatures during summer and early fall, and cooler temperatures in late fall and winter. These effects would be similar to those under the Proposed Action and would move this short reach away from consistently cooler water temperatures during summer and early fall months; however, passage structures would provide fish with some refuge from high temperatures because ~~the~~ of access to cooler water from tributaries ~~would flow directly into the mainstem Klamath River~~, in addition to that provided by 200 to 250 cfs of accretion from springs in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007; Hamilton et al. 2011). Under this alternative, flows and access would also be restored to the 1.4 mile Copco 2 bypass reach. Under

[10] This also takes into consideration slight differences in the Administrative Law Judge (2006) definition of the Project Reach from what is used in this report.

this alternative, suspended and bedload sediment, water quality, ~~water temperature,~~ and the occurrence of fish disease and algal toxins would be the same as under existing conditions.

This alternative would result in continuation of ~~many~~ some of the stresses that currently affect Chinook salmon populations. The presence of J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality, and high late summer and early fall water temperatures, ~~allowing~~allowing some conditions favorable for the transmission of fish disease to persist. Adult spring-run Chinook salmon in the Klamath River migrate upstream from April through June (and possibly earlier, Fortune et al. 1966), and most juveniles migrate from April through May or ~~October through November, as such, similar to trap and haul, poor~~in the fall, as flows increase. Therefore water quality in reservoirs ~~would~~is expected to have minor effects on ~~the fitness of~~ this species. ~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project dams would continue to trap fine and coarse sediment~~ and reduce the storage capacity of the reservoirs.~~ . The channel directly downstream from Iron Gate Dam would continue to be starved of fine sediment, but the effect would gradually decrease in the downstream direction as coarse sediment would be resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a).

Under the Fish Passage at Four Dams Alternative, the ~~lower~~ Lower Klamath River downstream ~~of~~ from Iron Gate Dam would continue to have seasonally poor water quality because of the continued presence of the reservoirs, with their increased hydraulic residence time and thermal mass (Bartholow et al. 2005). ~~Current cooler temperatures in spring and early summer could benefit both adult and juvenile migrant spring-run Chinook salmon; however, juveniles migrating later in the year would~~ Under this alternative, the current phase shift and lack of temporal temperature diversity will persist, including current warm temperatures in late summer and fall (Hamilton et al. 2011). Juveniles and adults migrating would continue to experience warm temperatures in late summer and fall that could be deleterious to health and survival~~.~~

~~Many of the primary factors influencing salmon infection and~~ , including increased risk of disease, and high rates ~~from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence~~ of ~~the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and their parasites *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. The Iron Gate Hatchery would continue to operate and would discharge its nutrient-rich effluent to the river. Upstream fish passage would likely reduce salmon~~delayed spawning ~~density immediately downstream of Iron Gate Dam, which in turn is likely to reduce the transfer of myxospores from salmon to their polychaete hosts. Therefore, under this alternative, disease impacts would~~ and prespawn mortality (Hetrick et al. 2009).

As described above, the incidence of fish disease for spring-run Chinook salmon would be reduced~~, but would continue to be detrimental to spring-run Chinook salmon.~~

under the Fish Passage at Four Dams Alternative relative to existing conditions.
Dissolved oxygen concentrations during ~~July~~ August-October immediately downstream ~~of~~from Iron Gate Dam would continue to be low (less than ~~8 mg/L).~~85 percent saturation during August-September and 90 percent saturation from October-November (see Section 3.2.4.3.1.4 – Lower Klamath River). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream ~~of~~from Iron Gate Dam.

Estuary
The Fish Passage at Four Dams Alternative is not expected to substantially change or affect spring-run Chinook salmon estuarine habitat relative to existing conditions.

Summary: Spring-Run Chinook Salmon

Under this alternative, ~~fish ladders~~ fishways at Four Dams could result in alterations in habitat availability which could affect spring-run Chinook salmon in the long term. Under the Fish Passage at Four Dams Alternative, spring-run Chinook salmon would regain access to mainstem and tributary habitat in the upper Klamath River and Hydroelectric Reach and thermal refugia within the Hydroelectric Reach. The expansion of habitat opportunities will allow maximum expression of life-history variation and the restoration of an additional population of spring-run Chinook salmon population to strengthen resiliency in the Klamath Basin, particularly because passage upstream of Iron Gate Dam will provide access to thermal refugia at groundwater areas (Hamilton et al. 2011). Stress to migrating adults and juveniles associated with potential interim seasonal trap and haul operation and poor reservoir water quality would likely be minor. ~~Predation~~ As described below, predation could result in ~~reduced survival~~some mortality of spring-run Chinook salmon juveniles passing through the reservoirs. Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006). Cooler water temperatures (similar to existing conditions) during the spring would continue to benefit upstream migrating adult and downstream migrant juvenile spring-run Chinook salmon. Warmer water temperatures in the fall would continue to be detrimental to juveniles and adults migrating at that time. These effects would be most pronounced for fish migrating through areas upstream of the Scott River.

This alternative would result in continuation of ~~many of~~ some the stresses that currently affect Chinook salmon populations. The presence of J.~~-~~C. Boyle, Copco 1, Copco 2, and Iron Gate Dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality, and high late summer and early fall water temperatures, allowing some conditions favorable for the transmission of disease for salmon to persist. These conditions would continue to have negative short- and long-term impacts on spring-run Chinook salmon populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the spring-run Chinook salmon population within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity. In addition, with large scale hydraulic mining operations now outlawed, spring-run Chinook salmon would no longer be subject to one of their most significant threats in the Klamath River (as discussed above in the subsection of Section 3.3.3.1.1). Current improved fisheries management also minimizes overharvest. However, smolts produced from the Salmon River and tributaries downstream ~~of~~from Iron Gate Dam would experience a continuation of existing ~~deleterious~~ effects. **Based on increased habitat availability the effect of the Fish Passage at Four Dams**

Alternative would be beneficial for spring-run Chinook salmon in the short- and long term.

Coho Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Hamilton et al. (2005) states that historically coho salmon occurred at least ~~to~~ as far as Spencer Creek (J.C. Boyle Reservoir). The Fish Passage at Four Dams Alternative may not affect coho salmon in the Upper Klamath Basin upstream of J.C. Boyle Reservoir Reach.

Hydroelectric Reach: ~~from~~ From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Coho salmon ~~below~~ downstream from Iron Gate Dam belonging to the Upper Klamath River Population Unit would migrate above the dam if access was provided by fishways (Administrative Law Judge 2006). Over time, access to habitat above Iron Gate Dam would benefit the Upper Klamath River Population Unit by: a) extending the range and distribution of the species thereby increasing the coho salmon's reproductive potential; b~~)~~) increase genetic diversity in the coho stocks; c) reduce the species vulnerability to the impacts of degradation; and d) increase the abundance of the coho salmon population (Administrative Law Judge 2006). Implementation of the Fish Passage at Four Dams Alternative would restore Upper Klamath River Population Unit access to the Hydroelectric Reach, thereby expanding their distribution to include historical habitat along the mainstem Klamath River not inundated by reservoirs ~~(although these areas would continue to be affected by the reservoirs)~~ and all tributaries upstream at least ~~to~~ as far as Spencer Creek, including Jenny, Shovel, and Fall creeks (Hamilton et al. 2005). Passage through the reach would provide approximately ~~48~~54 miles of additional habitat ~~within~~ along the mainstem and within accessible tributaries, based on access to 58 miles of anadromous fish (steelhead) habitat (Administrative Law Judge 2006),[11] taking into account the restricted distribution of coho salmon (DOI 2007), habitat in the bypass reaches, and the continuation of around 22 miles of spawning and rearing habitat inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. ~~Furthermore~~Under this alternative, the expected overall higher flow releases would result in more reservoir water entering the J.C. Boyle Bypass Reach and correspondingly warmer water temperatures during summer and early fall, and cooler temperatures in late fall and winter. These effects would be similar to those under the Proposed Action and would move this short reach away from consistently cooler water temperatures during summer and early fall months; however, upstream passage would provide fish with some refuge from high temperatures because ~~the~~ of access to cooler water from tributaries ~~would flow directly into the mainstem Klamath River~~, in addition to the 200 to 250 cfs provided by coldwater springs in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007; Hamilton et al. 2011).

[11] This also takes into consideration slight differences in the Administrative Law Judge (2006) definition of the Project Reach from what is used in this report.

Under this alternative, suspended and bedload sediment, water quality, ~~water temperature,~~ and the occurrence of ~~fish disease and~~ algal toxins would be the same as under existing conditions.

This alternative would result in continuation of ~~many~~ some of the stresses that currently affect coho salmon populations. The presence of J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality, and high late summer and early fall water temperatures, ~~allowing~~allowing some conditions favorable for the transmission of fish disease to persist. Although water temperature in the summer above Iron Gate Dam is an issue, the record evidence shows that water temperature would not preclude coho salmon from successfully utilizing the habitat within the Project area (Administrative Law Judge 2006). Adult coho salmon enter the Klamath River between late September and mid-December, with peak upstream migration occurring between late October and mid-November, and fry outmigrate to the ocean beginning in late February, with most outmigration occurring in April and May, as such, poor water quality in reservoirs would have minor ~~affect~~effect on this species. ~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, coho salmon and other anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project ~~Dams~~ dams would continue to trap fine and coarse sediment~~ and reduce the storage capacity of the reservoirs~~. The channel directly downstream from Iron Gate Dam would continue to be starved of fine sediment, but the effect would gradually decrease in the downstream direction as coarse sediment would be resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a). Most spawning and rearing takes place within tributaries. But for the few coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, coarsening of the bed could reduce spawning habitat for coho salmon between Iron Gate Dam and Cottonwood Creek over time. Rearing habitat would be expected to remain similar to existing conditions.

Under the Fish Passage at Four Dams Alternative, the ~~lower~~Lower Klamath River downstream ~~of~~ from Iron Gate Dam would continue to have seasonally poor water quality because of the continued presence of the reservoirs, with their increased hydraulic residence time and thermal mass (Bartholow et al. 2005).~~ The delay in thermal signature would continue to delay anadromous spawning downstream of Iron Gate Dam, and pre-spawn mortality would remain high (Hamilton et al. 2011).~~

~~Many of the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and their parasites *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. The Iron Gate Hatchery would continue to operate and would discharge its nutrient-rich effluent to the river. Upstream fish passage would likely reduce salmon spawning density immediately downstream of Iron Gate Dam, which in turn is likely to reduce the transfer of myxospores from salmon to their polychaete hosts. Therefore, under this alternative, disease impacts~~ As described above, the incidence of fish disease for coho salmon would be reduced~~, but continue to be detrimental to coho salmon.~~

under the Fish Passage at Four Dams Alternative relative to existing conditions. Dissolved oxygen concentrations during ~~July~~ August-October immediately downstream ~~of~~ from Iron Gate Dam would continue to be low (less than ~~8 mg/L).~~85 percent saturation during August-September and 90 percent saturation from October-November (see the subsection of Section 3.2.4.3.1, Lower Klamath River). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream ~~of~~from Iron Gate Dam.

Estuary
The Fish Passage at Four Dams Alternative is not expected to substantially change or affect ~~spring-run Chinook~~coho salmon estuarine habitat relative to existing conditions.

Summary: Coho Salmon

Under this alternative, ~~fish ladders~~ fishways at Four Dams could result in alterations in habitat availability which could affect coho salmon in the long term. Under the Fish Passage at Four Dams Alternative, coho salmon would regain access to mainstem and tributary habitat in the Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. Stress to migrating adults and juveniles associated with poor reservoir water quality and predation (as described below) would occur, but would likely be minor. Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, coho salmon and other anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

~~As the~~ The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality, and high late summer and early fall water temperatures, allowing some conditions favorable for the transmission of fish disease to persist. These conditions would continue to have negative short- and long-term impacts on coho salmon populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the Upper Klamath River Population Unit would have an increase in abundance, population spatial structure, and genetic diversity. It is also anticipated that as a result of the Fish Passage at Four Dams Alternative the Mid-Klamath River, Shasta River, Scott River, Salmon River population units would experience a continuation of existing ~~deleterious~~ effects, and the three Trinity River population units, and the ~~lower~~Lower Klamath River population units would not be affected. **Based on increased habitat availability the effect of the Fish Passage at Four Dams Alternative would be beneficial for coho salmon from the Upper Klamath River population unit in the short- and long term. Based on the continuation of existing conditions for populations downstream ~~of~~from Iron Gate Dam, this alternative would be no change from existing conditions for the coho salmon from the Mid-Klamath River, Shasta River, Scott River, and Salmon River, three Trinity River population units, and the Lower Klamath River population units in the short- and long term.**

Steelhead

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, steelhead would regain access to the Upper Klamath Basin upstream of J.C. Boyle Reservoir. This would expand the population's distribution to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005~~, Butler et al. 2010). Huntington (2006) estimated that the amount of~~ ,). This would be a potential ~~new habitat for steelhead could be 500 miles; only perennial streams were counted in this estimate, but steelhead are also known to spawn in intermittent streams. Current redband trout distribution within areas that would become accessible to steelhead has been estimated at~~

496 miles by ODFW (W. Tinniswood, pers. comm., 2011). Because steelhead have habitat requirements similar to those of redband trout, this can be used as a rough estimate of habitat that may also be available to steelhead. Reservoirs would continue to inundate 22.4 miles of potential spawning and rearing habitat (Cunanan 2009increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising 360 miles of additional potentially productive habitat (Huntington 2006; DOI 2007; NOAA Fisheries Service 2007). This alternative would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might preventimpede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011).

Poor water quality conditions, particularly in Lake Ewauna during the late spring and early summer could be detrimental to fish in this area, particularly anadromous salmonids (FERC 2007). Therefore, the Fish Passage at Four Dams Alternative includes interim seasonal trap and haul to capture and transport migrant fish (primarily adult fall-run Chinook salmon) around the Keno Impoundment/Lake Ewauna when water quality conditions would be prohibitively stressful. Long distance trap and haul could potentially increase stress on summer steelhead (entering the Klamath River from March to June) and winter steelhead (entering the river and migrating from August to March), potentially causing direct mortality as well as post-release pre-spawning mortality (Steward and Associates 2007; Buchanan et al. 2011b).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Fish Passage at Four Dams would provide steelhead with access to the Hydroelectric Reach, which would expand the population's distribution to include historical habitat in the mainstem Klamath River and its tributaries, including Jenny, Spencer, Shovel, and Fall creeks (Hamilton et al. 2005). Passage through the reach would provide approximately 59 miles of additional habitat along the mainstem and within accessible tributaries (Administrative Law Judge 2006), taking into account habitat in the bypass reaches, and the continuation of around 22 miles of spawning and rearing habitat inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. Overall, because of their greater capacity for ascending potential obstacles to migration that might exclude Chinook and coho salmon, the Fish Passage at Four Dams, consistent with mandatory conditions (DOI 2007). Under this Alternative would provide steelhead with access to approximately 59 miles of additional habitat in the mainstem and accessible tributaries, comprising hundreds of miles of additional potentially productive anadromous fish habitat upstream of Iron Gate Dam (DOI 2007), including access to groundwater discharge areas, the expected overall higher flow releases would result in more resistant to effects of climate change (Hamilton et al.2011).

~~There would continue to be 22.4 miles of spawning and rearing habitat inundated by reservoirs (Cunanan 2009).~~reservoir water entering the J. C. Boyle Bypass Reach and correspondingly warmer water temperatures during summer and early fall, and cooler water temperatures in late fall and winter. These effects would be similar to those under the Proposed Action and would move this short reach away from consistently cooler water temperatures during summer and early fall months.

Poor water quality conditions in reservoirs, such as high temperatures with low dissolved oxygen, fluctuations in dissolved oxygen, pH, ammonia associated with algal blooms, and microcystin from *M. aeruginosa* blooms would continue to be ~~severely~~ stressful to fish from June through September (Dunsmoor and Huntington 2006; FERC 2007). ~~Summer steelhead enter the Klamath River from March to June, while winter~~Winter steelhead enter and migrate from August to March; thus, poor water quality could have an effect on these fish as they move through reservoirs. Steelhead spawn in tributaries, and juveniles typically outmigrate from April through November, but the peak occurs from April through June, so most individuals would be likely to avoid poor reservoir water quality.~~ Juveniles would be subject to some predation by introduced resident species such as largemouth bass, catfish, and yellow perch, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous salmonid juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment dynamics would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project ~~Dams~~dams would continue to trap fine and coarse sediment~~ and reduce the storage capacity of the reservoirs~~. The channel directly downstream from Iron Gate Dam would continue to be starved of fine sediment, but the effect would gradually decrease in the downstream direction as coarse sediment would be resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a). Current summer steelhead distribution extends from the mouth of the Klamath River upstream to Empire Creek, while winter steelhead are distributed throughout the ~~lower~~Lower Klamath River up to Iron Gate Dam (Stillwater ~~Sciences~~Sciences 2010b). Summer and winter steelhead do not spawn in the mainstem Klamath River, nor are they expected to in the future, so spawning habitat would not be affected by alterations to bedload composition downstream ~~of~~from Iron Gate Dam under

the Fish Passage at Four Dams Alternative. Changes to bedload sediment would not be expected to affect juvenile rearing and migration.

Under the Fish Passage at Four Dams Alternative, the ~~lower~~Lower Klamath River downstream ~~of~~from Iron Gate Dam Reach would continue to ~~have~~have seasonally poor water quality because of the continued presence of the reservoirs, with their increased hydraulic residence time and thermal mass (Bartholow et al. 2005). ~~Current cooler temperatures in spring and early summer may benefit both adult and juvenile migrant steelhead; however, juveniles migrating later in the year would be deleteriously affected by warm temperatures in late summer and fall.~~

Dissolved oxygen concentrations during ~~July~~ August-October immediately downstream ~~of~~from Iron Gate Dam would continue to be low (less than ~~8 mg/L~~85 percent saturation during August-September and 90 percent saturation from October-November (see the subsection of Section 3.2.4.3.1, Lower Klamath River). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream ~~of~~from Iron Gate Dam.

Estuary
The Fish Passage at Four Dams Alternative is not expected to substantially change or affect steelhead estuarine habitat relative to existing conditions.

Summary: Steelhead
Under this alternative, ~~fish ladders~~ fishways at Four Dams could result in alterations in habitat availability which could affect steelhead in the long term. Under the Fish Passage at Four Dams Alternative, steelhead would regain access to mainstem and tributary habitat in the Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. Stress to migrating adults and juveniles associated with seasonally poor reservoir water quality would likely be minor. Survival during migration through reservoirs could be negatively affected at some level by predation.

This alternative would result in continuation of ~~many of~~ some the stresses that currently affect steelhead populations. The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality, and high late summer and early fall water temperatures~~, allowing conditions favorable for the transmission of fish disease to persist~~. These conditions would continue to have negative short- and long-term impacts on steelhead populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. FERC (FERC 2007) concluded that implementing fish passage would help to reduce adverse effects to steelhead associated with lost access to upstream spawning habitats. Hamilton et al. (2011) also concluded that access to additional habitat in the Upper Klamath River watershed would benefit steelhead runs. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the summer and winter steelhead

within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity. **Based on increased habitat availability, the Fish Passage at Four Dams Alternative would be beneficial for summer and winter steelhead in the short- and long term**.

Pacific Lamprey

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Pacific lamprey ~~did not~~ occurred historically ~~occur~~at least to Spencer Creek (Hamilton et al. 2005) although there is some uncertainty in this regard (Administrative Law Judge 2006). Pacific lamprey below Iron Gate dam would migrate above the dam if access was provided through fishways (Administrative Law Judge (2006). They may not have historically occurred upstream of J.C. Boyle Reservoir (~~Hamilton et al. 2005)~~ Administrative Law Judge 2006), and ~~are~~may not ~~anticipated to~~ occupy this reach after implementation of this alternative.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Fish Passage at Four Dams Alternative would provide Pacific lamprey with access to ~~the Hydroelectric Reach and to the mainstem Klamath River and all its tributaries~~ habitat upstream ~~as far as Spencer Creek, including Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005). Passage through the reach would provide additional habitat along the mainstem and within accessible tributaries (DOI 2007~~of Iron Gate Dam, which would benefit lamprey by providing them with additional spawning and rearing habitat (Administrative Law Judge 2006). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. In addition, passage would provide fish with some refuge from high temperatures by allowing cooler tributaries to flow directly into the mainstem Klamath River, adding to the 200 to 250 cfs provided by coldwater springs in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007; Hamilton et al. 2011). Under this alternative, suspended and bedload sediment, water quality, water temperature, and the occurrence of algal toxins would continue to be the same as under existing conditions.

Poor water quality conditions in reservoirs, such as high temperatures with low dissolved oxygen, changes in dissolved oxygen, pH, and ammonia associated with algal blooms, and microcystin from *M. aeruginosa* blooms would continue to be ~~severely~~ stressful from June to September (Dunsmoor and Huntington 2006; FERC 2007). Pacific lamprey adults migrate from winter through spring, while juveniles (age 2 to age 10) outmigrate year-round, with peaks during late spring and fall. ~~Poor~~ Seasonally poor reservoir quality would likely not affect migrating adults, but could affect juveniles. Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch (FERC 2007). Volitional passage for Pacific lamprey has been designed and is in place in other river systems (Administrative Law Judge 2006).

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam Under the Fish Passage at Four Dams Alternative, Klamath Hydroelectric Project Dams would continue to trap fine and coarse sediment ~~and reduce the storage capacity of the reservoirs~~. Suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. The channel directly downstream ~~of~~from Iron Gate Dam would continue to be starved of fine

sediment. Coarsening of the bed could reduce spawning habitat for lamprey downstream ~~of~~ from the dam over time, but this impact would be limited to the area upstream of Cottonwood Creek, as coarse sediment was resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a).

Under the Fish Passage at Four Dams Alternative, the ~~lower~~Lower Klamath River downstream ~~of~~ from Iron Gate Dam reach would continue to have seasonally poor water quality. Water quality would continue to be influenced by reservoirs, with increased hydraulic residence time and thermal mass (Bartholow et al. 2005). Finally, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur.

Estuary

The Fish Passage at Four Dams Alternative is not expected to substantially change or affect Pacific Lamprey estuarine habitat relative to existing conditions.

Summary: Pacific Lamprey

Under this alternative, ~~fish ladders~~fishways could result in alterations in habitat availability which could affect Pacific lamprey in the long term. Under the Fish Passage at Four Dams Alternative, lamprey would regain access to mainstem and tributary habitat in the ~~upper Klamath River and~~ Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. ~~Poor~~ Seasonally poor reservoir quality would likely not affect migrating adults, but could affect juveniles. Juveniles would also be exposed to predation from nonnative resident fish.

This alternative would result in continuation of ~~many of~~some the stresses that currently affect lamprey populations. The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause seasonally poor water quality and high late summer and early fall water temperatures. Climate change could also increase the frequency and duration of stressful water temperatures for lamprey under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the Pacific lamprey population within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity (Administrative Law Judge 2006). However, lamprey downstream ~~of~~from Iron Gate Dam would experience a continuation of existing ~~deleterious~~ effects. **Based on increased habitat availability, the Fish Passage at Four Dams Alternative would be beneficial for Pacific lamprey in the short- and long term**.

Green Sturgeon

Under this alternative, ~~fish ladders~~ fishways at Four Dams could result in alterations in habitat availability which could affect ~~Pacific lamprey~~ green sturgeon in the long term. Under the Fish Passage at Four Dams Alternative, conditions in the area occupied by green sturgeon are unlikely to change relative to existing conditions as green sturgeon occur downstream ~~of~~from Ishi Pishi Falls, and the effects of this alternative are not anticipated to extend that far downstream.

It is anticipated that as a result of the Fish Passage at Four Dams Alternative the green sturgeon population within the Klamath River watershed would experience a continuation of ~~deleterious~~ existing effects. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for green sturgeon in the short- and long term.**

Shortnose and Lost River Sucker

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir The KBRA would not be implemented under this alternative. However, ongoing restoration activities will continue to occur.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Construction of fishways could affect shortnose and Lost River Sucker populations by continuing poor water quality and high rates of predation. Shortnose and Lost River suckers would continue to be subject to seasonally poor water quality and high rates of predation within reservoirs. But with little or no successful reproduction (Buettner et al. 2006), populations downstream ~~of~~from Keno Dam contribute minimally to conservation goals and insignificantly to recovery (Hamilton et al. 2011). Fish passage was not prescribed for sucker species at Iron Gate, J.C. Boyle, Copco 1, or Copco 2 Dams.

Under the Fish Passage at Four Dams Alternative, existing efforts to restore habitat for shortnose and Lost River sucker and improve water quality conditions would continue. These actions would be expected to improve conditions for these species over time and their populations would be expected to increase. **The effect of the Fish Passage at Four Dams Alternative would be less-than-significant for Lost River and shortnose sucker populations in the short and long term.**

Redband Trout

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, redband trout would be able to migrate more successfully from the Hydroelectric Reach to the Upper Klamath Basin (Hamilton et al. 2011) than under existing conditions. Fish passage facilities would improve connectivity to Spencer Creek, which provides important spawning habitat and temperature refugia for redband trout (DOI 2007; Buchanan et al. ~~2011b~~2011a). Upstream fish passage would also restore connectivity of resident redband populations in the mainstem Klamath River to those in Lake Ewauna, the Link River, and Upper Klamath Lake (DOI 2007). The Fish Passage at Four Dams Alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease.

~~Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to redband trout above Iron Gate Dam (Administrative Law Judge 2006).~~ Redband could be affected by ~~increased~~the reintroduction of anadromous fish, including the potential for competition, predation ~~from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry~~, and ~~juveniles of reintroduced salmonids) (Hamilton et al. 2011). Adult salmon moving into the upper basin would likely bring with them genotypes of *C. shasta* that had previously been restricted to the lower~~

~~river. While the effects of these introductions are uncertain, at least some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, might not be susceptible to the new genotypes. Additionally, the changes in habitat that could result from dam removal (fewer areas of slow-flowing, stable habitat) would likely reduce the density of polychaete populations, resulting in reduced disease~~ exposure ~~for fish. The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco 1 Dam in 1917. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous salmon and resident rainbow/redband trout can co-exist and maintain abundant populations without deleterious consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006)~~to disease, as described for the Proposed Action above.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Fish passage resulting from the Fish Passage at Four Dams Alternative would allow redband trout to express the seasonal movements and migration patterns that were historically in place, restore population connectivity and genetic diversity, and allow greater utilization of existing habitat and refugia. Effective fishways at J.C. Boyle would greatly improve connectivity to Spencer Creek. Fish passage at Copco 1 and Copco 2 Dams would restore connectivity throughout the Hydroelectric Reach to Shovel Creek, which provides spawning habitat and temperature refugia (DOI 2007). Passage at Iron Gate Dam would restore connectivity between populations in the mainstem Klamath River and those in the Copco 2 bypass channel and in Slide, Scotch, Camp, Jenny, Salt, and Fall Creeks, which also provide spawning habitat and temperature refugia (DOI 2007). The current fish screen and ladder at the J.C. Boyle Dam do not meet current ~~state and federal~~State and Federal fish passage criteria and the ladder impairs upstream migration (Administrative ~~law~~Law Judge 2006). Improvements in efficiency to the fishway at J.C~~.~~. Boyle Dam would result in significant trout population migration above the dam over time (Administrative Law Judge 2006). Habitat in the J.C. Boyle bypass and peaking reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows.

Populations of nonnative species within the reservoirs of the Hydroelectric Reach would continue to prey on smaller redband trout rearing in those reservoirs at some level. Water quality would continue to be seasonally poor, although TMDL implementation would improve water quality conditions from existing conditions throughout the ~~basin~~Basin through time, benefiting this species. Climate change would result in warmer conditions, which would reduce the suitability of habitat.

Summary: Redband Trout
Under this alternative, ~~fish ladders~~ fishways at Four Dams and changes in operations could result in alterations in habitat availability and suitability which could affect redband trout in the long term. The Fish Passage at Four Dams Alternative would improve habitat connectivity throughout the Hydroelectric Reach and to the upper Klamath River in the long term, increasing access to spawning habitat and temperature

refugia. Redband trout would still be subject to seasonally poor water quality, and some level of predation within the reservoirs, but increases in connectivity and reduced effects of hydropower peaking operations would likely provide a benefit to redband trout populations. **Based on increased habitat connectivity, the effect of the Fish Passage at Four Dams Alternative would be beneficial for redband trout in the short- and long term.**

Bull Trout

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir ~~Bull trout upstream of J.C. Boyle Reservoir could be affected by increased predation from reintroduced salmonids, but this loss could be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Buchanan et al. 1997.~~ Effects to bull trout under this alternative are the same as those discussed in the subsection of Section 3.3.4.3.2, Alternative 2, Species Specific Impacts.

~~*Fish ladders*~~ *Fishways at Four Dams could alter habitat access for anadromous fish, which could affect bull trout.* **Based on the restricted distribution of bull trout, the Fish Passage at Four Dams Alternative would have a less-than-significant impact on bull trout in the short- and long term.**

Eulachon Under the Fish Passage at Four Dams Alternative, the extent and quality of eulachon habitat would be expected to remain similar to that under existing conditions. Because eulachon occur far downstream in the river, mixing and inflows from intervening tributaries would reduce seasonally poor water quality conditions originating in the dams. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for eulachon in the short and long term.**

Longfin Smelt Under the Fish Passage at Four Dams Alternative, the extent and quality of longfin smelt habitat would be expected to remain similar to that under existing conditions. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for longfin smelt in the short and long term.**

Introduced Resident Species *The Fish Passage at Four Dams Alternative would not affect introduced resident species upstream of J.C. Boyle Reservoir.* Under the Fish Passage at Four Dams Alternative, dams in the Hydroelectric Reach would not be removed, allowing reservoir habitat to remain similar to existing conditions. Connectivity between the reservoirs could increase available habitat area for these species if they are able to migrate through passage facilities. Over time the total volume of habitat would diminish, as sediment accumulates in the reservoirs. TMDL implementation would be expected to improve water quality conditions over time, but climate change would cause temperatures to increase. These species are adapted to warm-water conditions, and are not expected to be affected by these changes. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for introduced resident species population.**

Interactions Among Species The Fish Passage at Four Dams Alternative would restore access for anadromous salmon, lamprey, and steelhead to habitat upstream of Iron Gate Dam, as described in detail above. Restoration of access will result in anadromous salmon and steelhead potentially interacting with resident redband trout and bull trout. Juvenile salmonids and lamprey traveling through the four hydroelectric reservoirs would be exposed to some level of predation by introduced resident fish including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006). Other interactions among species under the Fish Passage at Four Dams Alternative would be the same as described for the Proposed Action.

Freshwater Mussels *Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions*, thus having no suspended sediment effects relative to existing conditions for any aquatic species. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for mussels in the short and long term.**

Benthic Macroinvertebrates Under the Fish Passage at Four Dams Alternative, ~~*suspended*~~Klamath Hydroelectric Project peaking operations (although reduced in frequency) in the hydroelectric reach would continue (although less frequently) to kill, through stranding, large numbers of young fish and aquatic invertebrates that are the primary prey food for resident trout (Administrative Law Judge 2006). Suspended sediment would also be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for benthic macroinvertebrates.

Under the Fish Passage at Four Dams Alternative, habitat conditions would be the same as under existing conditions~~, thus having no suspended sediment effects relative to existing conditions for any aquatic species~~. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for macroinvertebrates in the short and long term.**

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could affect aquatic species. Trap and haul measures would pass upstream and downstream migrating fish around Keno Impoundment and Link River during periods of seasonally poor water quality. The measures would provide effective migration for fall-run Chinook salmon when water quality is poor during the period from June 15 to November 15. During the limited period of use, fish collection and release facilities would be operated to minimize any delay and stress and provide for adequate acclimation. For adult fall-run Chinook salmon, fish transport would be an effective fish passage method because transport would be for a short distance on a seasonal, interim basis[12]~~.~~.[13] For adult fall-run Chinook salmon, seasonal collection and transport mortality when water quality is poor is likely to be minor compared to mortality associated with unaided passage through areas of poor water quality at this time of year.

In some instances, the collection and transport of fall-run Chinook salmon around ~~areas of poor water quality~~Keno Impoundment/Lake Ewauna could result in limited, seasonal mortality as follows:

~~1.~~ Some juvenile federally listed suckers would likely be collected incidentally and may suffer related stress and mortality. However, regardless of any remediation at an upstream collection facility, nearly all these downstream migrant suckers would eventually die in the absence of lacustrine habitat below Keno Impoundment/Lake Ewauna. There is little to no evidence of recruitment of suckers in downstream reservoirs currently and this habitat does not contribute significantly to the recovery of the species. Suckers may be collected and returned to habitat above Keno Impoundment~~.~~

~~[12] This seasonal, transport on an interim basis is not to be confused with permanent, year round trap and haul which does not provide equal benefits for the Klamath River when compared with the Services' fishway prescriptions (U.S. Department of the Interior (2007) The Department of the Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082). Sacramento, California: 650 p.; NOAA Fisheries Service (2007). NOAA Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis for the Klamath Hydroelectric Project (FERC Project No. 2082): 151 p.).~~

[13] This seasonal, transport on an interim basis is not to be confused with permanent, year round trap and haul which does not provide equal benefits for the Klamath River when compared with the Services' fishway prescriptions (U.S. Department of the Interior (2007) The Department of the Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082). Sacramento, California: 650 p.; NOAA Fisheries Service (2007). NOAA Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis for the Klamath Hydroelectric Project (FERC Project No. 2082): 151 p.).

1. /Lake Ewauna.
2. Some redband trout may be collected incidentally resulting in displacement and incidental collection-related stress and mortality. Redband trout may be collected and returned to habitat above Keno Impoundment.
2. /Lake Ewauna.
3. For fall-run Chinook salmon emigrants, the seasonalseasonally poor quality conditions are not expected to overlap with the peak migration period, thus the majority of juvenile Chinook salmon would not be affected. For those fall-run Chinook salmon emigrants collected and transported when water quality is

poor, transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.

4. For steelhead trout and spring-run Chinook salmon, migration would primarily be expected to occur when water quality was adequate, thus, collection and transport of these fish would not be necessary or minimal. However, all anadromous salmonids would be collected and transported when water quality is poor during the period from June 15 through November 15. Transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.

Limited, seasonal transport of fall-run Chinook salmon would provide a net benefit by allowing them migration to and from additional (historical) spawning habitat, by providing more effective migration, and by reducing the density of spawners below Keno Dam in certain poor water quality situations.

In the short- term, constructing fish handling facilities could have localized construction-related impacts; however, they could be avoided or minimized through implementation of best management practices, such as control and containment of sediment and toxic discharge, isolation of work areas from the active channel of streams or rivers where possible, and rescuing fish where mortality may result from an action. In the long term, trap and haul would benefit fish because of the access to additional habitat and avoidance of areas with seasonally poor water quality. **Based on access to additional, historical habitat and the anticipated improvements in fish health, implementation of trap and haul measures in the Fish Passage at Four Dams Alternative would be beneficial for fall-run Chinook salmon.**

3.3.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove ~~Copco~~ Copco 1 and Iron Gate

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative proposes to remove the two largest dams in the Hydroelectric Reach (Copco 1 and Iron Gate Dams) and install fishways for volitional fish passage on the remaining installations (J.C. Boyle and Copco 2). The prescriptions and conditions would still apply to the remaining dams, including flow requirements, the specific provisions and performance standards for both upstream and downstream fish passage facilities at the remaining dams, and the interim seasonal trap and haul trap actions at Keno Dam as described above under the Fish Passage at Four Dams Alternative.

Because the four dams would not be removed as required under the KHSA, the KBRA would not be implemented. The ongoing restoration actions described in the No Action/No Project Alternative would continue. Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, peaking power would not be generated due to limits on flow regulation at J.C. Boyle and Copco 2 Reservoirs. Similar to the Fish Passage at Four Dams Alternative, 40 percent of the inflow to J.C. Boyle

Reservoir would be passed through to the Bypass Reach, except in periods when inflow to J.C. Boyle Reservoir falls below ~~470~~ 470 cfs, at which point outflow to the Bypass Reach is required to equal reservoir inflow.

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, Iron Gate Hatchery would be operated to meet existing mitigation requirements until Iron Gate Dam is removed, after which time the disposition of the hatchery would be determined by the DFG in consultation with NOAA Fisheries Service, the USFWS and other Klamath River fish managers, in response to fish population monitoring trends. Funding for continued hatchery operations would need to be identified.

Key Ecological Attributes

Suspended Sediment

Under this alternative, SSCs have not been modeled, but would be very similar to those ~~under the Full Facilities Removal of Four Dams Alternative~~ described ~~in~~with the removal of all four facilities under the Proposed Action (see Section 3.3.4.3.2.1.1), because most stored sediment affecting downstream resources is stored in Copco 1 and Iron Gate Reservoirs. Therefore, this alternative would have very similar effects on aquatic species associated with suspended sediment transport as the Proposed Action.

Bedload Sediment

Under this alternative, J.C. Boyle Dam would continue to store sediment, but the storage capacity of Copco 2 Dam would likely be filled by the release of sediments during the Copco 1 Dam removal, and then bedload would likely pass through Copco 2. This scenario has not been modeled, but the effects of bedload sediment movement under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to, but of slightly lesser magnitude, than under the Proposed Action.

Water Quality

Under this alternative, the effects on water quality would have results intermediate between the Proposed Action and Fish Passage at Four Dams Alternatives. As Copco 1 and Iron Gate Reservoirs are the largest of the four reservoirs, they have the greatest impact on water quality (FERC 2007), and their removal would result in water quality conditions similar to those of the Proposed Action. Because of their small size and short residence times, the retention of J.C. Boyle and Copco 2 Dams would not result in the same poor water quality conditions ~~as~~that occur under current conditions.

Since Alternative 5 would include no peaking power generation or release of flow for recreation at J.C. Boyle, water temperature effects in the J.C. Boyle Bypass ~~and Peaking Reaches would be the same as under the Proposed Action, i.e., warmer and more variable water temperatures in the bypass reach during summer and early fall, and cooler temperatures in late fall and winter; and, slightly cooler and less variable water temperatures in the peaking reach during summer and early fall. Further downstream, at the Oregon-California state line, water temperatures~~ Reach would be similar to those under the Fish Passage at Four Dams Alternative because the Fish Passage at Four Dams Alternative also keeps J.C. Boyle Reservoir in place and includes significantly increased flow releases over the No Action/No Project Alternative ~~since large~~, approaching the

flow conditions for this alternative (i.e., no peaking power generation or release of recreation flows). Thus, the effects would be continued low diel temperature variation and overall warmer water temperatures in the Bypass Reach during summer and early fall, and cooler temperatures in late fall and winter. In the Peaking Reach, water temperature effects ~~of~~would be the same as under the Proposed Action (i.e., slightly lower maximum water temperatures and less artificial diel temperature variation during summer and early fall) since no peaking ~~operations do~~flows would occur and the effect of J.C. Boyle thermal mass on water temperatures does not extend this far downstream. ~~Within the remainder of~~

In the Hydroelectric Reach, ~~effects on water temperature under~~ the ~~Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as~~ effects ~~for the Hydroelectric Reach~~ of removing Iron Gate and Copco 1 Reservoirs and converting the reservoir areas to a free-flowing river under this alternative would be similar to effects for the lower Klamath River immediately downstream from Iron Gate Dam under the Proposed Action~~,~~ (i.e., long-term increases in spring water temperatures and decreases in late summer/fall water temperatures) (see Section 3.2.4.3.5~~.1).~~).

Fish Disease and Parasites

Under this alternative, there would be fewer deleterious effects in terms of fish disease as compared to ~~the No Action/No Project Alternative~~existing conditions. Although it would not result in the same level of reduction in fish disease as the Proposed Action, removal of Iron Gate and Copco 1 Dams would result in water quality improvements and would reduce favorable habitat for polychaete worms ~~below~~ downstream from Iron Gate Dam. The removal of the two dams would likely increase the availability of nutrients and physical habitat (i.e., periphyton mats) favorable to the polychaete host for *C. shasta* and *P. minibicornis* in the Hydroelectric Reach and downstream ~~of~~from Iron Gate Dam, although to a slightly lesser extent than under the Proposed Action because J.C. Boyle Dam would not be removed. Flow variability and scouring in the Hydroelectric Reach and downstream ~~of~~from Iron Gate Dam will be increased ~~similar to~~as described for the Proposed Action, with the exception of downstream ~~of~~from J.C~~.~~. Boyle Dam where peaking flows will be eliminated. Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins (see Section 3.2.4.3.5).

Under this alternative, spawning fish would be expected to disperse more fully throughout the watershed than under ~~the Fish Passage at Four Dams Alternative, as the remaining dams would be relatively small, and the ladders would, therefore, be easier to ascend~~existing conditions. Fish passage ~~conditions would not be as good as those under the Proposed Action.~~

~~As described for the Proposed Action, fish passage~~ upstream by anadromous salmonids ~~could be increased~~would increase under this alternative, ~~but would not be expected~~ which could reduce the concentration of salmon using the area immediately downstream from Iron Gate Dam for spawning, potentially reducing the transfer of myxospores from fish to the polychaete hosts. FERC's analysis concluded that restoring access to reaches above

Iron Gate Dam for anadromous fish would allow adult fall-run Chinook salmon to ~~be deleterious to aquatic resources in the Upper Basin through spread~~distribute over a greater length of the river, reducing crowding and the concentration of ~~the~~ disease pathogens that currently occur in the reach between Iron Gate Dam and the Shasta River (FERC 2007).

Evidence indicates that fish passage would not increase the risk of disease for resident species that occur upstream of Iron Gate Dam (Administrative Law Judge 2006). *C. shasta and P. minibicornis* exist throughout the Klamath River system in both the Upper and Lower Basins, so migration of wild anadromous fish upstream of and downstream from Iron Gate Dam would not increase the risk of introducing pathogens to resident trout residing above Iron Gate Dam (Administrative Law Judge 2006). In addition, trout are resistant to *C. shasta*. The remaining known pathogens do not impact non-salmonids, with the exception of *F. columnaris* and *Ich*.

Evidence also indicates that risks associated with dam removal to anadromous fish upstream of Iron Gate Dam are minimal. Steelhead within the Klamath River system are generally resistant to *C. shasta*, (Administrative Law Judge 2006). Since salmon and associated disease pathogens were present historically above Iron Gate Dam, C. shasta genotype movement would be a reintroduction of associated risk to these anadromous species.

While it is possible that the current infectious nidus (breeding place) for C. shasta and P. minibicornis may move upstream where salmon spawning congregations occur, the likelihood of this happening has uncertainty associated with it. However, any creation of an infectious zone (or zones) would be the result of the synergistic effect of numerous factors, such as those that occur within the current disease zone in the reach from the Shasta River downstream to Seiad Valley (factors noted by FERC (2007) and others). Reestablishment of a more natural flow and sediment transport rates to the river downstream from the current location of Iron Gate Dam would develop natural geomorphic channel forming processes to the river (Hetrick et al. 2009) which would make this synergy unlikely. The conditions that contribute to a current infectious nidus below IGD or would contribute to the same zone above IGD would not exist with dam removal.

In the Williamson River there is currently an infectious area due to the continual introduction of non-resistant rainbow trout that become infected and die within a reasonably small reach of the river. However, reintroduced salmon that would become infected are likely to migrate through this reach; dispersing spores over a greater area and more of these spores will be lost to the system, resulting in low spore concentrations.

There have been recently discovered *C. shasta* genotypes in the Klamath River. In this regard, risk is related to host specificity, which appears to exist at least to some degree (Atkinson and Bartholomew 2010). As an example, redband trout are thought to be susceptible to Type 0, which already occurs in the upstream Basin and Chinook salmon are susceptible to Type I, which occurs in the Lower Klamath Basin. Type 0 genotype

occurs in low densities and it is not very virulent (infection results in low or no mortality); if Type I genotype were to be reintroduced above Iron Gate Dam, it would affect only Chinook salmon. It is not expected that reintroduction of *C. shasta* genotypes upstream would be deleterious because fish in the upstream Basin have shown resistance to the downstream genotypes. Redband trout would presumably have been exposed to genotypes of *C. shasta* during the pre-dam period, and their populations were abundant. Because the salmonid species in the Klamath Basin already co-occur with the genotype of *C. shasta* to which they are susceptible, and the salmonid species are less susceptible to other genotypes of *C. shasta*, expanding the distribution of the different genotypes of *C. shasta* would be unlikely to be deleterious to salmonids. Recently discovered *C. shasta* genotypes and research findings in the past several years do not appear to contradict the finding that movement of anadromous salmonids into the Upper Klamath Basin presents a relatively low risk of introducing pathogens to resident fish (Administrative Law Judge 2006, USFWS/NOAA Fisheries Service Issue 2(B)). Under this alternative *C. shasta* impacts would be reduced but not eliminated.

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir This region is upstream of any proposed dam removal; therefore, the Fish Passage at J.C~~.~~ Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would not affect fish health as related to algal toxins. Any changes in algal toxin production in this region would be a result of other factors, including TMDL implementation. The effects in this area would be similar to those described for the No Action/No Project Alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in the Hydroelectric Reach, alleviating high seasonal concentrations of algal toxins and associated bioaccumulation of microcystin in fish tissue for species in this reach. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Hydroelectric Reach and would be beneficial.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam The Fish Passage at J.C~~.~~ Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative ~~would~~ would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*~~,~~, alleviating the transport of high seasonal concentrations of algal toxins to the Klamath River downstream ~~of~~ from Iron Gate Dam. This would also decrease the associated bioaccumulation of microcystin in fish and mussel tissue for species downstream ~~of~~ from the dam. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish and mussel tissue would be expected to decrease in the Klamath River downstream ~~of~~ from Iron Gate Dam and would be beneficial.

Aquatic Habitat

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, flow increases would provide more habitat than under existing conditions for redband/rainbow trout and other resident riverine species, as well as any anadromous fish or lamprey that reestablish in the Hydroelectric Reach, but habitat gains would be less than under the Proposed Action. The removal of the two dams would eliminate existing habitat in Copco 1 and Iron Gate Reservoirs for adult shortnose and Lost River suckers, as well as nonnative species, while habitat within J.C. Boyle Reservoir would remain. This ~~Alternative~~alternative would restore ~~22.4~~around 19 miles of riverine habitat (Cunanan 2009) for resident and anadromous fish through removal of reservoirs. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009).

The alternative would incorporate barriers to prevent juvenile salmonid entrainment into turbines. There would also be substantial changes to hydroelectric operations. J.C~~.~~ . Boyle would no longer generate in peaking mode, and higher flow releases would be made through the J.C. Boyle Bypass Reach than under existing conditions. Higher base flows would also be provided in the Copco 2 Bypass Reach, and ramping rates would be slower than they are currently. These modifications would benefit fish in this reach, including redband trout and anadromous fish. Seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle bypass reach by increasing the sediment deposit within the channel and decreasing reed canary grass (Administrative Law Judge 2006). The more normative flow regime associated with this alternative would provide these seasonal high flows. ~~Similar to~~ As described for the Proposed Action, under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, flow-related habitat changes for species downstream ~~of~~from Iron Gate Dam would increase over ~~the No Action/No Project Alternative~~existing and historical conditions (Hetrick et al. 2009).

Following drawdown of the reservoirs, revegetation efforts would be initiated to support establishment of native wetland and riparian species on newly exposed reservoir sediment. No short-term effects are anticipated from these reservoir restoration efforts; however, aquatic habitat ~~may~~would likely be improved from restored riparian vegetation in the long term.

Aquatic Resources Effects

Critical Habitat

As described below, ~~lowering the water surface elevation of the reservoirs~~ reservoir drawdown associated with dam removal under this alternative could alter the quality of critical habitat. In addition, the removal of two dams and two reservoirs could alter the availability and quality of critical habitat.

Coho Salmon The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would increase the amount of habitat available to coho salmon

(currently upstream of designated critical habitat) and the quality of the existing critical habitat by improving water quality in the mainstem Klamath River. NOAA Fisheries Service may consider whether to designate the newly available habitat as critical habitat as part of its 5 year status review or as a separate reconsideration of the critical habitat designation for the species (J. Simondet, NOAA Fisheries Service, pers. comm., 2011). The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on critical habitat for coho salmon would be similar to those for the Proposed Action, but somewhat reduced by the ongoing presence of Copco 2 and J.C~~.~~ . Boyle Reservoirs. The same habitat expansion expected under the Proposed Action would occur, with the exception of habitat under Copco 2 and J.C. Boyle Reservoirs and the downstream portion of Spencer Creek, which would continue to be inundated by J.C~~.~~ . Boyle Reservoir~~ and may be designated as critical habitat in the future~~. Fish passage would be provided past the two remaining dams~~, and because only two fishways would need to be negotiated instead of four and are considerably smaller than Iron Gate or Copco 1, passage through the ladders would be improved~~. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through elimination of peaking operations and higher baseflows.

~~The NOAA Fisheries Service (2010a) current biological opinion for Reclamation's Klamath Project, specifies flows downstream of Iron Gate Dam, and this biological opinion would likely need to be revised to reflect flows that would need to be provided below Copco 2 Dam if this alternative were adopted.~~

Copco 1 and Iron Gate Reservoirs also cause the majority of the water temperature and water quality issues in the Hydroelectric Reach, so ~~these~~ water quality conditions would be ~~more similar to the Proposed Action than to the Fish Passage at Four Dams Alternative. These water quality improvements would accrue~~ improved relative to existing conditions within the Hydroelectric Reach and to areas downstream ~~of~~ from Iron Gate Dam as well. ~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle and Copco 2 Reservoirs, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~

Although upstream of current designated critical habitat, implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would expand the geographic extent of habitat available to coho salmon. Water quality within currently designated critical habitat is anticipated to improve relative to existing conditions. **Based on reduced habitat quality during reservoir drawdown affecting PCEs, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a significant effect on coho salmon critical habitat in the short term. Based on benefits to the PCEs downstream ~~of~~from Iron Gate Dam, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a beneficial effect on critical habitat for coho salmon in the long term.**

Bull Trout -The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be expected to have a similar effect on critical habitat for bull trout as the Fish Passage at Four Dams Alternative. **Based on the restricted distribution of bull trout, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant impact on critical habitat for bull trout in the short- and long term.**

Southern Resident Killer Whales -The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be expected to have a similar impact on critical habitat for Southern Resident Killer Whales as the Proposed Action. Chinook salmon would be provided access to areas upstream of Iron Gate Dam and into the upper watershed, boosting natural production. Water quality issues would be improved both in

the Hydroelectric Reach and in the ~~lower~~Lower Klamath River. Fish parasitism would likely decrease as conditions became less favorable for the polychaetes host of *C. shasta* and *P*~~.~~. *minibicornis*. However, because Chinook salmon from the Klamath River make up a very small proportion of the Southern Resident Killer Whale diet, this benefit to Southern Resident Killer Whales is expected to be small. **Based on small influence of the Klamath River on PCEs of Southern Resident Killer Whales, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant impact on critical habitat for Southern Resident Killer Whales in the short- and long term.**

Essential Fish Habitat *As described below, ~~lowering the water surface elevation of the reservoirs~~reservoir drawdown associated with dam removal under this alternative could alter the quality of ~~Essential Fish Habitat (~~EFH~~)~~. In addition, the removal of two dams and two reservoirs could alter the availability and quality of EFH.*

Chinook and Coho Salmon EFH The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on EFH for Chinook and coho salmon would be similar to those for the Proposed Action, but would be somewhat reduced by the ongoing presence of Copco 2 and J.C. Boyle Reservoirs. Water quality in the mainstem Klamath River is expected to be improved. Most of the habitat expansion expected (upstream of currently designated EFH) under the Proposed Action would occur, with the exception of habitat under Copco 2 and J.C. Boyle Reservoirs and the downstream portion of Spencer Creek, which would continue to be inundated by J.C~~.~~. Boyle Reservoir. Fish passage would be ~~provided past the remaining dams, and because only two fishways would need to be negotiated instead of four and these remaining dams are considerably smaller than Iron Gate or Copco 1 dams, passage through the ladders would be~~ improved over existing conditions~~.~~ by providing passage past the remaining two dams.

~~The NOAA Fisheries Service (2010a) current biological opinion for Reclamation's Klamath Project, specifies flows downstream of Iron Gate Dam, and this biological opinion would likely need to be revised to reflect flows that would need to be provided below Copco 2 Dam if this alternative were adopted.~~ Copco 1 and Iron Gate reservoirs also cause the majority of the water temperature and water quality issues in the Hydroelectric Reach, so these conditions would be ~~more similar to the Proposed Action than to the Fish Passage at Four Dams Alternative~~improved relative to existing conditions. These water quality improvements would accrue to areas downstream ~~of~~from Iron Gate Dam as well.

Based on a substantial reduction in EFH quality during reservoir drawdown, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a significant effect on EFH for Chinook and coho salmon in the short term. Based on benefits to the habitat quality, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a beneficial effect on EFH for Chinook and coho salmon in the long term.

Groundfish EFH -The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those of the Proposed Action Alternative, with similar effects on SSCs, bedload and water quality.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on EFH for groundfish in the short- and long term.

Pelagic Fish EFH The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on pelagic fish EFH would be similar to those described for the Proposed Action.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on EFH for pelagic fish in the short- and long term.

Species-Specific Impacts

As described below, ~~lowering the water surface elevation of the reservoirs~~reservoir drawdown associated with dam removal under this alternative could affect aquatic species. In addition, the removal of two dams and two reservoirs could alter the availability and quality of habitat, resulting in effects on aquatic species.

Fall-Run Chinook Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 Dams would allow fall-run Chinook salmon to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising ~~420~~hundreds miles of additional potentially productive habitat (DOI 2007), including access to groundwater discharge areas resistant to effects of climate change (Hamilton et al. 2011).

~~The removal of~~ Poor water quality (e.g., severe hypoxia, temperatures exceeding 25 °C, high pH) in the ~~two dams would likely reduce the availability of physical habitat favorable~~ reach from Keno Dam to ~~the polychaete host for *C. shasta* and *P. minibicornis*~~Link Dam might impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009).

Dispersal of spawners and carcasses under this alternative would diminish disease conditions. Flow variability would not be as great as under the Proposed Action;

therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist. Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore fall-run Chinook salmon access to the Hydroelectric Reach. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include removal of Copco 1 and Iron Gate Reservoirs, with continued power generation at J.C. Boyle and Copco 2 hydroelectric plants. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through elimination of peaking operations and higher baseflows. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). Spencer Creek would continue to flow into J.C. Boyle Reservoir at its upstream end. Anadromous fish provided access to these reaches would have access to the tributaries as well.

~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle and Copco 2 Reservoirs, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in~~The potential habitat under the two remaining reservoirs ~~and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk~~ for ~~juvenile salmon during~~ the ~~seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest,~~ production of anadromous ~~juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~salmonids, redband trout, and Pacific lamprey would however not be reached under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative.

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam
The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate Reservoirs downstream to the ~~lower~~Lower Klamath River. Of the reservoirs in the Hydroelectric

Reach, J.C. Boyle Reservoir stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on fall-run Chinook salmon in the ~~lower~~Lower Klamath River reach would be similar to those described for the Proposed Action, but would be of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under existing conditions. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality from increased suspended sediment concentrations, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

Disease conditions would be reduced under this alternative. Dispersal of spawners and carcasses would diminish myxospore proximity to the intermediate host. A more mobile bed relative to current conditions would disrupt habitat for the intermediate host.

Estuary

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect fall-run Chinook salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Fall-Run Chinook Salmon

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect fall-run Chinook salmon. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for fall-run Chinook salmon in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect fall-run Chinook salmon. As stated above, dam removal would also restore connectivity to ~~420~~ hundreds of miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for fall-run Chinook salmon in the long term.**

Spring-Run Chinook Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 Dams would allow spring-run Chinook salmon to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the spring-run Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising ~~420~~ hundreds of miles of additional potentially productive habitat (DOI 2007), including access to important thermal refugia within areas influenced by groundwater ~~discharge areas~~ exchange that are more resistant to ~~effects of~~ climate change (Hamilton et al. 2011). ~~Similar to~~Some of these areas, such as the lower Williamson River, have habitat that would provide substantial holding areas for spring-run Chinook salmon (Hamilton et al. 2010). Other holding areas with suitable temperatures upstream of J.C. Boyle Reservoir include groundwater influenced areas on the west side of Upper Klamath Lake, and the Wood River (Gannett et al. 2007).

As described for the Proposed Action, this alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins ~~and disease~~. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25 °C, high pH) in the reach from Keno Dam to Link Dam might ~~prevent~~impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that ~~UKL~~Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Historically, adult spring-run Chinook salmon migrated upstream of the current location of Iron Gate Dam perhaps as early as February and March (Klamath Republican articles in Fortune et al. 1966) and likely held over in large holding pools in the mainstem in tributaries fed by cool water, and in refugia habitat upstream of Upper Klamath Lake (CDFG 1990c; Moyle 2002; Snyder 1931). One benefit of such early migration would be the avoidance of periods of poor water quality. The restored water temperature regime under the Proposed Action may restore upstream migration timing of adult spring-run Chinook salmon because of the shift in water temperatures downstream from Iron Gate dam (Bartholow et al. 2005).

Huntington (2006) reasoned that spring-run Chinook salmon likely accounted for the majority of the Upper Klamath Basin's actual salmon production under historical conditions. Huntington (2006) cautioned that while access to the Upper Klamath Basin provides considerable promise of increasing spring-run abundance, the existing potential for Chinook salmon production within the Basin upstream of Upper Klamath Lake is

clearly much lower than his estimate of historical potential. However, Huntington (2006) did not fully account for the historical (and unknown) production potential of Upper Klamath Lake itself, which could have been considerable, as suggested by a recent experimental reintroduction into Upper Klamath Lake (Maule et al. 2009).

Hydroelectric Reach: ~~from~~ From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore spring-run Chinook salmon access to the Hydroelectric Reach. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

Habitat in the J.C. Boyle bypass and peaking reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). Spencer Creek would continue to flow into J.C. Boyle Reservoir at its upstream end. Anadromous fish provided access to these reaches would have access to the tributaries as well.

~~The removal of the two dams would likely reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*, although to a lesser extent than under the Proposed Action. Flow variability would not be as great as under the Proposed Action; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist.~~ Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins.

~~Juveniles~~ As with conditions for fall-run Chinook salmon, disease conditions would be ~~subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs~~ reduced under ~~similarly difficult circumstances (Administrative Law Judge 2006).~~this alternative.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam The Fish Passage at J.C~~.~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate reservoirs downstream to the ~~lower~~ Lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle

stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on spring-run Chinook salmon in the ~~lower~~ Lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under existing conditions. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

Estuary~~ The~~

Under the Fish Passage at J.C. ~~Boyle~~Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, habitat in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream from Iron Gate Dam. These peaks would still be substantial, and ~~Copco 2, Remove Copco 1 and Iron Gate Alternative is~~would be higher than the extreme values estimated by the sediment transport model for existing conditions (see the subsection of Section 3.2.4.3.2). However, this alternative not expected to substantially change or affect spring-run Chinook salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Spring-Run Chinook Salmon

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect spring-run Chinook salmon. **Based on minimal reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for spring-run Chinook salmon in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect spring-run Chinook salmon. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for spring-run Chinook salmon in the long term.**

Coho Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir ~~Coho~~As described for the Proposed Action, coho salmon did not historically occur upstream of J.C. Boyle Reservoir, and are not anticipated to occupy this reach after implementation of ~~this alternative. Implementation of~~ the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative ~~may not affect coho salmon in the Upper Klamath Basin upstream of J.C. Boyle Reservoir Reach.~~

.

Hydroelectric Reach: ~~from~~ **From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam** Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative~~, coho salmon~~ access would be restored for the upper Klamath River Population coho salmon to the Hydroelectric Reach ~~would be restored, which would expand the population's current range~~, expanding their distribution to include historical habitat ~~within~~along the mainstem Klamath River and all tributaries upstream at least as far as Spencer Creek~~,~~; including in Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005), including around 76 miles of potential habitat within the Hydroelectric Reach, as described in the No Action/No Project Alternative analysis above. The NRC of the National Academy of Science reviewed causes of decline and strategies for recovery of endangered and threatened fishes of the Klamath Basin. The NRC concluded that "removal of Iron Gate Dam... could open new habitat, especially by making available tributaries that are now completely blocked to coho" (NRC 2004). Spencer Creek flows into the upstream end of J.C. Boyle Reservoir and would still be partially inundated under this alternative, but suitable habitat in the Spencer Creek would be accessible to coho salmon. Suspended and bedload sediment effects would be similar to those described for

the Proposed Action. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows.

~~The removal of the two dams would likely reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*, although to a lesser extent than under the Proposed Action. Flow variability would not be as great as under the Proposed Action; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist.~~ Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins.

~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs~~As described for fall-run and ~~near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~spring-run Chinook salmon above, disease conditions would be reduced under this alternative.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate Reservoirs downstream to the ~~lower~~Lower Klamath River. Suspended and bedload sediment conditions and effects on coho salmon in the ~~lower~~Lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two Dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under current conditions. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality, from increased ~~suspended sediment concentrations~~SSCs, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

Estuary

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect coho salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Coho Salmon

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect coho salmon. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, Scott River, and Salmon River population units in the short term. Based on indistinguishable effects predicted to occur during reservoir drawdown, the effect of the Fish Passage at J.C~~.~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for the coho salmon from the three Trinity River population units, and the Lower Klamath River Population Unit in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect coho salmon. Dam removal would restore connectivity to habitat on the mainstem Klamath River up to and including Spencer Creek and would create additional habitat within the Hydroelectric Reach. It is anticipated that as a result of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative the upper Klamath River, mid-Klamath River, ~~lower~~Lower Klamath River, Shasta River, Scott River, and Salmon River coho salmon population units would have an increase in abundance, productivity, population spatial structure, and genetic diversity. It is anticipated that as a result of the Fish Passage at J.C~~.~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative the three Trinity River population units would have increased productivity. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for the coho salmon from the Upper Klamath River, Mid-Klamath River, Lower Klamath River, Shasta River, Scott River, and Salmon River population units in the long term**. **Based on improved habitat quality, the effect of the Fish Passage at J.C~~.~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for the coho salmon from the three Trinity River population units in the long term.**

Steelhead

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Two Dams Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 would allow steelhead to regain access to the upper Klamath River upstream of J.C. Boyle Reservoir. This would expand the population's distribution to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood rivers (Hamilton et al. 2005). ~~Steelhead are known to use intermittent tributaries for spawning, and because redband trout have habitat requirements similar to those of steelhead, this can be used as a rough estimate of habitat~~

~~that may also be available to steelhead. Current distribution of redband trout within areas that~~This would be ~~accessible to steelhead has been estimated at 496 miles by ODFW (W. Tinniswood, pers. comm., 2011). Similar to the Proposed Action~~a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising hundreds of miles of additional potentially productive habitat (DOI 2007). As described for the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins~~ and disease~~. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Poor water quality (e.g., severe hypoxia, temperatures exceeding 25 °C, high pH) in the reach from Keno Dam to Link Dam might ~~prevent~~impede volitional fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that ~~UKL~~Upper Klamath Lake habitat is presently suitable to support salmonids for at least the October through May period (Maule et al. 2009).

Hydroelectric Reach: ~~from~~ From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore steelhead access to the Hydroelectric Reach. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include removal of Copco 1 and Iron Gate reservoirs, with continued power generation at J.C. Boyle and Copco 2 hydroelectric plants. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). Spencer Creek would continue to flow into J.C. Boyle Reservoir at its upstream end. Anadromous fish provided access to these reaches would have access to the tributaries as well.

~~The removal of the two dams would be likely to reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*, although to a lesser extent than the Proposed Action. Flow variability would not be as great; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist. Steelhead are not as susceptible to these parasites, as Chinook salmon or coho salmon, but may still receive some benefit.~~ Removal of the two dams would likely result in more favorable water temperature for salmonids, as well as improved water quality and reduced instances of algal toxins.

~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).~~

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam The Fish Passage at J.C~~.~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate reservoirs downstream to the ~~lower~~Lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle Reservoir stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on steelhead in the ~~lower~~Lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under current condition. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality from increased ~~suspended sediment concentrations~~SSCs, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for ~~polychaetes and~~ algal toxins.

Estuary

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect steelhead estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Steelhead

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect steelhead. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for summer and winter steelhead in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, and temperature variation, which could affect steelhead. Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore connectivity to ~~496~~ hundreds of miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach ~~(W. Tinniswood, pers. comm., 2011).~~ ~~**Based**~~, as described for the Proposed Action. **As described for the Proposed Action, based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for summer and winter steelhead in the long term**.

Pacific Lamprey

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Pacific lamprey ~~did not~~occurred historically ~~occur upstream of J.C. Boyle Reservoir~~at least to Spencer Creek (Hamilton et al. 2005) ~~and are not anticipated to occupy this reach after implementation of this alternative.~~although there is some uncertainty in this regard (Administrative Law Judge 2006). Pacific lamprey below Iron Gate dam would migrate above the dam if access was provided through fishways (Administrative Law Judge (2006).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Pacific lamprey below Iron Gate Dam would migrate above the dam if access was provided (Administrative Law Judge 2006). Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 Dams would provide Pacific lamprey access to the Hydroelectric Reach, which would expand the population's current range to include habitat within the mainstem Klamath River and its tributaries upstream at least as far as Spencer Creek, including Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005). Spencer Creek flows into the upstream end of J.C. Boyle Reservoir and would still be potentially accessible to lamprey. ~~Pacific lamprey below Iron Gate Dam would migrate above the dam if access was provided through fishways (Administrative Law Judge 2006).~~ Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel Creeks and Big Springs to flow directly into the mainstem Klamath River~~, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011)~~. Removal of the two dams would likely result in more favorable water temperature for lamprey and other native fishes, and would improve water quality.

~~Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Volitional fish passage for Pacific lamprey has been designed and is in place in other river systems (Administrative Law Judge 2006).~~

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam The Fish Passage at J.C~~.~~. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would release sediment stored within Copco 1 and Iron Gate Reservoirs downstream to the ~~lower~~Lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle Reservoir stores the least amount of sediment—less than 10 percent of the total. As such, suspended and bedload sediment conditions and effects on Pacific lamprey in the ~~lower~~Lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in water temperature more favorable for Pacific lamprey occurring in the mainstem, as well as improve water quality. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality from increased ~~suspended sediment concentrations~~SSCs, but these effects would be short term.

Estuary

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect Pacific lamprey estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Pacific Lamprey

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and Pacific lamprey. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for Pacific lamprey in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect Pacific lamprey. Dam removal would restore connectivity ~~to usable habitat in~~among the Lower Klamath

Basin, the Hydroelectric Reach and its tributaries among the Lower Klamath Basin, the Hydroelectric Reach and its tributaries, and would ~~create additional spawning and rearing~~rehabilitate and increase availability of riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for Pacific lamprey in the long term**.

Green Sturgeon

Upper Klamath River Green sturgeon did not historically occur upstream of Iron Gate Dam (Hamilton et al. 2005) and are not anticipated to occupy this reach after implementation of this alternative. The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would not affect green sturgeon upstream of Iron Gate Dam.

Lower Klamath River: Downstream ~~of~~ from Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate reservoirs downstream to the ~~lower~~Lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on green sturgeon in the ~~lower~~Lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

Bedload sediment effects related to dam-released sediment or sediment resupply would likely extend as far as the Cottonwood Creek. Current green sturgeon distribution extends from the mouth of the Klamath River upstream to the Ishi Pishi Falls (Moyle 2002; FERC 2007), with some observed migrating into the Salmon River. Short- and long-term changes to bedload sediment under the Fish Passage at J.C. Boyle and ~~Copco~~ Copco 2, Remove Copco 1 and Iron Gate Alternative are not expected to affect green sturgeon.

The ~~-~~removal of two dams and restoration of free flowing sections of river would likely result in water temperature more favorable for green sturgeon occurring in the mainstem, as well as improve water quality and reduce instances of algal toxins. As with SSCs, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to poor water quality due to dam removal, but these effects would be short term.

Estuary

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Summary: Green Sturgeon

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Alternative could alter SSCs and affect green sturgeon. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for green sturgeon in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in flow regime, water quality, temperature variation, and algal toxins which could affect green sturgeon. **Based on small improvements in habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for green sturgeon in the long term.**

Shortnose and Lost River Sucker

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Shortnose and Lost River suckers upstream of Keno Dam would not be affected by the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative. Effects on populations downstream ~~of~~from Keno Dam are detailed below in the description of the Hydroelectric Reach. The KBRA would not be implemented under this alternative. However, ongoing restoration activities will continue to occur.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Federally endangered shortnose and Lost River suckers are found within reservoirs in Hydroelectric Reach, but in lower abundance than in reservoirs and lakes upstream. ~~Similar to~~ As described for the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would ~~eliminate~~reduce reservoir habitat as dams within the Hydroelectric Reach were removed and sediment was allowed to move downstream. Adult Lost River and shortnose suckers in ~~reservoirs downstream of Keno Dam~~Iron Gate and Copco 1 reservoirs would be captured and relocated to Upper Klamath Lake (Buchanan et al.2011a). Those not relocated to the Upper Klamath Basin would likely be lost, but with little or no successful reproduction (Buettner et al. 2006), the populations downstream ~~of~~from Keno Dam contribute minimally to conservation goals and insignificantly to recovery (Hamilton et al. 2011). Lost River and shortnose suckers are listed as fully protected species under California Fish and Game; thus any take of these species is prohibited. ~~-~~However, ~~a component of this alternative would include~~if there is an Affirmative Determination by the Secretary, and a concurrence by the State of California, CDFG will provide draft legislation to ~~permit~~ the other KHSA/KBRA parties which would authorize limited take of ~~some individuals during implementation.~~

these fully protected species.

Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Generally, with the exception of *F. columnaris* and Ich, pathogens associated with anadromous fish do not impact non-salmonids (e.g~~.~~ . suckers) (Administrative Law Judge 2006).

Based on the low occurrence of suckers within Iron Gate and Copco 1 reservoirs, only a small reduction in abundance could occur, and therefore the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for Lost River and shortnose sucker populations in the short- and long term.

Redband Trout

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 dams would allow redband trout to migrate more successfully from the Hydroelectric Reach to the Upper Klamath Basin (Hamilton et al. 2011) than under existing conditions.

Under this alternative, a flow regime that more closely mimics natural conditions would not be established downstream ~~of~~ from Keno Dam; therefore, the increases in stream habitat upstream of J.C. Boyle Dam might not be realized under this alternative. ~~Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows.~~

~~Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).~~ Redband could be affected by ~~increased~~the reintroduction of anadromous fish, including the potential for competition, predation ~~from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry~~, and ~~juveniles of reintroduced salmonids) (Hamilton et al. 2011). Adult salmon moving into the upper basin would likely bring with them genotypes of *C. shasta* that had previously been restricted to the lower river. While the effects of these introductions are uncertain, at least some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, might not be susceptible to the new genotypes. Additionally, the changes in habitat that could result from dam removal (fewer areas of slow-flowing, stable habitat) would likely reduce the density of polychaete populations, resulting in reduced disease~~ exposure ~~for fish. The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco 1 Dam in 1917. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous salmon and resident rainbow/redband trout can co-exist and maintain abundant populations without deleterious consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006).~~ to disease, as described for the Proposed Action above.

Hydroelectric Reach: ~~from~~ From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam ~~Similar to~~ As described for the Proposed Action, dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would allow redband trout to migrate between tributaries and reservoirs to complete their lifecycle, and would restore ~~22.4~~around 19 miles of reservoir habitat to riverine habitat (Cunanan 2009). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided excellent salmonid spawning and rearing habitats (Hetrick et al. 2009). Under this alternative this habitat would be restored. Suspended and bedload sediment effects would be similar to those described for the Proposed Action. However, sediment would continue to be trapped in J.C. Boyle, and spawning habitat would not likely improve for redband trout in the mainstem.~~—~~.

Summary: Redband Trout

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and affect redband trout. **Based on a small proportion of the population with a potential to be exposed to short-term effects, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for redband trout in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability and flow regime, which could affect redband trout. As described for the Proposed Action, dam removal would ~~increase~~ restore connectivity ~~between Upper~~among the Lower Klamath Basin ~~and~~, the Hydroelectric Reach and its tributaries, and the Upper Klamath Basin, and would ~~create additional~~rehabilitate and increase availability of riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for redband trout in the long term.**

Bull Trout

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir ~~Similar to~~As described for the Proposed Action, under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative bull trout upstream of J.C. Boyle Reservoir could be affected by increased predation from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Buchanan et al. 1997).

Based on the restricted distribution of bull trout, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less than significant impact on bull trout in the short~~-~~ and long term.

Eulachon

Lower Klamath River: Downstream ~~of~~from Iron Gate Dam Under this alternative, suspended sediment conditions and effects on eulachon in the ~~lower~~ Lower Klamath River would be similar to those described for the Proposed Action, but of slightly lesser magnitude. Short-term decreases in water quality might also be associated with this alternative and would affect adults and larvae in the mainstem Klamath River. As with SSCs, these effects could be muted by tributary inputs.

Estuary ~~Similar to the Proposed Action~~Based on the lower magnitude of SCC, the ~~Fish Passage at J.C. Boyle and Copco 2,~~ Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect estuarine habitat.

Based on no substantial reduction in the abundance of a year class, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be a less-than-significant effect on eulachon in the short term. Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on eulachon in the ~~short- and~~ long term.

Longfin Smelt The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would release dam-stored sediment downstream to the ~~lower~~Lower Klamath River, but would not be expected to reach the area potentially used by longfin smelt. Longfin smelt using the ~~lower~~Lower Klamath River after January 2020 could be exposed to high SSCs for a portion of their migration period. SSCs would likely decrease in the downstream direction from Iron Gate Dam due to dilution from tributaries, so the magnitude of the effect would likely be low. Short-term decreases in water quality could also affect adults and larvae in the mainstem Klamath River. As with SSCs, these effects could be muted by tributary inputs.

Estuary ~~Similar to~~

As described for the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect estuarine habitat.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on longfin smelt in the short- and long term.

Introduced Resident Species

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Introduced resident species upstream of J.C. Boyle Reservoir would not be affected by the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative.

Hydroelectric Reach: ~~from~~ From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam ~~Similar to~~ As described for the Proposed Action, implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would eliminate reservoir habitat associated with the two largest reservoirs Copco 1 and Iron Gate Dam, but would retain the habitat associated with the smaller J.C. Boyle and Copco 2 reservoirs. This would be detrimental to nonnative fishes upstream of Iron Gate Dam. Abundance of these species would decline substantially as the majority of their preferred reservoir habitat would be eliminated (Buchanan et al.2011a).

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would reduce habitat for introduced resident species in the Hydroelectric Reach. **Because these species were introduced and they occur in other nearby water bodies, their loss would not be considered important from a biological perspective, and would benefit native species. This impact would be less than significant from a biological perspective. Their loss would, however, decrease opportunities for recreational fishing for these species, as discussed in Section 3.20, Recreation.**

Interactions Among Species

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore access for anadromous salmon, lamprey, and steelhead to habitat upstream of Iron Gate Dam, as described in detail above. Restoration of access would result in anadromous salmon and steelhead potentially interacting with resident redband trout and bull trout. Juvenile salmonids and lamprey would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle and Copco 2 Reservoirs, resulting in mortality rates that would depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006), as described for the Fish Passage at Four Dams Alternative. Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006). The other effects of interactions among these species would be the same as described for the Proposed Action.

Freshwater Mussels

Suspended Sediment Concentrations Most stored sediment that would affect downstream Klamath River resources is stored in Iron Gate Reservoir, and SSCs resulting from implementation of this alternative would be the same as, or very similar to, those levels described previously for the Proposed Action.

Therefore, SSCs resulting from the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have the same effects on freshwater mussels, as previously described for the Proposed Action.

Changes in Bed Elevation Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, free-flowing river conditions would be restored

through most of the mainstem Klamath River. The release of sediment currently stored behind Iron Gate and Copco 1 Dams would occur and changes in streambed elevation downstream ~~of~~ from Iron Gate Dam would be similar, but slightly smaller in magnitude than those of the Proposed Action because the J.C. Boyle and Copco 2 Dams would remain in place and the sediment stored behind them would not be removed. Therefore, the effects of this alternative on bedload elevation changes would be similar, but perhaps slightly smaller in magnitude, than those associated with the Proposed Action.

Changes in Bed Substrate

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, changes in bed substrate would be similar as those described for the Proposed Action. Therefore, this alternative would have similar effects on freshwater mussels in the mainstem Klamath River as the Proposed Action.

Based on substantial reduction in the abundance of multiple year classes in the short term and the slow recovery time of freshwater mussels, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for freshwater mussels in the short term.

Based on increase in habitat availability, the effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial to freshwater mussels in the long term.

Benthic Macroinvertebrates

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, Klamath Hydroelectric Project peaking operations would no longer kill, through stranding, large numbers of young fish and aquatic invertebrates that are the primary prey food for resident trout (Administrative Law Judge 2006).

Suspended Sediment Concentrations

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the release of sediment currently stored behind Iron Gate and Copco 1 Dams would occur. The effects of SSCs on BMIs would be the same as, or very similar to, those described for the Proposed Action.

Changes in Bed Elevation

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the effects on BMIs resulting from bedload elevation changes are expected to be similar, if not the same as, those associated with the Proposed Action.

Changes in Bed Substrate

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the effects on BMIs resulting from changes in bed substrate in the mainstem Klamath River would be similar to those described for the Proposed Action.

Summary: Benthic Macroinvertebrates

As described for the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect benthic macroinvertebrates. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for macroinvertebrates downstream from Iron Gate Dam in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, and temperature variation, which could affect macroinvertebrates. While a large proportion of their populations in the Hydroelectric Reach and in the mainstem Klamath River downstream ~~of~~from Iron Gate Dam would be affected, their populations would be expected to recover quickly because of the many sources for recolonization and their rapid dispersion through drift or aerial movement of adults. Habitat quality would also be improved in the Hydroelectric Reach by the ending of deleterious Klamath Hydroelectric Project peaking operations (Administrative Law Judge 2006). **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on macroinvertebrates would be beneficial in the long term.**

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could affect aquatic species. The trap and haul measures around Keno Impoundment/Lake Ewauna and Link River would have the same impacts under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative as the Fish Passage at Four Dams Alternative. **Based on access to additional, historical habitat and the anticipated improvements in fish health, implementation of trap and haul measures in the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for fall-run Chinook salmon.**

3.3.4.4 Mitigation Measures

3.3.4.4.1 AR-1: Protection of Mainstem Spawning

It is anticipated that short-term effects of the Proposed Action (SSCs and bedload movement) will result in up to 100~~%~~ percent mortality of fall Chinook and coho salmon embryos and pre-emergent alevin within redds that were constructed in the mainstem in the fall of 2019. In addition, any steelhead or Pacific lamprey migrating within the mainstem Klamath River after December 30th could be directly affected. As described in Appendix E, around ~~4,600~~1,700 fall-Chinook salmon redds are predicted to be affected, and around 13 redds from the Upper Klamath River Population Unit for coho salmon.

Deleterious short-term effects of the Proposed Action on mainstem spawning could be reduced by capturing migrating adult fish (Chinook, coho, steelhead, or Pacific lamprey) in the mainstem Klamath River and relocating them to suitable habitat. Capture of adult

fish could be accomplished with the use of an Alaskan-style weir and box trap, similar to that currently used at the Willow Creek and Trinity River site. The most suitable location for the trap appears to be directly upstream of the Shasta River, where the mainstem Klamath River is small enough to effectively trap, and would ensure that fish returning to key tributaries downstream ~~of~~from, and including the Shasta River would not be interrupted. The weir would be installed at the beginning of the fall migration and continue past the initial dam drawdown period until high flows require the trap to be dismantled. Captured fish would periodically be transported to receiving tributaries. Fish could be released either in under-seeded tributaries downstream ~~of~~from Iron Gate Dam (e.g., Scott River), or in tributaries upstream of Iron Gate Dam if that were consistent with post-dam removal management goals. The relocated fish would then spawn naturally in the tributary streams and their progeny would not be affected by the SSCs and bedload movement during the dam removal process. In addition, the trap would only be operated periodically, so that some ~~violotional~~volitional passage upstream of the Shasta River would occur, allowing fish to return to Bogus Creek and the hatchery during 2019.

Additional surveys in the mainstem downstream ~~of~~from Shasta River could be conducted to locate coho salmon spawning in the mainstem. Any identified adult coho, Chinook, steelhead, or Pacific lamprey could be captured using dip-nets, electrofishing, or seines and transported to tributary habitat. Surveys should be conducted in December 2019, immediately prior to the first release of sediment associated with facilities removal. A detailed plan describing capture techniques, release locations, and monitoring methods would be developed by the Dam Removal Entity (DRE) prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

The effectiveness of the measure will depend on how effectively adults can be captured with the weir. Based on operation of similar traps in other rivers, it is anticipated that when operational the trap could capture nearly all upstream migrants. However, it is the intention to allow a portion of the adult to migrate ~~violitionally~~volitionally to access Bogus Creek or the hatchery. Therefore it is assumed some fall Chinook salmon will continue to spawn within the mainstem during 2019. Depending on the condition of captured adults, some may be injured during transport, or may not spawn when released. However, the progeny of these adults is predicted to suffer 100~~%~~ percent mortality if they spawn in the mainstem, so relocation is considered worth the risk of reduced spawning success. Overall effectiveness of the adult relocation operation would be measured by using radio-tagged individuals to track the -tagged fish to determine spawning success and location.

3.3.4.4.2 AR-2: Protection of Outmigrating Juveniles

It is anticipated that short-term effects of the Proposed Action (SSC) will result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook, coho, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River upstream of Orleans during late winter and early spring of 2020 (Appendix E).

Deleterious short-term effects on outmigrating juveniles could be reduced by capturing juveniles outmigrating from tributaries prior to their entry into the mainstem. This measure includes the installation of downstream migrant traps on up to 13 key tributary streams downstream of from Iron Gate Dam including Bogus Creek, Dry Creek, Walker Creek, Shasta River, Seiad Creek, Oneil Creek, Scott River, Grider Creek, Tom Martin Creek, Horse Creek, Beaver Creek, Cottonwood Creek, and Humbug Creek. Results of spawning surveys in fall 2019 could be used to focus trapping efforts within these or other tributaries. Trapping on all of these streams is proposed to help preserve the genetic integrity and varied life history tactics that are represented by this group of streams that have a high diversity with respect to size, channel types, water temperature regimes, geographic distribution, and other attributes.

The trapping would involve the standard CDFG/USFWS rotary screw trap/fyke net/pipe trap methods currently in use. However, placement of a second trap downstream ofFrom the first would increase the number of captures. Captured fish could then be placed in aerated tank trucks and transported to a release site downstream ofFrom the Trinity River or other locations that have suitable water quality.

The procedures of trapping, handling, trucking, and releasing outmigrating salmonids could result in harm or mortality to some individuals, and releasing fish at downstream locations could reduce natal cues and increase stray rates. Therefore fish will be captured and transported only if conditions within the mainstem are as poor as predicted. Due to the uncertainties with suspended sediment modeling, water quality monitoring during spring 2020 would be used to trigger the initiation and cessation of the capture program and inform suitable release locations. Release locations should be varied to prevent predators from congregating at release locations. Alternatively, in a portion of tributaries juveniles could be held in temporary facilities within tributaries and released when SSC in the mainstem were non-stressful. This would prevent any decrease in the natal cue, as well as any potential associated effects of fish transport.

A detailed plan describing trapping techniques, release locations, and monitoring methods would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

The effectiveness of this measure depends on the efficiency of trapping efforts. Trap efficiency varies with species and tributary. Current trapping efforts in the Shasta River and Scott River typically have trap efficiencies between around 5 and 30 percent, averaging around 15 percent (Underwood et al. 2010). It is anticipated that trapping efficiency could be increased over current efforts by more aggressive trapping efforts using either multiple traps and/or increased weir panels. However, not all tributaries with outmigrating juveniles will be trapped, and within trapped tributaries some individuals will avoid traps and migrate to the mainstem (particularly during high flows). Overall, it is assumed 50 percent of juveniles outmigrating to the mainstem could be captured. Current predictions of mortality estimate a total of 2,668 to 6,536 smolts for an impact of 9 to 22 percent from the upper Klamath River, mid-Klamath River, Scott River, and

Shasta River population units depending on a most-likely-to-occur or worst case scenario. Assuming 50 percent capture efficiency this mitigation measure would reduce mortality a total of 1,334 to 3,268 smolts for an impact of 4 to 11 percent depending on a most-likely-to-occur or worst-case scenario. To evaluate the effectiveness of the mitigation

measure, the trapping procedures would need to assess trap efficiency that would lead to the development of estimates of stream production and numbers of fish assumed missed by trapping effort.

3.3.4.4.3 AR-3: Fall Flow Pulses

It is anticipated that short-term effects of the Proposed Action (SSCs) will result in sublethal effects for green sturgeon adults remaining in the mainstem Klamath River during fall 2019, mortality for mainstem spawning fall-run Chinook salmon, mortality for migrating adult winter steelhead, and sublethal effects for adult coho salmon remaining in mainstem prior to entering tributaries.

Deleterious short-term effects on adults could be reduced by augmented flows during fall 2019 prior to dam removal. It has been observed that fall pulse flows result in the downstream migration of post-spawned green sturgeon out of the Klamath River (Benson et al. 2007), and increased flows during fall prior to dam removal may increase the rate and proportion of fall-run Chinook salmon, steelhead, and coho salmon spawning in tributaries, and thus reducing the proportion of the population spawning in the mainstem or being exposed to ~~SSC~~SSCs in the mainstem during migration (Stillwater Sciences 2009a).

Water releases in the fall prior to dam removal should mimic the natural hydrograph that would have existed in the Klamath River during a "wet year" prior to the Reclamation project, consistent with recommendations in NRC (2004). However, if the water year during dam removal is dry, managers will need to balance the benefits of increased flows during fall with the risk of impacts to the ~~basin~~Basin if less water is available during the following spring (during smolt outmigration). Increases in fall flows would likely be most successful if conducted synchronously with increased flows in unregulated tributaries, to help create enough of a pulse of water to encourage migration. Doing so will also ensure that adults that are attracted up the mainstem by increasing fall flows are not blocked from accessing their natal streams due to natural low flow conditions.

A detailed plan describing target flows and monitoring methods would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is anticipated that this measure will be effective for reducing deleterious short-term effects on adult green sturgeon during fall 2019. Benson et al. (2007) reported that the majority of adult green sturgeon outmigrating during the first major flow event of the fall. Analysis of the mainstem natural spawner fraction versus flow suggests that, generally, increased numbers of naturally produced fall-run Chinook salmon adults spawn in the mainstem during years when fall flows are low (Stillwater Sciences 2009a). The minimum proportion of fall-Chinook salmon spawning in the mainstem is 5.3~~%~~ percent, suggesting that if fall-pulse flows are successful at increasing tributary spawning the proportion of fall-run Chinook salmon spawning in the mainstem could be reduced to this level.

Currently on average less than 4 percent of coho salmon migrate into monitored tributaries after December 15th, and in many years no fish are observed migrating after this date (Appendix E). Migration of coho salmon adults into tributaries also appears to be affected by flow, with earlier tributary entrance times observed in Blue Creek, Shasta River, Bogus Creek and other tributaries during years with high flows during fall (Stillwater Sciences 2009a). A fall pulse-flow is anticipated to be effective at ensuring nearly all adult coho salmon migrate into tributaries prior to initiation of reservoir drawdown on December 15. The effectiveness of the measure could be monitored with spawning surveys during 2019. The proportion of steelhead migrating upstream after December 15th is highly variable (USFWS 1998). Although no analysis has been conducted, it is possible that increased fall flows could result in a greater proportion of steelhead migrating upstream and into tributaries prior to dam removal, as is observed in some years (USFWS 1998).

3.3.4.4.4 AR-4: Hatchery Management

It is anticipated that short-term effects of the Proposed Action (SSC) will result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook, coho, and steelhead smolts outmigrating from tributary streams to the Klamath River upstream of Orleans during late winter and early spring of 2020 (Appendix E).

Deleterious short-term effects on outmigrating hatchery Chinook and coho salmon smolts could be reduced by adjustments to hatchery management. Hatchery managers could adjust the timing of hatchery releases during spring 2020. Although it would be out of synch with natural life history timing, if smolts are released later in the spring (e.g., mid-May), survival is anticipated to be higher based on current conditions (Beeman et al. 2008), as well as avoiding the peak in spring release of sediment in the year following dam removal.

An alternative to adjusting the hatchery release timing would be to allow the sub-yearling and yearling smolts to imprint at the hatchery and then truck them to release locations downstream where SSC effects may be muted by tributary accretion flow. Trucking could be accomplished during the normal releasing timing period.

The implementation of this mitigation measure is dependent on the hatchery remaining open and having a suitable water supply. A detailed plan describing adjustments to hatchery management would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is anticipated that this measure will effectively reduce short-term lethal effects on hatchery released smolts to sublethal effects.

3.3.4.4.5 AR-5: Pacific lamprey Capture and Relocation

Based on predictions of low dissolved oxygen and the analysis of SSC that was conducted (Appendix E), high rates of mortality are predicted in the short term as a result of the Proposed Action. An action to mitigate this deleterious short-term effect would be

to salvage and relocate lamprey ammocoetes from preferred habitat areas where dissolved oxygen levels would be particularly low, including pools, alcoves, backwaters, and channel margins that experience low water velocities and sand and silt deposition (Streif 2009) from areas downstream ~~of~~from Iron Gate Dam. The focus of relocation efforts would be within 3 km of Iron Gate Dam, where SSC is predicted to be highest, and dissolved oxygen levels the lowest. However, the density of lamprey within this reach is not known, and reconnaissance surveys should be conducted prior to the implementation of this measure to assess if enough ammocoetes are present to warrant mitigation.

The salvage operation, if implemented, would be conducted by first identifying preferred (and high risk) areas and then utilize a specialized electrofisher to capture ammocoetes. Collection of lamprey ammocoetes has been demonstrated in the Klamath River (Karuk Tribe and USFWS unpublished data). Captured individuals would be transported to suitable locations (with current low occurrences of lamprey) within tributaries upstream or upstream of Keno Dam. A detailed plan describing lamprey capture and relocation would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is expected that implementation of this mitigation measure would reduce dissolved oxygen and SSC-related stress or mortality for a proportion of lamprey ammocoetes. An unknown number of lamprey ammocoetes remaining in the mainstem Klamath River downstream ~~of~~ from Iron Gate Dam would still experience stress and mortality resulting from elevated SSC and bedload movement. Mitigation effectiveness monitoring would consist of reporting the number of individuals captured, release location, and their condition upon release.

3.3.4.4.6 AR-6: Sucker Rescue and Relocation

It is anticipated that short-term effects of the Proposed Action will result in mostly sublethal, and in some cases lethal impacts to Lost River and shortnose suckers within reservoirs in Hydroelectric Reach. Under this measure adult Lost River and shortnose suckers in reservoirs downstream ~~of~~from Keno Dam could be captured and relocated to Upper Klamath Lake (Buchanan et al. 2011a).

If deemed feasible in 2019 prior to dam removal, Klamath smallscale suckers will be collected directly downstream ~~of~~from J.C. Boyle Dam and terminating approximately ~~2~~ 2 miles downstream in the approximate area of the current powerhouse. Fish will be collected using electro- fishing techniques. Salvaged Klamath smallscale sucker will be relocated to Spencer Creek immediately downstream ~~of~~from the Spencer Creek hook up road (upper limits for sucker in Spencer creek). Smallscale suckers will not be relocated upstream of Keno Dam.

Lost River and shortnose suckers can also be captured using electrofishing and trammel nets. It is recommended that these and other approved capture techniques be utilized for this relocation effort. Captured Lost River and shortnose suckers could then be placed in

aerated tank trucks and transported to suitable release sites in Upper Klamath Lake. A detailed plan describing sucker rescue and relocation would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is expected that implementation of this mitigation measure would reduce the deleterious short-term effects from the Proposed Action. However, it is not known how many suckers inhabit the Hydroelectric Reach reservoirs, therefore it is unknown what proportion of the population would be captured and successfully relocated. Those Lost River and shortnose suckers not relocated to the Upper Klamath Basin would likely be lost, but with little or no successful reproduction (Buettner et al. 2006), and no connection to upstream populations, the individuals downstream ~~of~~from Keno Dam contribute minimally to conservation goals or recovery (Hamilton et al. 2011).

3.3.4.4.7 AR-7: Freshwater Mussel Relocation

Freshwater mussels in the Hydroelectric Reach and in the ~~lower~~Lower Klamath River, downstream ~~of~~from Iron Gate Dam, are likely to be deleteriously affected by prolonged SSCs and bedload movement during the later part of reservoir drawdown and subsequent dam removal. Freshwater mussels cannot move to avoid these impacts, and some species are very long lived, and may not reproduce successfully (or at all) each year. An action to mitigate this effect is to relocate freshwater mussels prior to drawdown. Freshwater mussels could be relocated to tributary streams or upstream of the Hydroelectric Reach, then moved back to their approximate location or to other suitable habitat in the river after dam removal has been completed.

Freshwater mussel relocation success depends on a variety of factors including the availability of suitable habitat (for juveniles, adults, reproduction, feeding, growth, and host fish), population density at the relocation site, and handling during relocation (Hamilton et al. 1997; Bolden and Brown 2002). While many (and still unknown) factors influence the survival and reproduction of freshwater mussels in their natural environment, relocation adds an additional stress. Thus, the variables associated with the characteristics of freshwater mussel habitat at the source and destination sites as well as with the relocation methods should be as similar as possible for all life stages (Cope and Waller 1995; Cope et al. 2003). Previous studies indicate varied success of freshwater mussel relocation projects, with most mortality observed within one year (Thomas 2008). Habitat selection is important for success, as changes in habitat (e.g., substrate size) from the original site appear to influence mortality (Cope and Waller 1995; Bolden and Brown 2002). As such, the presence of existing freshwater mussel populations should guide site selection. Cope et al. (2003) found that proper handling and transport and selection of suitable habitat improved survivorship of relocated freshwater mussels.

Luzier and Miller (2009) developed some general guidelines for freshwater mussel relocation projects, including 1) an initial evaluation of freshwater mussel populations to ~~identify species, estimate abundance, and sex ratio and age distribution (if possible), 2)~~ site evaluation for relocation to determine (among other factors) habitat quality and

presence of appropriate fish hosts, 3) careful and quick transport to minimize stress, and 4) monitoring relocated populations to determine initial survival, recruitment, and persistence through the range of environmental conditions at the site. Following these guidelines, prior to drawdown (e.g., fall 2019 or before) surveys would be conducted to evaluate current freshwater mussel species and habitat ~~below~~downstream from Iron Gate Dam and to identify potential sites for relocation. Freshwater mussels would be relocated to suitable habitats and monitored over the duration of high SSCs. After dissipation of effects, original locations could be resurveyed to determine habitat suitability. If suitable, then the relocated freshwater mussels could be returned to their source location. Most relocation projects are conducted during warm periods when reproductive stress is presumably low for most species, and their metabolic rates are sufficient for burrowing in the substrate (Cope and Waller 1995).

If suitable in-stream habitat cannot be found for the time period of increased SSCs, it may be possible to temporarily house relocated freshwater mussels in fish hatchery raceways at facilities near to the removal sites. ~~This was apparently performed on the Elwha during dam removal (no citation available) using river water so they could filter feed.~~ However, many freshwater mussels need to burrow to reduce the energy needs of holding their valves closed for extended periods. Thus, such artificial holding areas should not be used for long periods. Aquaculture ponds have sometimes been used as well (Cope et al. 2003).

This mitigation measure would benefit from a pilot program prior to initiation, to assess the success and potential levels of mortality associated with relocation. Relocation should also consider the potential for transmission of disease or interbreeding between genetically distinct populations. A detailed plan describing freshwater mussel rescue and relocation would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

With the proposed mitigation, these impacts freshwater mussels would be reduced.

3.3.4.4.8 Summary of Mitigation Measures

The DRE would be responsible for implementation of Mitigation Measures AR-1 through AR-7. Although all proposed mitigation measures would reduce short-term deleterious effects of the Proposed Action, significant effects would continue to occur for some species, as described in detail in the Proposed Action Species-Specific impacts analysis provided in Section 3.3.4.3.2.2.3 and detailed in Tables 3.3-11 through 3.3-18.

Table 3.3-11. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-likely Scenario (i.e., 50% Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Fall Chinook Salmon	**Proposed Action**				
	No effects	Up to 100% mortality of the progeny of mainstem spawners (about 8% of escapement)	No juvenile progeny anticipated rearing in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	N/A	**Type I:** Major stress and reduced growth for Type I fry (about 60% of production) **Type II:** No effects **Type III:** Major stress, reduced growth, and up to 20% mortality for Type III outmigrants (less than 1% of production)
	Proposed Action with Mitigation Measures AR-1, 2, 3, and 4				
	Increased escapement into tributaries due to augmented attraction flows	Reduced effects due to increased hatchery production, trapping and relocation of adult spawners and additional redds being constructed in tributaries	Reduced effects due to mainstem progeny now rearing in hatchery and tributary streams.	N/A	**Type I:** Major stress on smolts not rescued and relocated; Growth-related effects for non-hatchery smolt; reduced effects on hatchery smolts due to delayed release **Type II:** Same as above for naturally spawned progeny. Reduced effects for hatchery-reared fish due to release timing modification. Reduced effects for rescued and relocated smolts. **Type III:** Major stress, reduced growth, and up to 20% mortality for Type III outmigrants. Reduced effects for rescued and relocated smolts.

Table 3.3-11. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-likely Scenario (i.e., 50% Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon.

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Spring Chinook Salmon	**Proposed Action**				
	Spring Migration: Major stress, impaired homing for adults returning to Salmon R. (about 5% of run) Summer Migration: No effects	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	Type I: Major stress for Type I fry from Salmon R. (about 80% of Salmon R. production)
					Type II: Major to moderate stress for 1 to 3 days
					Type III: Major stress, reduced growth, but no mortality
	Proposed Action with Mitigation Measures AR- 2 and 3				
	Spring Migration: Same as above Summer Migration: Same as above	Same as above	Same as above	Same as above	Type I: Major stress on smolts not rescued and relocated
					Type II: Same as above for non-rescued and relocated fish.
					Type III: 20-40% mortality (about 31 smolts)

Table 3.3~~-~~-11. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-likely Scenario (i.e., 50% Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon~~.~~

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Coho Salmon	**Proposed Action**				
	Major stress and impaired homing	Up to 100% mortality of progeny of mainstem spawners (typically <1% of run)	**Age 0+ summer:** Reduced growth for age 0+ from 2020 cohort in upper mainstem (<50% of fry). No effect on juveniles rearing in tributaries	**Age 1+ winter:** Major stress, reduced growth, and up to 60% mortality for age 1+ juveniles from 2019 cohort in mainstem (assume <1% of juveniles). No effect on juveniles rearing in tributaries	**Early spring outmigration:** Major stress, reduced growth, and up to 20% mortality for smolts coming from tributaries in upper mainstem in early spring (about 44% of production)
					Late spring outmigration: Major stress and reduced growth for smolts coming from tributaries in the upper mainstem in late spring (about 56% of production)
	Proposed Action with Mitigation Measure AR-2 and 3				
	Same as above	Reduced effects due to relocation of adult spawners and additional redds being constructed in tributaries upstream of Hydroelectric ~~reach~~Reach	**Age 0+ summer:** Same as above	**Age 1+ winter:** Same as above	**Early spring outmigration:** Major stress, reduced growth, and up to 4% mortality***; Reduced mortality***
					Late spring outmigration: Major stress and mortality on smolts not rescued and relocated; Growth-related effects

Table 3.3-12. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Most-likely scenario (i.e., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Summer and Winter Steelhead	**Proposed Action**					
	Summer run: Major stress and impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 45% of escapement) Winter run: Major stress, impaired homing, and up to 36% mortality for fish spawning in mid- and upper-Klamath tributaries (about 1,008 adults)	Adult runbacks: Major stress; depending on time spent in mainstem Half-pounder residency: Most assumed to remain in tributaries; major stress for any remaining in mainstem	Most spawning takes place in tributaries; no effects predicted	Major stress resulting in reduced growth and up to 100% mortality for juveniles in that migrate from tributaries to the mainstem	Age 1+ rearing: Major stress, reduced growth, and up to 100% mortality for juveniles in that migrate from tributaries to the mainstem Age 2+ rearing: Reduced growth and up to 60% mortality for juveniles in mainstem	Major stress and reduced growth; about 57% outmigrate from Trinity R. and would have less exposure

Table 3.3-12. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Most-likely scenario (i.e., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Summer and Winter Steelhead	**Proposed Action with Mitigation Measure AR-2**					
	Summer run: Same as above Winter run: Same as above	Adult runbacks: Same as above Half-pounder residency: Same as above	Same as above	Reduced effects for those migrating fish that are captured and relocated. Same effects as above for non-relocated fish.	Age 1+ rearing: Reduced effects for those migrating fish that are captured and relocated. Same effects as above for non-relocated fish. Age 2+ rearing: Reduced effects for those migrating fish that are captured and relocated. Same effects as above for non-relocated fish.	Major stress and reduced growth for that portion of the population not captured by the outmigrant rescue program.

Table 3.3-12. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Most-likely scenario (i.e., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Pacific Lamprey	**Proposed Action**					
	Major stress, reduced growth, and up to 36% mortality; later-returning adults and those returning to lower tributaries would have less exposure	N/A	See adult migration	**Ammocoete rearing:** Major stress, reduced growth, and up to 52% mortality for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would not suffer mortality		**Spring outmigration:** Major stress **Fall and winter outmigration:** Moderate stress
	Proposed Action with Mitigation Measure AR-5					
	Same as above	N/A	Same as above	**Ammocoete rearing:** Reduced effects for ammocoetes that are captured and relocated. Major stress, reduced growth, and up to 52% mortality for lamprey not captured and relocated.		**Spring outmigration:** Same as above **Fall and winter outmigration:** Same as above

Table 3.3-13. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-Likely Scenario (i.e., 50% Exceedance Probabilities) for Green Sturgeon and Suckers.

Species/Run	Life History Stage			
	Adult migration	**Adult Post-spawning Holding**	**Spawning through larvae**	**Juvenile Rearing (year-round) and Outmigration**
Green Sturgeon	**Proposed Action**			
	Major stress; 75% of adults not expected to migrate in 2020	No effects	76% mortality for all mainstem production; about 30% that spawn in Trinity R. would be unaffected (based on salmonid literature; effects likely overestimated)	Reduced growth and up to 20% mortality; about 30% of juveniles rear in Trinity R. and would be unaffected (based on salmonid literature; effects likely overestimated)
	Proposed Action with Mitigation Measure AR-4			
	Reduced effects due to fall flow pulse moving adults downstream; 75% of adults not expected to migrate in 2020.	Same as above	Same as above	Same as above
Suckers (spp)	**Proposed Action**			
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.
	Proposed Action with Mitigation Measure AR-6			
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all adults within the Hydroelectric Reach that were not captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.

Table 3.3-14. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measure AR-8 for Freshwater Mussels

Species/Run	Adults	Spawning	Larvae
Freshwater mussels	**Proposed Action**		
	Major physiological stress and substantial mortality	Major physiological stress and substantial mortality during the spawning season	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced in downstream reaches or tributaries may contribute to population recovery.
	Proposed Action with Mitigation Measure AR-8		
	Major physiological stress and substantial mortality. Some individuals would be relocated and would assist in reseeding the population.	Major physiological stress and substantial mortality during the spawning season. Relocated individuals may spawn in upstream reaches.	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced by relocated individuals, in downstream reaches, or in tributaries may contribute to population recovery.

Table 3.3-15. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Fall- and Spring-run Chinook Salmon.

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Fall-run Chinook Salmon	**Proposed Action**				
	No effect	Up to 100% mortality of the progeny of mainstem spawners (about 8% of escapement)	No juvenile progeny anticipated rearing in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	N/A	**Type I:** Major stress and reduced growth for the about 40% of fry entering mainstem in April/May
					Type II: Moderate to major stress for the about 60% of Type II juveniles entering mainstem in Sept/Nov
					Type III: Major stress, reduced growth, and up to 71% mortality for about 0.18% of all juveniles entering mainstem in Feb-April
	Proposed Action with Mitigation Measures AR-1, 2, 3, and 4				
	Increased escapement into tributaries due to augmented attraction flows	Reduced effects due to increased hatchery production, relocation of adult spawners and additional redds being constructed in tributaries	Reduced effects due to mainstem progeny now rearing in hatchery and tributary streams	N/A	**Type I:** Major stress on smolts not rescued and relocated; Growth-related effects for non-hatchery smolt; reduced effects on hatchery smolts due to delayed release
					Type II: Same as above for naturally spawned progeny. Reduced effects for hatchery-reared fish due to release timing modification.
					Type III: Major stress, reduced growth, and up to 60% mortality***; Reduced mortality***

Table 3.3-15. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Fall- and Spring-run Chinook Salmon.

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Spring-run Chinook Salmon	**Proposed Action**				
	Spring Migration: Major stress and impaired homing Summer Migration: Impaired homing	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	Type I: Major stress for Type I fry from Salmon R. (about 80% of Salmon R. production)
					Type II: Moderate stress for Type II juveniles from Salmon R. (about 20% of Salmon R. production)
					Type III: Major stress for Type III juveniles from Salmon R. (<1% of Salmon R. production)
	Proposed Action with Mitigation Measure s AR- 2				
	Spring Migration: Same as above Summer Migration: Same as above	Same as above	Same as above	Same as above	Type I: Reduced impacts for those fish that are rescued and relocated. Same impacts as above for fish not rescued.
					Type II: Reduced impacts for those fish that are rescued and relocated. Same impacts as above for fish not rescued.
					Type III: Reduced impacts for those fish that are rescued and relocated. Same impacts as above for fish not rescued.

Table 3.3-16. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Coho Salmon and Steelhead.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Coho Salmon	**Proposed Action**					
	Major stress and impaired homing	N/A	Up to 100% mortality of progeny of mainstem spawners (typically <1% of run)	**Age 0+ summer:** No growth for 2020 cohort rearing in upper mainstem (< 50% of fry). No effect on juveniles rearing in tributaries	**Age 1+ winter:** Major stress, reduced growth and up to 52% mortality for 2018 age-1+ cohort in mainstem (assume <1% of juveniles). No effect on juveniles rearing in tributaries	**Early spring outmigration:** Major stress, reduced growth, and up to 49% mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of the run outmigrates in early spring). (Mortality for approximately 8% of total population)
						Late spring outmigration: Major stress and reduced growth for smolts coming from tributaries in the upper mainstem in late spring (about 56% of production)
	Proposed Action with Mitigation Measures AR-2 and 3					
	Same as above	N/A	~~Same as above~~Reduced effects due to relocation of adult spawners and additional redds being constructed in tributaries upstream of Hydroelectric Reach	**Age 0+ summer:** Same as above	**Age 1+ winter:** Same as above	**Early spring outmigration:** Major stress, reduced growth, and up to 11% mortality***; Reduced mortality***
						Late spring outmigration: Reduced impacts for those fish that are rescued and relocated.

Table 3.3-16. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Coho Salmon and Steelhead.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Summer and Winter Steelhead	**Proposed Action**					
	Summer run: Major stress, impaired homing, and up to 20% mortality (From 0 to 130 adults, or from 0 to 9 percent of the basin-wide escapement). Winter run: Major stress, impaired homing, and up to 71% mortality. The proportion migrating prior to January would not be affected. (Up to 1,988 adults, or up to 28 percent of the basin-wide escapement).	Adult runbacks: Major stress; exposure dependant on time it takes runbacks to return to sea Half-pounder residency: Major stress and reduced growth for any in mainstem; Most assumed to remain in tributaries;	Most spawning takes place in tributaries; no effects predicted	Major stress and reduced growth for age 0+ juveniles in mainstem (about 60% of juveniles)	Age 1+ rearing: Stress, reduced growth, and up to 71% mortality Up to 11,207 juveniles or around 19% of total age 1 production). Age 2+ rearing: Stress, reduced growth and up to 71% mortality (Up to 9,412 juveniles or around 18% of total age 2 production).	Major stress resulting in reduced growth, about 57% outmigrate from Trinity R. and will have less exposure
	Proposed Action with Mitigation Measures AR-2					
	Summer run: Same as above Winter run: Same as above	Adult runbacks: Same as above Half-pounder residency: Same as above	Same as above	Same as above	Age 1+ rearing: Same as above Age 2+ rearing: Same as above	Major stress and reduced growth for that portion of the population not captured by the outmigrant rescue program.

Table 3.3-17. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-case Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers.

Species	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Pacific Lamprey	**Proposed Action**				
	Major stress, reduced growth, and up to 71% mortality; later-returning adults and those returning to lower tributaries would have less exposure	See adult migration	**Ammocoete rearing:** Major stress, reduced growth, and up to 71% mortality for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would not suffer mortality		**Spring outmigration:** Moderate to major stress and reduced growth **Fall and winter outmigration:** Major stress
	Proposed Action with Mitigation Measure AR-5				
	Same as above	Same as above	**Ammocoete rearing:** Same as above for any ammocoetes not captured and relocated		**Spring outmigration:** Same as above **Fall and winter outmigration:** Same as above

Table 3.3-17. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-case Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers

Species	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Green Sturgeon	**Proposed Action**				
	Major stress; about 25% of adults expected to be exposed in 2020	**Adult Post-spawning Holding:** Short period (<1 wk) of relatively low SSCs, not expected to result in deleterious effects; about 75% of adults hold in mainstem after spawning; remainder return to ocean	95% mortality for all mainstem production; about 30% that spawn in Trinity R. would be unaffected (based on salmonid literature; effects likely overestimated)	**Juvenile Rearing (year-round) and Outmigration:** Reduced growth and up to 36% mortality; about 30% of juveniles rear in Trinity R. and would be unaffected	N/A
	Proposed Action with Mitigation Measure AR-3				
	Reduced effects due to fall flow pulse moving adults downstream	**Adult Post-spawning Holding:** Reduced effects due to fall flow pulse moving adults downstream	Same as above	**Juvenile Rearing (year-round) and Outmigration:** Same as above	N/A

Table 3.3-17. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-case Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers.

Species	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Suckers (spp)	**Proposed Action**				
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	NA
	Proposed Action with Mitigation Measure AR-6				
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all adults within the Hydroelectric Reach that will not be captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.	NA

Table 3.3-18. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (i.e., 10% Exceedance Probabilities) for Freshwater Mussels.

Species	Adults	Spawning	Larvae
Freshwater mussels	**Proposed Action**		
	Major physiological stress and substantial mortality	Major physiological stress and substantial mortality during the spawning season	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced in downstream reaches or tributaries may contribute to population recovery.
	Proposed Action with Mitigation Measure AR-8		
	Major physiological stress and substantial mortality. Some individuals would be relocated and would assist in reseeding the population.	Major physiological stress and substantial mortality during the spawning season. Relocated individuals may spawn in upstream reaches.	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced by relocated individuals, in downstream reaches, or in tributaries may contribute to population recovery.

3.3.5 References

Ackerman NK, N. K., Pyper, B., Courter, I., Cramer, S. 2006. Estimation of returns on naturally produced coho to the Klamath River – review draft. Klamath coho integrated modeling framework technical memorandum #1 of 8.. Klamath Coho Integrated Modeling Framework Technical Memorandum 1 of 8. Review draft. Prepared by Cramer Fish Sciences, Gresham, Oregon for US Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon.

Adams PB, P.B., Grimes CB, C.B., Hightower JE, J.E., Lindley ST, S.T., Moser ML., M.L. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. National Marine Fisheries Service, Santa Cruz, California.

Addley RC, R.C., Bradford, B., Ludlow, J. 2005. Klamath River bioenergetics report. Utah State University, Institute for Natural Systems Engineering, Utah Water Research Lab, Logan, Utah.

Administrative Law Judge. 2006. Decision in the matter of Klamath Hydroelectric Project, FERC Project Number 2082. Docket Number 2006-NOAA Fisheries Service-0001, September 27, 2006. Alameda, California. Available at: http://www.fws.gov/yreka/P2082/20060927/2Klamath_DNO_Final.pdf.

Aldridge DW, D.W., Payne BS, B.S., Miller BC., B,C. 1987. The effects of intermittent exposure to suspended solids and turbulence on three species of freshwater mussels. Environmental Pollution 45: 17-28.

Andreasen JK., J.K. 1975. Systematics and status of the family Catostomidae in southern Oregon. Doctoral dissertation, Oregon State University, Corvallis, Oregon.

Aquatic Scientific Resources. – 2005. – Preliminary research on Aphanizomenon flos-aquae at Upper Klamath Lake, Oregon. – Investigations to set direction for research of factors with potential for influencing Aphanizomenon growth at Upper Klamath Lake. Prepared by Aquatic Scientific Resources, Portland, Oregon for Klamath Basin Ecosystem Restoration Office, Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon.

Araki, H., Cooper B., Blouin, M.S. 2007. Genetic effects of captive breeding cause a rapid, cumulative fitness decline in the wild. Science 318: 100-103.

~~Araki H, Cooper B, Blouin.~~ _____. 2009. Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild. Biology Letters 5: 621-624.

Atkinson, S., Bartholomew, J. 2010. Disparate infection patterns of *Ceratomyxa shasta* (Myxozoa) in rainbow trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) correlate with internal transcribed spacer-1 sequence variation in the parasite. International Journal for Parasitology 40: 599-604.

Balance Hydrologics, Inc. 1996. Initial assessment of pre-and post-Klamath Project Hydrology on the Klamath River and impacts of the Project on instream flows and fishery habitat. Berkeley, California.

Banish, N.P., Adams, B.J., Shively, R.S., Mazur, M.M., Beauchamp, D.A., Wood, T.M. 2009. Distribution and habitat associations of radio-tagged adult Lost River and shortnose suckers in Upper Klamath Lake, Oregon. Transactions of the American Fisheries Society 138: 153–168.

Barnhart ~~RA.~~, R.A. 1994. Salmon and steelhead populations of the Klamath-Trinity Basin, California. Pages 73-97 in TJ Hassler, editor. Klamath Basin fisheries symposium. ~~Humboldt State University,~~ California Cooperative Fishery Research Unit, Humboldt State University, Arcata.

Bartholow ~~JM.~~, J.M. 2005. Recent water temperature trends in the lower Klamath River, California. North American Journal of Fisheries Management 25: 152-162.

Bartholow ~~JH~~, J.M., Campbell ~~SG~~, S.G., Flug, M. 2005. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34: 856-874.

Bartholomew, J.L. ~~1998. Host resistance to infection by the myxosporean parasite *Ceratomyxa shasta*: a review. Journal of Aquatic Animal Health 10, 112-120.~~

~~Bartholomew JL~~, Whipple ~~MJ~~, M.J., Stevens ~~DG~~, D.G., Fryer, JL. 1997. The life cycle of *Ceratomyxa shasta*, a myxosporean parasite of salmonids, requires a freshwater polychaete as an alternate host. Journal of Parasitology 83: 859-868.

Bartholomew, J.L., Atkinson ~~SD~~, S.D., Hallett ~~SL~~, S.L., Zielinski ~~CM~~, C.M., Foott ~~JS.~~, J.S. 2007. Distribution and abundance of the salmonid parasite *Parvicapsula minibicornis* (Myxozoa) in the Klamath Basin (Oregon-California, USA). Diseases of Aquatic Organisms 78: 137.

Bartholomew~~ JL~~, J.L., Foott~~ JS.~~, J.S. 2010. Compilation of information relating to myxozoan disease effects to inform the Klamath Basin Restoration Agreement. ~~Oregon State University,~~ Department of Microbiology, Oregon State University, Corvallis, and U.S. Fish and Wildlife Service, California-Nevada Fish Health Center.

~~Beak Consultants, Inc. 1987. Shortnose and Lost River sucker studies: Copco Reservoir and the Klamath River. Prepared for City of Klamath Falls, Oregon.~~

Beamish~~ RJ~~, R.J., Levings~~ CD.~~, C.D. 1991. Abundance and freshwater migrations of the anadromous parasitic lamprey, *Lampetra tridentata*, in a tributary of the Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 48: 1250-1263.

Beeman, J.W., Stutzer~~ GM~~, G.M., Juhnke~~ SD~~, S.D., Hetrick~~ NJ.. 2007.~~, N.J. 2008. Survival and migration behavior of juvenile coho salmon in the Klamath River relative to discharge at Iron Gate Dam, 2006. ~~Final Report. Prepared by US Geological Survey, Cook, Washington and US Fish and Wildlife Service, Arcata, California for US Bureau of Reclamation, Mid-Pacific Region, Klamath Area Office, Klamath Falls, Oregon.~~

~~Beeman JW, Stutzer GM, Juhnke SD, Hetrick NJ. 2008. Survival and migration behavior of juvenile coho salmon in the Klamath River relative to discharge at Iron Gate Dam, 2006.~~ Open-File Report 2008-1332. U.S. Geological Survey. Available at: http://pubs.usgs.gov/of/2008/1332/pdf/ofr20081332.pdf.

Behnke~~ RJ.~~, R.J. 1992. Native trout of western North America. American Fisheries Society, Bethesda, Maryland.

~~**Behnke RJ.**~~_____. 2002. Trout and salmon of North America. The Free Press, New York.

Belchik, M. 2003. Use of thermal refugial areas on the Klamath River by juvenile salmonids; summer 1998. Final report, Grant #8-FG-20-17510. Prepared for Bureau of Reclamation, Klamath Area Office by Yurok Tribal Fisheries Program, Klamath, California.

Benson~~ RL~~, R.L., Turo, S., McCovey~~ BW.~~, B.W. 2007. Migration and movement patterns of green sturgeon (Acipenser medirostris) in the Klamath and Trinity rivers, California, USA. Environmental Biology of Fishes 79: 269-279.

Bisson~~ PA~~, P.A., Crisafulli~~ CM~~, C.M., Fransen~~ BR~~, B.R., Lucas~~ RE~~, R.E., Hawkins~~ CP.~~, C.P. 2005. Responses of fish to the 1980 eruption of Mount St. Helens. Pages 163-181 in Dale VH, Swanson~~ FJ~~, F.J., Crisafulli~~ CM~~, C.M., editors. Ecological responses to the 1980 eruption of Mount St. Helens. Springer, New York.

Bjork~~ SJ~~, S.J., Bartholomew~~ JL.~~, J.L. 2010. Invasion of Ceratomyxa shasta (Myxozoa) and comparison of migration to the intestine between susceptible and resistant fish hosts. International Journal for Parasitology 40~~,~~; 1087-1095.

Bjornn~~ TC~~, T.C., Brusven~~ MA~~, M.A., Molnau~~ MP~~, M.P., Milligan~~ JH~~, J.H., Klamt~~ RA~~, R.A., Chacho, E., Schaye, C. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Research Technical Completion Report, Project B-036-IDA. Prepared by University of Idaho, Moscow for Office of Water Research and Technology, U.~~-~~S~~.~~. Department of the Interior, Washington, D~~.~~C.

Bolden~~ SR~~, S.R., Brown~~ KM.~~, K.M. 2002. Role of stream, habitat, and density in predicting translocation success in the threatened Louisiana pearlshell, *Margaritifera hembeli* (Conrad). Journal of the North American Benthological Society 21: 89-96.

Brett~~ JR.~~, J.R. 1971. Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). American Zoologist 11: 99-113.

~~BRT (Eulachon Biological Review Team). 2010. Status review update for eulachon in Washington, Oregon, and California. http://www.nwr.noaa.gov/Other-Marine-Species/upload/eulachon-review-update.pdf~~

Buchanan, D.V~~, ME.~~, Hanson, ~~and RM Hootonl.~~M.E., Hooton, R.M. 1997. Status of Oregon's bull trout: distribution, life history, limiting factors, management considerations, and status. Oregon Department of Fish and Wildlife, Portland.

Buchanan, D., Buettner, M., Dunne, T., Ruggerone, G. 2011a. Scientific assessment of two dam removal alternatives on resident fish. Draft report. Klamath River Expert Panel. Available at: http://klamathrestoration.gov/sites/klamathrestoration.gov/files/Resident%20Fish%20Final%2004%2011%2011.pdf~~-~~.

Buchanan, R., Townsend, R., Skalski, J., Ham, K. 2011b. The effect of bypass passage on adult returns of salmon and steelhead: an analysis of PIT-tag data using the program ROSTER. Draft report. Prepared by Battelle, Pacific Northwest Division, Richland, Washington for U.S. Army Corps of Engineers, Walla Walla District, Washington.

~~Buettner M, Larson R, Hamilton J, Curtis G. 2006. Contribution of Klamath reservoirs to federally listed sucker populations and habitat. U.S. Fish and Wildlife Service, Yreka, California.~~

~~Buettner M~~Buer, K. 1981. Klamath and Shasta rivers spawning gravel enhancement study. Department of Water Resources, Northern District, Red Bluff, California.

Buettner, M., Scoppettone, G. 1990. Life history and status of Catostomids in Upper Klamath Lake, Oregon. Completion Report. U.S. Fish and Wildlife Service, National Fisheries Research Center, Reno Field Station, Nevada.

Buettner, M., Larson, R., Hamilton, J., Curtis, G. 2006. Contribution of Klamath reservoirs to federally listed sucker populations and habitat. U.S. Fish and Wildlife Service, Yreka, California.

Bureau of Land Management~~.~~ (BLM). 2002. Instream flow analysis for the Bureau of Land Management Federal Reserved Water Right, Claim Number 376, for the Klamath Wild and Scenic River in Oregon.~~.~~

~~Busby PJ, Wainwright TC, Waples RS. 1994. Status review for Klamath Mountains Province steelhead. NOAA Technical Memorandum NOAA Fisheries Service-NWFSC-19. National Marine Fisheries Service, Seattle, Washington.~~
~~Butler VL, Miller JA, Yang DY, Misarti N. 2010. The use of archaeological fish remains to establish predevelopment salmonid biogeography in the Upper Klamath Basin. Final Report. Portland State University Department of Anthropology, Portland, Oregon.~~
~~CALFED. 2007. Green sturgeon (*Acipenser medirostris*). *In* Delta regional ecosystem restoration implementation plan. Draft report. CALFED Ecosystem Restoration Program, Sacramento, California.~~
~~http://www.delta.dfg.ca.gov/erpdeltaplan/docs/cm_Risk%20Model_Green%20Sturgeon_Edited_10_31_06.pdf~~
~~CBD et al. (Center for Biological Diversity, Oregon Wild, Environmental Protection Information Center, and The Larch Company). 2011. Petition to list Upper Klamath Chinook salmon (*Oncorhynchus tshawytscha*) as a threatened or endangered species.~~

~~CDFG (California Department of Fish and Game). 1990a. Juvenile salmonid sampling within the Klamath-Trinity Basin, 1984. Draft report. CDFG, Inland Fisheries Division, Arcata, California.~~

~~CDFG. 1990. Distribution, abundance, fork length and coded-wire tag recovery data for juvenile anadromous salmonids within the Klamath-Trinity Basin, 1985. Draft report. CDFG, Inland Fisheries Division, Arcata, California.~~

~~CDFG. 2000. Documentation of the Klamath River fish kill, June 2000. Memorandum. Redding, California. 27pp.~~

~~CDFG. 2002a. Status review of California coho salmon north of San Francisco. Candidate Species Status Review Report 2002-3. Report to the California Fish and Game Commission.~~

~~CDFG. 2002b. California Department of Fish and Game comments to NOAA Fisheries Service regarding green sturgeon listing.~~

~~CDFG. 2004. September 2002 Klamath River fish kill: final analysis of contributing factors and impacts. Northern California-North Coast Region. Redding, California.~~

~~CDFG. 2009. Filing of notice of determination in compliance with §21108 of the Public Resources Code. California Department of Fish and Game, Sacramento.~~

~~Cech JJ, Jr, Doroshov SI, Moberg GP, May BP, Schaffter RG, Kohlhorst DM. 2000. Biological assessment of green sturgeon in the Sacramento-San Joaquin watershed (phase 1). Final Report to the CALFED Bay-Delta Program. Project # 98-C-15, Contract #B-81738.~~

~~CH2M Hill. 1985. Klamath Basin fisheries resource plan. Prepared for U.S. Department of the Interior, Bureau of Indian Affairs by CH2M Hill, Redding, California.~~

~~Chesney WR, Yokel EM. 2003. Shasta and Scott River juvenile salmonid outmigrant study, 2001-2002. Project 2a1. Steelhead Research and Monitoring Program annual report. California Department of Fish and Game, North Coast Region, Redding, California.~~

~~Chesney, WR, Crombie WB, Langendorf HD. 2009. Shasta and Scott River juvenile salmonid outmigration monitoring project. Final report. California Department of Fish and Game, Anadromous Fish Research and Monitoring Project, Yreka, California.~~

~~City of Klamath Falls. 1986. Application for license – Salt Caves Hydroelectric Project. Initial Stage consultation, Volume II. Klamath Falls, Oregon.~~

~~Close D, Docker M, Dunne T, Ruggerone G. 2010. Scientific assessment of two dam removal alternatives on lamprey. Final report. Klamath River Expert Panel.~~

~~Close DA, Fitzpatrick MS, Li HW. 2002. The ecological and cultural importance of a species at risk of extinction, Pacific lamprey. Fisheries 27:19-25.~~

~~Coleman ME, McGie AM. 1988. Annual Progress Report 1987, Fish Research Project, No. E-2, Oregon. Oregon Department of Fish and Wildlife, Portland.~~

~~Cope WG, Waller DL. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. Regulated Rivers: Research and Management 11: 147-155.~~

~~Cope WG, Hove MC, Waller DL, Hornbach DJ, Bartsch MR, Cunningham LA, Dunn HL, Kapuscinski. 2003. Evaluation of relocation of unionid mussels to in situ refugia. Journal of Molluscan Studies 69: 27-34.~~

~~Cunanan M. 2009. Historic anadromous fish habitat estimates for Klamath River mainstem and tributaries under Klamath Hydropower reservoirs. U.S. Fish and Wildlife Service, Arcata, California.~~

~~Curran KJ, Hill PS, Milligan TG. 2002. Fine-grained suspended sediment dynamics in the Eel River flood plume. Continental Shelf Research 22: 2537-2550.~~

~~Daniels RA, Moyle PB. 1984. Geographic variation and a taxonomic reappraisal of the marbled sculpin, *Cottus klamathensis*. Copeia, 4: 949-959.~~

~~Dean, M. 1994. Life history, distribution, run size, and harvest of spring Chinook salmon in the south fork Trinity River Basin. Chapter VII - job VII in Trinity River Basin monitoring project 1991-1992.~~

~~Dean, M. 1995. Life history, distribution, run size, and harvest of spring Chinook salmon in the south fork Trinity River Basin. Chapter VII - job VII in Trinity River Basin monitoring project 1992-1993.~~

~~Department of the Interior (DOI). 2007. Modified terms and conditions, and prescriptions for fishways filed pursuant to sections 4(e) and 18 of the Federal Power Act with the Federal Energy Regulatory Commission for the Klamath River Hydroelectric Project No. 2082. Bureau of Land Management,~~ Bureau of Reclamation~~, Fish and Wildlife Service, and National Marine Fisheries Service. Sacramento, California.~~

~~Dunne T, Ruggerone G, Goodman D, Rose K, Kimmerer W, Ebersole J. 2011. Scientific assessment of two dam removal alternatives on coho salmon and steelhead. Klamath River Expert Panel final report. Prepared with assistance of Atkins.~~
~~http://klamathrestoration.gov/sites/klamathrestoration.gov/files/FINAL%20Report_Coho%20Salmon-Steelhead_Klamath%20Expert%20Panels_04%2025%2011.pdf~~

~~Dunsmoor LK. 2006. Observations and significance of fish and invertebrate stranding during the first few major peaking cycles in 2006 downstream of the J.C. Boyle Hydroelectric Project. Technical memorandum. Klamath Tribes, Chiloquin, Oregon.~~

~~Dunsmoor LK, Huntington CW. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical memorandum. Klamath Tribes, Chiloquin, Oregon.~~

~~Elder D, Olson B, Olson A, Villeponteaux J, Brucker P. 2002. Salmon River subbasin restoration strategy: steps to recovery and conservation of aquatic resources. Prepared by Klamath National Forest, Yreka California and Salmon River Restoration Council, Sawyers Bar, California for the Klamath Basin Restoration Task Force.~~

~~Elliott JM. 1981. Some aspects of thermal stress on freshwater teleosts. Pages 209-245 in AD Pickering, editor. Stress and fish. Academic Press, London.~~

~~Emmett RL, Stone SL, Hinton SA, Monaco ME. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries. Volume 2: Species life history summaries. Estuarine Living Marine Resources Program Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.~~

~~EPRI (Electric Power Research Institute). 1987. Turbine-related fish mortality: review and evaluation of studies. Final Report EPRI AP-5480, Project 2694-4. EPRI, Palo Alto, California.~~

~~Felleman FL, Heimlich-Boran JR, Osborne RW. 1991. Feeding ecology of the killer whale (*Orcinus orca*). Pages 113-147 *in* Pryor K, Norris KS, editors. Dolphin societies. University of California Press, Berkeley.~~

~~FERC (Federal Energy Regulatory Commission). 1990. Salt Caves Hydroelectric Project (FERC No. 10199-000). Final Environmental Impact Statement. Volume 1. FERC, Washington, DC.~~

~~FERC. 2006. Licensing for the continued operation of PacifiCorp's Klamath Hydroelectric Project, located principally on the Klamath River, in Klamath County, Oregon and Siskiyou County, California, FERC Project No. 2082. Prepared by FERC, Office of Energy Projects, Washington, D. C.~~

~~FERC. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, D.C.~~
~~Fetcho K. 2006. Klamath River blue-green algae bloom report: Water Year 2005. Prepared for Yurok Tribe Environmental Program. http://www.yuroktribe.org/departments/ytep/Water.htm~~

~~Foott JS, Stone R, Wiseman E, True K, Nichols K. 2007. Longevity of *Ceratomyxa shasta* and *Parvicapsula minibicornis actinospore* infectivity in the Klamath River. Journal of Aquatic Animal Health 19: 77–83.~~
~~Ford JKB, Ellis GM, Olesiuk PF, Balcomb KC III. 2009. Linking killer whale survival and prey abundance: food limitations in the oceans' apex predator? Biology Letters. doi:10.1098/rsbl.2009.0468.~~

~~Fry DH, Jr. 1979. Anadromous fishes of California. California Department of Fish and Game, Sacramento.~~
~~Gathard Engineering Consulting. 2006. Klamath River dam and sediment investigation. Technical Report. Seattle, Washington.~~

~~Goodman D, Harvey M, Hughes R, Kimmerer W, Rose K, Ruggerone G. 2011. Scientific assessment of two dam removal alternatives on Chinook salmon. Klamath River Expert Panel Draft Report. Prepared with the assistance of ATKINS, Portland, Oregon.~~

~~Greimann, BP, Varyu D, Godaire J, Russell K, Lai YG. 2010. Hydrology, hydraulics and sediment transport studies for the Secretary's determination on Klamath River dam removal and basin restoration, Klamath River, Oregon and California. Draft Technical Report SRH-2010-XX. USDI Bureau of~~ (Reclamation~~, Mid-Pacific Region.~~

~~Gutermuth B, Watson C, Kelly J. 2000. Link River Hydroelectric Project (Eastside and Westside Powerhouses). Final Entrainment Study Report. Cell Tech, Klamath Falls, Oregon and PacifiCorp Environmental Services, Portland, Oregon.~~

~~Haley L, Ellis M, Cook J. 2007. Reproductive timing of freshwater mussels and potential impact of pulsed flows on reproductive success. PEIR Final Project Report. Contract 500-01-044. California Energy Commission, Sacramento.~~

~~Hamilton H, Box JB, Dorazio RM. 1997. Effects of habitat suitability on the survival of relocated freshwater mussels. Regulated Rivers: Research and Management 13: 537-?~~

~~Hamilton JB, Curtis GL, Snedaker SM, White DK. 2005. Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams - a synthesis of the historical evidence. Fisheries 30: 10-20.~~

~~Hamilton J, Quinones R, Rondorf D, Schultz K, Simondet J, Stresser S.2011. Biological synthesis for the secretarial determination on potential removal of the lower four dams on the Klamath River. Draft report. Prepared by the Biological Subgroup for the Secretarial Determination Regarding Potential Removal of the Lower Four Dams on the Klamath River.~~

~~Hanson MB, Baird RW, Ford JKB, Hempelmann-Halos J, Van Doornik DM, Candy JR, Emmons CK, Schorr GS, Gisborne B, Ayres KL, Wasser SK, Balcomb KC, Balcomb-Bartok K, Sneva JG, Ford MJ. 2010. Species and stock identification of prey consumed by endangered Southern Resident Killer Whales in their summer range. Endangered Species Research 11: 69-82.~~

~~Hardy, TDB, Addley RMC. 2001. Evaluation of interim instream flow needs in the Klamath River. Phase II. Final report. Prepared for U.S. Department of the Interior, Washington, D.C. Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan.~~

~~Hardy T, Addley C, Saraeva E. 2006. Evaluation of instream flow needs in the lower Klamath River. Phase II. Final report. Prepared for U.S. Department of the Interior, Washington, D.C. Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan.~~

~~Hayden TR, and Gale DB. 1999. Juvenile salmonid emigration monitoring from the Hunter Creek Basin, lower Klamath River, California, 1996-1997. Technical report 6. Prepared by Yurok Tribal Fisheries Program, Biological Monitoring Division, Klamath, California.~~

~~Heimlich-Boran JR. 1988. Behavioral ecology of killer whales (*Orcinus orca*) in the Pacific Northwest. Canadian Journal of Zoology 66: 565-578.~~

~~Hendrix N. 2011. Forecasting the response of Klamath Basin Chinook populations to dam removal and restoration of anadromy versus no action. Review Draft Report. R2 Resource Consultants, Redmond, Washington.~~

~~Henley WF, Patterson MA, Neves RJ, Lemly AD. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. Reviews in Fisheries Science 8: 125-139.~~

~~Hetrick NJ, Shaw TA, Zedonis P, Polos JC, and Chamberlain CD. 2009. Compilation of information to inform USFWS principals on the potential effects of the proposed Klamath Basin Restoration Agreement (Draft 11) on fish and fish habitat conditions in the Klamath Basin, with emphasis on fall Chinook salmon. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California. http://www.fws.gov/arcata/newsReleases/KBRAEffects/USFWS%20Arcata%20Klamath%20Compilation%20Cover.pdf~~

~~Hillemeier D, Soto T, Silloway S, Corum A, Kleeman M, Lestelle L. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (*Oncorhynchus kisutch*) May 2007-May 2008. Submitted to U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Area Office, Klamath Falls, Oregon.~~

~~Hiner M. 2006. Seasonal water quality in the Klamath River estuary and surrounding sloughs, 2001-2003. Yurok Tribal Fisheries Program, Klamath, California.~~

~~Hopelain JS. 1998. Age, growth, and life history of Klamath Basin steelhead trout (*Oncorhynchus mykiss irideus*) as determined from scale analysis. Inland Fisheries Administration Report 98-3. California Department of Fish and Game, Sacramento.~~

~~Howard JK, Cuffey KM. 2003. Freshwater mussels in a California North Coast Range river: occurrence, distribution, and controls. Journal of The North American Benthological Society 22: 63-77.~~

~~Huang J, Greimann B. 2010. User's manual for SRH-1D 2.5, Sedimentation and River Hydraulics – One Dimension Version 2.5, USDI Bureau of Reclamation, Technical Service Center, Denver, Colorado.~~

~~Hubbs CL. 1925. A revision of the osmerid fishes of the North Pacific. Proceedings of the Biological Society of Washington 38: 49-56.~~

~~Huntington CW. 2004. Klamath River flows within the JC Boyle Bypass and below the JC Boyle Powerhouse. Clearwater BioStudies, Inc., Canby, Oregon.~~

~~Huntington CW. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc, Canby, Oregon.~~

~~Israel AJ, Cordes JF, Blumberg MA, May B. 2004. Geographic patterns of genetic differentiation among collections of green sturgeon. North American Journal of Fisheries Management 24: 922-931.~~

~~Jacobs SE, Starcevich SJ, Tinniswood W. 2008. Effects of impoundments and hydroelectric facilities on the life history of redband trout in the upper Klamath River: a summary and synthesis of past and recent Studies. Pages 67-75 in Carline RF, and LoSapio C, editors. Sustaining wild trout in a changing world. Proceedings of the Wild Trout IX Symposium, Bozeman, Montana. http://oregonstate.edu/dept/ODFW/NativeFish/pdf_files/KlamathRiverRedbandWildTroutIX.pdf~~

~~Jassby A, and Kann J. 2010. Upper Klamath Lake monitoring program: preliminary analysis of status and trends for 1990-2009. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences for Klamath Tribes Natural Resources Department, Chiloquin, Oregon.~~

~~Jelks HL, Walsh SJ, Burkhead NM, Contreras-Balderas S, Diaz-Pardo E, Hendrickson DA, Lyons J, Mandrak NE, McCormick F, Nelson JS, Platania SP, Porter BA, Renaud CB, Schmitter-Soto JJ, Taylor EB, Warren ML, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33:372–407.~~

~~Johnson OW, Ruckelshaus MH, Grant WS, Waknitz FW, Garrett AM, Bryant GJ, Neely K, Hard JJ. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. NOAA Technical Memorandum NOAA Fisheries Service NWFSC-37. National Marine Fisheries Service, Seattle, Washington.~~

~~Kann J. 2008. Microcystin bioaccumulation in Klamath River fish and freshwater mussel tissue: preliminary 2007 results. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences for Karuk Tribe of California, Orleans, California.~~

~~Kann J. 2010. Compilation of Klamath Tribes upper Klamath Lake water quality data, 1990-2009. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Klamath Tribes Natural Resources Department, Chiloquin, Oregon.~~

~~Kann J, Bowater L, Johnson G, Bowman C. 2011. Preliminary 2010 microcystin bioaccumulation results for Klamath River salmonids (updated 4-7-2011). Technical Memorandum. Prepared by Aquatic Ecosystem Sciences for Karuk Tribe Department of Natural Resources, Orleans, California.~~

~~KFHAT (Klamath Fish Health Assessment Team). 2005. End of Year Report, 2004. Available at: http://nener-isb.dfg.ca.gov/KFP/DesktopDefault.aspx~~

~~Klimley AP, Allen PJ, Israel JA, Kelly JT. 2007. The green sturgeon and its environment: introduction. Environmental Biology of Fishes 79: 187-190.~~
~~Knight RL, Margraf FJ, Carline RF. 1984. Piscivory by walleyes and yellow perch in western Lake Erie. Transactions of the American Fisheries Society 113: 677-693.~~

~~Knudsen D, Mills T. 1980. Copco Lake, Siskiyou County, fish sampling, spring 1980. File report, California Department of Fish and Game, Endangered Species Project, Sacramento.~~

~~Kondolf GM, Wolman MG. 1993. The sizes of salmonid spawning gravels. Water Resources Research 29: 2275-2285.~~

~~KRBFTF (Klamath River Basin Fisheries Task Force). 1991. Long range plan for the Klamath Basin Conservation Area Fishery Restoration Program. Prepared with assistance from William M. Kier Associates, Sausalito. Yreka, California.~~

~~Krahn MM, Ford MJ, Perrin WF, Wade PR, Angliss RP, Hanson MB, Taylor BL, Ylitalo GM, Dahlheim ME, Stein JE, Waples RS. 2004. 2004 Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-62, Northwest Fisheries Science Center, Seattle, Washington. http://www.nwfsc.noaa.gov/assets/25/5932_02102005_172234_krahnstatusrevtm62final.pdf~~

~~KRSIC (Klamath River Stock Identification Committee). 1993. Salmon and steelhead populations of the Klamath-Trinity Basin. Prepared for Klamath River Task Force.~~
~~Larson ZS, Belchik MR. 1998. A preliminary status review of eulachon and Pacific lamprey in the Klamath Basin. Yurok Tribal Fisheries Program, Klamath, California.~~
~~Leidy R.A., Leidy GR. 1984. Life stage periodicities of anadromous salmonids in the Klamath River basin, northwestern California. Sacramento, California, USDI Fish and Wildlife Service: 1-30.~~

~~Lemly AD. 1982. Modification of benthic insect communities in polluted streams: combined effects of sedimentation and nutrient enrichment. Hydrobiologia 87: 229-245.~~
~~Lindley ST, Davis H. 2011. Using model selection and model averaging to predict the response of Chinook salmon to dam removal. Review Draft Report. National Marine Fisheries Service, Fisheries Ecology Division, NMFS Southwest Fisheries Science Center, Santa Cruz, California.~~

~~Logan DJ, Markle DF. 1993. Fish faunal survey of Agency Lake and northern Upper Klamath Lake, Oregon. 1992 Annual Report. Department of Fisheries and Wildlife, Oregon State University, Corvallis.~~

~~Lorion C.M., Markle D.F., Reid S.B., Docker M.F. 2000. Redescription of the~~

~~presumed-extinct Miller Lake lamprey, *Lampetra minima*. Copeia 2000:1019-1028.~~

~~Luzier C.W., Brostrom J., Cook-Tabor C., Goodman D., Nelle R.D., Ostrand K.G., Schaller H., Streif B.. 2009. Proceedings of the Pacific lamprey conservation initiative work session. US Fish and Wildlife Service, Regional Office, Portland, Oregon.~~

~~Luzier C., Miller S. 2009. Freshwater mussel relocation guidelines. Pacific Northwest Native Freshwater Mussel Workgroup. http://www.xerces.org/wp-content/uploads/2009/10/mussel-relocation-position-statement.pdf~~

~~Magneson M.D., Gough S. 2006. Mainstem Klamath River coho salmon redd surveys 2001 to 2005. Arcata Fisheries Data Series Report DS 2006-7. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.~~

~~Maule A.G., VanderKooi S.P., Hamilton J.B., Stocking R., Bartholomew J. 2009. Physiological development and vulnerability to *Ceratomyxa shasta* of fall-run Chinook salmon in the Upper Klamath River watershed. North American Journal of Fisheries Management 29: 1743-1756.~~

~~McAllister D.E. 1963. A revision of the smelt family, Osmeridae. Bulletin of the National Museum of Canada 191: 1-53.~~

~~McLean J.E., Bentzen P., Quinn T.P. 2003. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout (*Oncorhynchus mykiss*) through the adult stage. Canadian Journal of Fisheries and Aquatic Sciences 60: 433–440.~~

~~McClelland WT, Brusven MA. 1980. Effects of sedimentation on the behavior and distribution of riffle insects in a laboratory stream. Aquatic Insects 2: 161-169.~~

~~McCullough D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon, Prepared for U. S. Environmental Protection Agency Region 10, Seattle, Washington. www.critfc.org/tech/EPAreport.htm~~

~~McGinnis S.M. 1984. Freshwater fishes of California. California Natural History Guides: 49. University of California Press, Berkeley.~~

~~Meeuwig M.H., Bayer J.M., Seelye J.G. 2005. Effects of temperature on survival and development of early life stage Pacific and western brook lamprey. Transactions of the American Fisheries Society 134:19-27.~~

~~Mertes L.A.K., Warrick J.A. 2001. Measuring flood output from 110 coastal watersheds in California with field measurements and SeaWiFS. Geology 29: 659-662.~~
~~Messmer R., Smith R.. 2007. Adaptive management for Klamath Lake redband trout. *In* Schroeder RK and JD Hall, editors. Redband trout: resilience and challenge in a changing landscape. Oregon Chapter of the American Fisheries Society, Corvallis.~~
~~Miller R.R., Smith G.R.. 1981. Distribution and evolution of Chasmistes (Pisces: Catostomidae) in western North America. Occasional Papers of the Museum of Zoology, University of Michigan, Ann Arbor 696:1-46.~~

~~Montgomery D.R., Buffington J.M. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109:596–611.~~
~~Moser M.L, Lindley ST. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79: 243-253.~~

~~Moyle P.B. 1976. Inland fishes of California. University of California Press, Berkeley and Los Angeles.~~

~~Moyle P.B.~~). 2002. ~~Inland fishes of California. Second edition. University of California Press, Berkeley.~~

~~Moyle P.B., Brown L.R., Chase S.D., Quiñones R.M. 2009. Status and conservation of lamprey in California. Pages 279-292 in LR Brown, SD Chase, MG Mesa, RJ Beamish, and PB Moyle, editors. Biology, management, and conservation of lamprey in North America. American Fisheries Society Symposium 72, Bethesda, Maryland.~~

~~Moyle P.B., Isreal J.A., Purdy S.E. 2008. Salmon, steelhead, and trout in California: status of an emblematic fauna. Prepared for California Trout by University of California Davis, Center for Watershed Sciences.~~

~~Moyle P.B., Yoshiyama R.M., Williams J.E., Wikramanayake E.D. 1995. Fish species of special concern in California. Prepared by Department of Wildlife and Fisheries Biology, University of California, Davis for California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova.~~

~~Myers, J.M., Kope R.G., Bryant, Teel D., Lierheimer L.J., Wainwright T.C., Grant W.S., Waknitz F.W., Neely K., Lindley S.T., and Waples R.S. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. NMFS-NWFSC-35. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.~~

~~Nawa R. 2003. A petition for rules to list: Pacific lamprey (*Lampetra tridentata*); river lamprey (*Lampetra ayresi*); western brook lamprey (*Lampetra richardsoni*); and Kern brook lamprey (*Lampetra hubbsi*) as threatened or endangered under the Endangered Species Act. Letter to U.S. Fish and Wildlife Service, Washington, D.C.~~

~~NCRWQCB (North Coast Regional Water Quality Control Board). 2010. Action plan for the Klamath River Total Maximum Daily Loads addressing temperature, dissolved oxygen, nutrient, and Microcystin impairments in the Klamath River, California, and Site-specific objectives for dissolved oxygen in the Klamath River in California, and implementation plans for the Klamath and Lost River basins. NCRWQCB, Santa Rosa, California.~~
~~http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/~~

~~Nedeau E, Smith A.K., Stone J. 2005. Freshwater mussels of the Pacific Northwest. U.S. Fish and Wildlife Service, Vancouver, Washington.~~

~~Nedeau E.J., Smith A.K., Stone J., Jepsen S. 2009. Freshwater mussels of the Pacific Northwest. Second edition. The Xerces Society for Invertebrate Conservation.~~

~~Newcombe C.P., Jensen J.O.T. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16: 693-727.~~

~~NOAA (National Oceanic and Atmospheric Administration). 2008. Unfavorable ocean conditions likely cause of low 2007 salmon returns along west coast. News from NOAA. March 3. http://www.noaanews.noaa.gov/stories2008/20080303_salmon.html~~

~~NOAA Fisheries Service. 1997a. Endangered and threatened species: threatened status for southern Oregon/northern California coast evolutionarily significant unit (ESU) of coho salmon. Federal Register 62: 24588-24609.~~

~~NOAA Fisheries Service. 1997b. Designated critical habitat; Central California Coast and Southern Oregon/Northern California Coast Coho Salmon. Federal Register 62: 62741-62751.~~

~~NOAA Fisheries Service. 1999a. Status review update for deferred ESUs of west coast Chinook salmon (*Oncorhynchus tshawytscha*) from Washington, Oregon, California, and Idaho. Report of West Coast Biological Review Team to NOAA Fisheries Service, Seattle, Washington. http://www.nwr.noaa.gov/Publications/Biological-Status-Reviews/loader.cfm?csModule=security/getfile&pageid=21676~~

~~NOAA Fisheries Service. 1999b. Designated critical habitat; Central California Coast and Southern Oregon/Northern California Coast coho salmon. Federal Register 64: 24049-24062.~~

~~NOAA Fisheries Service. 2001. Endangered and threatened species: final listing determination for Klamath Mountains Province steelhead. Federal Register 66:17845-17856.~~

~~NOAA Fisheries Service. 2002. Biological opinion: Klamath Project Operations. NOAA Fisheries Service, Southwest Region. Long Beach, California.~~

~~NOAA Fisheries Service. 2004. Endangered or threatened wildlife and plants; 90-day finding on a petition to list three species of lamprey as threatened or endangered. Federal Register 69: 77158-77167.~~

~~NOAA Fisheries Service. 2005. Endangered and threatened wildlife and plants: endangered status for Southern Resident Killer Whales. Federal Register 70: 69903-69912.~~

~~NOAA Fisheries Service. 2006a. Endangered and threatened wildlife and plants: threatened status for Southern Distinct Population Segment of North American green sturgeon: final rule. Federal Register 71: 17757-17766.~~

~~NOAA Fisheries Service. 2006b. Endangered and threatened species; designation of critical habitat for Southern Resident Killer Whale. Federal Register 71: 69054-69070.~~

~~NOAA Fisheries Service. 2007. Magnuson-Stevens Reauthorization Act Klamath River coho salmon recovery. Prepared by FR Rogers, Lagomarsino IV, and Simondet JA for NOAA Fisheries Service, Southwest Region, Long Beach, California.~~

~~NOAA Fisheries Service. 2009a. Endangered and threatened wildlife and plants; proposed threatened status for Southern Distinct Population Segment of eulachon. Federal Register 75 13012-13024.~~

~~NOAA Fisheries Service. 2009b. Endangered and threatened wildlife and plants; final rulemaking to designate critical habitat for the threatened Southern Distinct Population Segment of North American green sturgeon. Federal Register 74: 52300-52351.~~

~~NOAA Fisheries Service. 2010a. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for U.S. Bureau of Reclamation by NOAA Fisheries Service, Southwest Region. http://www.Reclamation.gov/mp/kbao/operations/FINAL%20-Klamath%20Ops_3-15-10.pdf~~

~~NOAA Fisheries Service. 2010b. Endangered and threatened wildlife and plants; threatened status for Southern Distinct Population Segment of eulachon. Federal Register 75 13012-13024.~~

~~NOAA Fisheries Service. 2011. Endangered and threatened species, designation of critical habitat for Southern Distinct Population Segment of eulachon. Federal Register 76: 515-536.~~

~~NRC (National Research Council). 2004. Endangered and threatened fishes in the Klamath Basin: causes of decline and strategies for recovery. The National Academies Press, Washington, D.C. http://www.nap.edu/openbook.php?isbn=0309090970~~

~~NRC. 2008. Hydrology, ecology, and fishes of the Klamath Basin. The National Academies Press, Washington, D.C. http://www.nap.edu/catalog.php?record_id=12072#orgs~~

~~ODEQ (Oregon Department of Environmental Quality). 2002. Upper Klamath Lake drainage Total Maximum Daily Load and Water Quality Management Plan. ODEQ, Portland.~~

~~ODEQ. 2010. Upper Klamath and Lost River Subbasins Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WPMP). DEQ 10-WQ-030. ODEQ, Portland, Oregon. http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/uklost/KlamathLostTMDLWQMP.pdf~~

~~ODFW (Oregon Department of Fish and Wildlife). 2003. Klamath River redband trout investigations. ODFW, Klamath Falls, Oregon.~~

~~Olson, A. 1996. Freshwater rearing strategies of spring Chinook salmon (*Oncorhynchus tshawytscha*) in Salmon River tributaries, Klamath Basin, California. Master's thesis. Humboldt State University, Arcata, California.~~

~~Olson J.M. 1998. Temporal and spatial distribution patterns of sightings of southern community and transient orcas in the inland waters of Washington and British Columbia. Master's thesis, Western Washington University, Bellingham, Washington.~~

~~Oosterhout G.R.. 2005. KlamRAS results of fish passage simulations on the Klamath River. Final report. Eagle Point, Oregon.~~

~~Osborne R.W.. 1999. A historical ecology of Salish Sea "resident" killer whales (*Orcinus orca*): with implications for management. Doctoral dissertation. University of Victoria, Victoria, British Columbia.~~

~~PacifiCorp. 2004a. Final License Application: Volume 2, Exhibit E: Environmental Report. Klamath Hydroelectric Project, FERC No. 2082. Portland, Oregon.~~
~~PacifiCorp. 2004b. Final Technical Report: Water Resources. Klamath Hydroelectric Project, FERC No. 2082, Final License Application. PacifiCorp, Portland, Oregon.~~
~~PacifiCorp. 2004c. Analysis of potential Klamath Hydroelectric Project effects on water quality aesthetics for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Prepared by PacifiCorp, Portland, Oregon.~~

~~PacifiCorp. 2006. PacifiCorp positions on important topics. Klamath Hydroelectric Project, FERC No. 2082. Portland, Oregon.~~
~~Papa R., Israel J.A., Nonnis Marzano F., May B. 2007. Assessment of genetic variation between reproductive ecotypes of Klamath River steelhead reveals differentiation associated with different run-timings. Journal of Applied Ichthyology 23: 142-146.~~

~~Perkins D.J., Kann J., Scoppettone G. 2000. The role of poor water quality and fish kills in the decline of endangered Lost River and shortnose suckers in the Upper Klamath Lake. Final Report. Prepared by US Geological Survey, Biological Resources Division for US Bureau of Reclamation, Klamath Falls Project Office, Klamath Falls, Oregon.~~

~~Perry R., Shaw T., Hardy T., Williamson S. 2011. SALMOD II. Chapter 3 in Hendrix N, et al. 2011. Fall Chinook salmon life cycle production model: report to expert panel. Prepared for Expert Panel reviewing Chinook salmon of the Klamath River basin.~~

~~Petersen Lewis R.S. 2009. Yurok and Karuk traditional ecological knowledge: insights into Pacific lamprey populations of the lower Klamath Basin. American Fisheries Society Symposium 72: 1-39.~~

~~Reclamation. 2002.~~ Final biological assessment: the effects of proposed actions related to Klamath Project Operation (April 1, 2002~~–~~–March 31, 2012) on federally listed and endangered species. ~~US~~ Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office, Oregon.

~~Reclamation.~~ _____. 2010. Biological opinion: operation of the Klamath Project between 2010 and 2018. Prepared by National Marine Fisheries Service, Southwest Region for ~~US~~ Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office, Oregon.

~~Reclamation.~~ _____. 2011. Sedimentation and River Hydraulics – One Dimension (SRH-1D) model. Reclamation Sedimentation and River Hydraulics Group, Technical Service Center, Denver, Colorado. Available at: http://www.Reclamation.gov/pmts/sediment/model/srh1d/index.html.

_____. 2012. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration,

Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO. Report dated April 2011, updated January 2012. Available at: http://klamathrestoration.gov/keep-me-informed/secretarial-determination/role-of-science/secretarial-determination-studies.

Busby, P.J., Wainwright, T.C., Waples, .RS. 1994. Status review for Klamath Mountains Province steelhead. NOAA Technical Memorandum NWFSC-19. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Butler, V.L., Stevenson, A.E., Miller, J.A., Yang, D.Y., Speller, C.F., Misarti, N. 2010. The use of archaeological fish remains to establish predevelopment salmonid biogeography in the Upper Klamath Basin. Final Report. Department of Anthropology, Portland State University, Portland, Oregon.

California Bay-Delta Authority (CALFED). 2007. Green sturgeon (*Acipenser medirostris*). *In* Delta regional ecosystem restoration implementation plan. Draft report. CALFED Ecosystem Restoration Program, Sacramento, California. Available at: http://www.delta.dfg.ca.gov/erpdeltaplan/docs/cm_Risk%20Model_Green%20Sturgeon_Edited_10_31_06.pdf.

California Department of Fish and Game (CDFG). 1990a. Juvenile salmonid sampling within the Klamath-Trinity Basin, 1984. Draft report. CDFG, Inland Fisheries Division, Arcata, California. CDFG. 1990b. Distribution, abundance, fork length and coded-wire tag recovery data for juvenile anadromous salmonids within the Klamath-Trinity Basin, 1985. Draft report. CDFG, Inland Fisheries Division, Arcata, California.

CDFG. 1990c. Status and management of spring-run chinook salmon. CDFG, Inland Fisheries Division, Arcata, California.

_____. 2000. Documentation of the Klamath River fish kill, June 2000. Memorandum. Redding, California. 27pp.

_____. 2002a. Status review of California coho salmon north of San Francisco. Candidate Species Status Review Report 2002-3. Report to the California Fish and Game Commission.

_____. 2002b. California Department of Fish and Game comments to NOAA Fisheries Service regarding green sturgeon listing.

_____. September 2002 Klamath River fish-kill: final analysis of contributing factors and impacts. Northern California-North Coast Region. Redding, California.

_____. Unpublished data. Spring-run Chinook salmon escapement for the Salmon River, 1992–2001. Available at: http://www.krisweb.com/krisklamathtrinity/krisdb/webbuilder/sa_c8.htm.

Cech, J.J., Jr., Doroshov, S.I., Moberg, G.P., May, B.P., Schaffter, R.G., Kohlhorst, D.M. 2000. Biological assessment of green sturgeon in the Sacramento-San Joaquin watershed (Phase 1). Final Report to the CALFED Bay-Delta Program. Project 98-C-15, Contract B-81738.

Center for Biological Diversity (CBD), Oregon Wild, Environmental Protection Information Center (EPIC), and The Larch Company. 2011. Petition to list Upper Klamath Chinook salmon (*Oncorhynchus tshawytscha*) as a threatened or endangered species.

CH2M Hill. 1985. Klamath Basin fisheries resource plan. Prepared for U.S. Department of the Interior, Bureau of Indian Affairs by CH2M Hill, Redding, California.

_____. 2009a. Analysis of microcystin in resident fish and mussel tissues in the vicinity of the Klamath Hydroelectric Project in 2008. Prepared for PacifiCorp Energy, Portland, Oregon by CH2M Hill, Redding, California.

_____. 2009b. Occurrence of microcystin in Chinook salmon and steelhead in the Klamath River in 2007. Prepared for PacifiCorp Energy, Portland, Oregon by CH2M Hill, Redding, California.

Chesney, W.R., Yokel, E.M. 2003. Shasta and Scott River juvenile salmonid outmigrant study, 2001-2002. Project 2a1. Steelhead Research and Monitoring Program annual report. California Department of Fish and Game, North Coast Region, Redding.

Chesney, W.R., Crombie, W.B., Langendorf, H.D. 2009. Shasta and Scott River juvenile salmonid outmigration monitoring project. Final report. California Department of Fish and Game, Anadromous Fish Research and Monitoring Project, Yreka.

City of Klamath Falls. 1986. Application for license – Salt Caves Hydroelectric Project. Initial Stage consultation, Volume II. Klamath Falls, Oregon.

Close, D.A., Fitzpatrick, M.S., Li, H.W. 2002. The ecological and cultural importance of a species at risk of extinction, Pacific lamprey. Fisheries 27: 19-25.

Close, D.A., Docker, M., Dunne, T., Ruggerone, G. 2010. Scientific assessment of two dam removal alternatives on lamprey. Final report. Klamath River Expert Panel.

Coleman, M.E., McGie, A.M. 1988 . Annual Progress Report 1987, Fish Research Project, No. E-2, Oregon. Oregon Department of Fish and Wildlife, Portland.

Cooperman, M.S., Markle, D.F. 2004. Abundance, size, and feeding success of larval shortnose suckers and Lost River suckers from different habitats of the littoral zone of Upper Klamath Lake. Environmental Biology of Fishes 71: 365-377

Coots, M. 1962. Shasta River, Siskiyou County, 1958 king salmon count, with yearly totals from 1930-1961. California Department of Fish and Game, Inland Fisheries Branch, Sacramento, California.

Cope ,W.G., Waller, D.L. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. Regulated Rivers: Research and Management 11: 147-155.

Cope, W.G., Hove, M.C., Waller, D.L., Hornbach, D.J., Bartsch, M.R., Cunningham, L.A., Dunn, H.L., Kapuscinski, A.R. 2003. Evaluation of relocation of unionid mussels to *in situ* refugia. Journal of Molluscan Studies 69: 27-34.

Cunanan, M. 2009. Historic anadromous fish habitat estimates for Klamath River mainstem and tributaries under Klamath Hydropower reservoirs. U.S. Fish and Wildlife Service, Arcata, California.

Daniels, R.A., Moyle, P.B. 1984. Geographic variation and a taxonomic reappraisal of the marbled sculpin, *Cottus klamathensis*. Copeia 4: 949-959.

Dean, M. 1994. Life history, distribution, run size, and harvest of spring Chinook salmon in the south fork Trinity River Basin. Chapter VII - Job VII in Trinity River Basin monitoring project 1991-1992.

_____. 1995. Life history, distribution, run size, and harvest of spring Chinook salmon in the south fork Trinity River Basin. Chapter VII - Job VII in Trinity River Basin monitoring project 1992-1993.

De Robertis, A., Morgan, C.A., Schabetsberger, R.A., Zabel, R.W., Brodeur, R.D., Emmett, R.L., Knight, C.M., Krutzikowsky, G.K., Casillas, E. 2005 Columbia River plume fronts. II. Distribution, abundance, and feeding ecology of juvenile salmon. Marine Ecology Progress Series 299: 33-44.

Department of the Interior (DOI). 2007. Modified terms and conditions, and prescriptions for fishways filed pursuant to sections 4(e) and 18 of the Federal Power Act with the Federal Energy Regulatory Commission for the Klamath River Hydroelectric Project No. 2082. Bureau of Land Management, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. Sacramento, California.

Dunne, T., Ruggerone, G., Goodman, D., Rose, K., Kimmerer, W., Ebersole, J. 2011. Scientific assessment of two dam removal alternatives on coho salmon and steelhead. Klamath River Expert Panel final report. Prepared with assistance of Atkins. Available at: http://klamathrestoration.gov/sites/klamathrestoration.gov/files/FINAL%20Report_Coho%20Salmon-Steelhead_Klamath%20Expert%20Panels_04%2025%2011.pdf.

Dunsmoor, L.K. 2006. Observations and significance of fish and invertebrate stranding during the first few major peaking cycles in 2006 downstream from the J.C. Boyle Hydroelectric Project. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Dunsmoor LK, Huntington, C.W. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Elder, D., Olson, B., Olson, A., Villeponteaux, J., Brucker, P. 2002. Salmon River subbasin restoration strategy: steps to recovery and conservation of aquatic resources. Prepared by Klamath National Forest, Yreka California and Salmon River Restoration Council, Sawyers Bar, California for the Klamath Basin Restoration Task Force.

Electric Power Research Institute (EPRI). 1987. Turbine-related fish mortality: review and evaluation of studies. Final Report EPRI AP-5480, Project 2694-4. Palo Alto, California.

Emmett, R.L., Stone, S.L., Hinton, S.A., Monaco, M.E. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volume 2: Species life history summaries. Estuarine Living Marine Resources Program Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.

Everest, F.H., Beschta, R.L., Scrivener, J.C., Koski, K.V., Sedell, J.R., Cederholm, C.J. 1987. Fine sediment and salmonid production: a paradox. Pages 98-142 in EO Salo and T.W. Cundy, editors. Streamside management. forestry and fishery interactions. Contribution No. 57. University of Washington, Institute of Forest Resources, Seattle.

Farnsworth, K.L., Warrick, J.A. 2007. Sources, dispersal, and fate of fine sediment supplied to coastal California. U.S. Geological Survey Scientific Investigations Report 2007-5254.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Felleman, F.L., Heimlich-Boran, J.R., Osborne, R.W. 1991. Feeding ecology of the killer whale (*Orcinus orca*). Pages 113-147 *in* Pryor K, Norris KS, editors. Dolphin societies. University of California Press, Berkeley.

Fetcho, K. 2006. Klamath River blue-green algae bloom report: Water Year 2005. Prepared for Yurok Tribe Environmental Program. Available at: www.klamathwaterquality.com/documents/Yurok_Fetcho_2006.pdf.

_____. 2011. Final 2009 Klamath River blue-green algae summary report. Yurok Tribe Environmental Program, Klamath, California.

Foott, J.S., Stone, R., Wiseman, E., True, K., Nichols, K. 2007. Longevity of *Ceratomyxa shasta* and *Parvicapsula minibicornis* actinospore infectivity in the Klamath River. Journal of Aquatic Animal Health 19: 77–83.

Foott, J.S., Fogerty, R., Stone, R., Bjork, S., Bigelow, J. 2012. Effects of a simulated Klamath River summer temperature profile on juvenile Chinook salmon (*Oncorhynchus tshawytscha*) immune function. FY 2010 Technical Report. U.S. Fish and Wildlife Service, California Nevada Fish Health Center, Anderson, California.

Ford, J.K.B., Ellis, G.M., Olesiuk, P.F., Balcomb, K.C., III. 2009. Linking killer whale survival and prey abundance: food limitations in the oceans' apex predator? Biology Letters. doi:10.1098/rsbl.2009.0468.

Fortune, J.D., Gerlach, A.R., Hanel, C.J. 1966. A study to determine the feasibility of establishing salmon and steelhead in the Upper Klamath Basin. Pacific Power and Light.

Fry, D.H., Jr. 1979. Anadromous fishes of California. California Department of Fish and Game, Sacramento. Available at: http://cdm15024.contentdm.oclc.org/cdm4/item_viewer.php?CISOROOT=/p178601ccp2&CISOPTR=103.

Gannett, M., Lite, K.E., Jr, La Marche, J.L., Fisher, B.J., Polette, D.J. 2007. Ground-water hydrology of the Upper Klamath Basin, Oregon and California. Scientific Investigations Report 2007-5050. U.S. Geological Survey in cooperation with Oregon Water Resources Department.

Gathard Engineering Consulting. 2006. Klamath River dam and sediment investigation. Technical Report. Seattle, Washington.

Geyer, W.R., Hill, P., Milligan, T., and Traykovski, P. 2000. The structure of the Eel River plume during floods. Continental Shelf Research 20: 2067–2093.

Goodman, D., Harvey, M., Hughes, R., Kimmerer, W., Rose, K., Ruggerone, G. 2011. Klamath River Expert Panel, Addendum to Final Report, Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon. Addendum to Final Report. Prepared with the assistance of Atkins, Portland, Oregon.

Grimes, C.B., Finucane, J.H. 1991. Spatial distribution and abundance of larval and juvenile fish, chlorophyll and macrozooplankton around the Mississippi River discharge plume, and the role of the plume in fish recruitment. Marine Ecology Progress Series 75: 109-119.

Gustafson, R.G., Ford, M.J., Teel, D., Drake, J.S. 2010. Status review of eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-105. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle and Port Orchard, Washington.

Gutermuth, B., Watson, C., Kelly, J. 2000. Link River Hydroelectric Project (Eastside and Westside Powerhouses). Final Entrainment Study Report. CellTech, Klamath Falls, Oregon and PacifiCorp Environmental Services, Portland, Oregon.

Haley, L., Ellis, M., Cook, J. 2007. Reproductive timing of freshwater mussels and potential impact of pulsed flows on reproductive success. PEIR Final Project Report. Contract 500-01-044. California Energy Commission, Sacramento.

Hamilton, H., Box, J.B., Dorazio, R.M. 1997. Effects of habitat suitability on the survival of relocated freshwater mussels. Regulated Rivers: Research and Management 13: 537-541.

Hamilton, J.B. 2010. August 27, 2010 Williamson River water temperature survey. Memorandum. U.S. Fish and Wildlife Service, Yreka Fish and Wildlife Office, Yreka, California.

Hamilton, J.B., Rondorf, D., Hampton, M., Quinones, R., Simondet, J., Smith, T.. 2011. Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath. Prepared by the Biological Subgroup for the Secretarial Determination Regarding Potential Removal of the Lower Four Dams on the Klamath River. Accessed on December 21, 2011. Available at: http://klamathrestoration.gov/keep-me-informed/secretarial-determination/role-of-science/secretarial-determination-studies.

Hanson, M.B., Baird, R.W., Ford, J.K.B., Hempelmann-Halos, J., Van Doornik, D.M., Candy, J.R., Emmons, C.K., Schorr, G.S., Gisborne, B., Ayres, K.L., Wasser, S.K., Balcomb, K.C., Balcomb-Bartok, K., Sneva, J.G., Ford, M.J. 2010. Species and stock identification of prey consumed by endangered Southern Resident Killer Whales in their summer range. Endangered Species Research 11: 69-82.

Hardy, T., Addley, C. 2001. Evaluation of interim instream flow needs in the Klamath River. Phase II. Final Report. Prepared for U.S. Department of the Interior, Washington, DC by Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan.

Hardy, T., Addley, C., Saraeva, E. 2006. Evaluation of instream flow needs in the lower Klamath River. Phase II. Final Report. Prepared for U.S. Department of the Interior, Washington, DC by Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan.

Heimlich-Boran, J.R. 1988. Behavioral ecology of killer whales (*Orcinus orca*) in the Pacific Northwest. Canadian Journal of Zoology 66: 565-578.

Hendrix, N. 2011. Forecasting the response of Klamath Basin Chinook populations to dam removal and restoration of anadromy versus no action. Review Draft Report. R2 Resource Consultants, Redmond, Washington.

Henley, W.F., Patterson, M.A., Neves, R.J., Lemly, A.D. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. Reviews in Fisheries Science 8: 125-139.

Hetrick, N.J., Shaw, T.A., Zedonis, P., Polos, J.C., Chamberlain, C.D. 2009. Compilation of information to inform USFWS principals on the potential effects of the proposed Klamath Basin Restoration Agreement (Draft 11) on fish and fish habitat conditions in the Klamath Basin, with emphasis on fall Chinook salmon. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California. Available at: http://www.fws.gov/arcata/newsReleases/KBRAEffects/USFWS%20Arcata%20Klamath%20Compilation%20Cover.pdf.

Hillemeier, D., Soto, T., Silloway, S., Corum, A., Kleeman, M., Lestelle, L. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (*Oncorhynchus kisutch*) May 2007-May 2008. Submitted to Bureau of Reclamation, Mid-Pacific Region, Klamath Area Office, Klamath Falls, Oregon.

Hiner, M. 2006. Seasonal water quality in the Klamath River estuary and surrounding sloughs, 2001–2003. Yurok Tribal Fisheries Program, Klamath, California.

Hoar, W.S. 1988. The physiology of smolting salmonids. Pages 275-343 *in* WS Hoar and DJ Randall, editors. Fish physiology: Vol. XI, The physiology of developing fish, Part B, Viviparity and posthatching juveniles. Academic Press, San Diego.

Hooton, B., Smith, R. 2008. A plan for the reintroduction of anadromous fish in the Upper Klamath Basin. Public Review Draft. Oregon Department of Fish and Wildlife, Klamath Watershed District.

Hopelain, J.S. 1998. Age, growth, and life history of Klamath Basin steelhead trout (Oncorhynchus mykiss irideus) as determined from scale analysis. Inland Fisheries Administration Report 98-3. California Department of Fish and Game, Sacramento.

Howard, J.K., Cuffey K,M. 2003. Freshwater mussels in a California North Coast Range river: occurrence, distribution, and controls. Journal of The North American Benthological Society 22: 63-77.

Huang, J., Greimann, B. 2010. User's manual for SRH-1D 2.5, Sedimentation and River Hydraulics – One Dimension Version 2.5. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

_____. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Canby, Oregon.

Israel, A.J., Cordes, J.F., Blumberg, M.A., May, B. 2004. Geographic patterns of genetic differentiation among collections of green sturgeon. North American Journal of Fisheries Management 24: 922-931.

Jacobs, .S.E., Starcevich, S.J., Tinniswood, W. 2008. Effects of impoundments and hydroelectric facilities on the life history of redband trout in the upper Klamath River: a summary and synthesis of past and recent Studies. Pages 67-75 *in* Carline RF, and LoSapio C, editors. Sustaining wild trout in a changing world. Proceedings of the Wild Trout IX Symposium, Bozeman, Montana. Available at: http://oregonstate.edu/dept/ODFW/NativeFish/pdf_files/KlamathRiverRedbandWildTroutIX.pdf.

Jassby, A, Kann, J. 2010. Upper Klamath Lake monitoring program: preliminary analysis of status and trends for 1990-2009. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences for Klamath Tribes Natural Resources Department, Chiloquin, Oregon.

Jelks, H.L., Walsh, .SJ., Burkhead, N.M., Contreras-Balderas, S., Diaz-Pardo, E., Hendrickson, D.A., Lyons, J., Mandrak, N.E., McCormick, F., Nelson, J.S., Platania, S.P., Porter, B.A., Renaud, C.B., Schmitter-Soto, J.J., Taylor, E.B., Warren, M.L., Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33: 372–407.

Jepsen, S., LaBar, C., Zarnoch, J. 2010. *Gonidea angulata* (Lea, 1838) Western ridged mussel. The Xerces Society for Invertebrate Conservation, Portland, Oregon.

Johnson, O.W., Ruckelshaus, M.H., Grant, W.S., Waknitz, F.W., Garrett, A.M., Bryant, G.J., Neely, K., Hard, J.J. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. NOAA Technical Memorandum NOAA Fisheries Service-NWFSC-37. National Marine Fisheries Service, Seattle, Washington.

Kann, J. 2008. Microcystin bioaccumulation in Klamath River fish and freshwater mussel tissue: preliminary 2007 results. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, Ashland, Oregon for Karuk Tribe of California, Orleans, California.

Kann, J. 2010. Compilation of Klamath Tribes Upper Klamath Lake water quality data, 1990–2009. Prepared by Aquatic Ecosystem Sciences, Ashland, Oregon for the Klamath Tribes Natural Resources Department, Chiloquin, Oregon.

Kann, J., Bowater, L., Corum, S. 2010a. Middle Klamath River toxic cyanobacteria trends, 2009. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, Ashland, Oregon, and Karuk Tribe Department of Natural Resources, Orleans, California.

Kann, J., Corum, S., Fetcho, K. 2010b. Mycrocystin bioaccumulation in the Klamath River, freshwater mussel tissue: 2009 results. Technical Memorandum. Aquatic Ecosystem Sciences, Ashland, Oregon; Karuk Tribe Natural Resources Department, Orleans, California; and Yurok Tribe Environmental Program, Klamath, California.

Kann, J., Bowater, L., Johnson, G., Corum, S. 2011. Preliminary 2010 microcystin bioaccumulation results for Klamath River salmonids (updated 4-7-2011). Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, Ashland, Oregon and Karuk Tribe Department of Natural Resources, Orleans, California.

Kiffney, P.M., Pess, G.R., Anderson, J.H., Faulds, P., Burton, K., Riley, S.C. 2009. Changes in fish communities following recolonization of the Cedar River, Washington, USA by Pacific salmon after 103 years of local extirpation. River Research and Applications 25: 438-452.

Kinziger, A.P., Hellmair, M., Hankin, D.G. 2008. Genetic structure of Chinook salmon (*Oncorhynchus tshawytscha*) in the Klamath-Trinity Basin: implications for within-basin genetic stock identification. Hoopa Valley Tribal Fisheries Department and Humboldt State University, Department of Fisheries Biology, Arcata, California.

Klamath River Basin Fisheries Task Force (KRBFTF). 1991. Long range plan for the Klamath Basin Conservation Area Fishery Restoration Program. Prepared with assistance from William, M. Kier Associates, Sausalito. Yreka, California.

Klimley, A.P., Allen, P.J., Israel, J.A., Kelly, J.T. 2007. The green sturgeon and its environment: introduction. Environmental Biology of Fishes 79: 187-190.

Knight, R.L., Margraf, F.J., Carline, R.F. 1984. Piscivory by walleyes and yellow perch in western Lake Erie. Transactions of the American Fisheries Society 113: 677-693.

Kondolf, G.M., Wolman, M.G. 1993. The sizes of salmonid spawning gravels. Water Resources Research 29: 2275-2285.

Krahn, M.M., Ford, M.J., Perrin, W.F., Wade, P.R., Angliss, R.P., Hanson, M.B., Taylor, B.L., Ylitalo, .GM., Dahlheim, M.E., Stein, J.E., Waples, R.S. 2004. 2004 Status review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-62, Northwest Fisheries Science Center, Seattle, Washington. Available at: http://www.nwfsc.noaa.gov/assets/25/5932_02102005_172234_krahnstatusrevtm62final.pdf.

Larson, Z.S., Belchik, M.R. 1998. A preliminary status review of eulachon and Pacific lamprey in the Klamath Basin. Yurok Tribal Fisheries Program, Klamath, California.

Leidy, R.A., Leidy, G.R. 1984. Life stage periodicities of anadromous salmonids in the Klamath River basin, northwestern California. Sacramento, California. U.S. Fish and Wildlife Service.

Lemly, A.D. 1982. Modification of benthic insect communities in polluted streams: combined effects of sedimentation and nutrient enrichment. Hydrobiologia 87: 229-245.

Lindley, S.T., Davis, H. 2011. Using model selection and model averaging to predict the response of Chinook salmon to dam removal. Review Draft Report. National Marine Fisheries Service, Fisheries Ecology Division, NOAA Fisheries Service Southwest Fisheries Science Center, Santa Cruz, California.

Lorion, C.M., Markle, D.F., Reid, S.B., Docker, M.F. 2000. Redescription of the presumed-extinct Miller Lake lamprey, *Lampetra minima*. Copeia 2000: 1019-1028.

Luzier, C.W., Brostrom, J., Cook-Tabor, C., Goodman, D., Nelle, R.D., Ostrand, K.G., Schaller, H., Streif, B. 2009. Proceedings of the Pacific lamprey conservation initiative work session. U.S. Fish and Wildlife Service, Regional Office, Portland, Oregon.

Luzier, C., Miller, S. 2009. Freshwater mussel relocation guidelines. Pacific Northwest Native Freshwater Mussel Workgroup. Available at: http://www.xerces.org/wp-content/uploads/2009/10/mussel-relocation-position-statement.pdf.

Magneson, M.D., Gough, S. 2006. Mainstem Klamath River coho salmon redd surveys 2001 to 2005. Arcata Fisheries Data Series Report DS 2006-7. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Magneson, M.D., Wright, K. 2010. Mainstem Klamath River fall Chinook salmon redd survey 2009. Arcata Fisheries Data Series Report DS 2010-19. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Maule, A.G., VanderKooi, S.P., Hamilton, J.B., Stocking, R., Bartholomew, J. 2009. Physiological development and vulnerability to *Ceratomyxa shasta* of fall-run Chinook salmon in the Upper Klamath River watershed. North American Journal of Fisheries Management 29: 1743-1756.

McAllister, D.E. 1963. A revision of the smelt family, Osmeridae. Bulletin of the National Museum of Canada 191: 1-53.

McClelland, W.T., Brusven, M.A. 1980. Effects of sedimentation on the behavior and distribution of riffle insects in a laboratory stream. Aquatic Insects 2: 161-169.

McCovey, B.W., Jr. 2011. Klamath River green sturgeon acoustic tagging and biotelemetry monitoring 2010. Final Technical Report. Yurok Tribal Fisheries Program, Klamath River Division, Hoopa, California.

McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Available at: www.critfc.org/tech/EPAreport.htm.

McGinnis, S.M. 1984. Freshwater fishes of California. California Natural History Guides: 49. University of California Press, Berkeley.

McLean, J.E., Bentzen, P., Quinn, T.P. 2003. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout (*Oncorhynchus mykiss*) through the adult stage. Canadian Journal of Fisheries and Aquatic Sciences 60: 433–440.

Meeuwig, M.H., Bayer, J.M., Seelye, J.G. 2005. Effects of temperature on survival and development of early life stage Pacific and western brook lamprey. Transactions of the American Fisheries Society 134: 19-27.

Mertes, L.A.K., Warrick, J.A. 2001. Measuring flood output from 110 coastal watersheds in California with field measurements and SeaWiFS. Geology 29: 659-662.

Messmer, R., Smith, R. 2007. Adaptive management for Klamath Lake redband trout. *In* Schroeder, R.K. and J.D. Hall, editors. Redband trout: resilience and challenge in a changing landscape. Oregon Chapter of the American Fisheries Society, Corvallis.

Miller, R.R., Smith, G.R. 1981. Distribution and evolution of Chasmistes (Pisces: Catostomidae) in western North America. Occasional Papers of the Museum of Zoology, University of Michigan, Ann Arbor 696: 1-46.

Montgomery, D.R., Buffington, J.M. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109: 596–611.

Morgan, C.A., De Robertis, A., Zabel R.Q. 2005. Columbia River plume fronts. I. Hydrology, zooplankton distribution, and community composition. Marine Ecology Progress Series 299: 19-31.

Moser, M.L., Lindley, S.T. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79: 243-253.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley and Los Angeles.

_____. 2002. Inland fishes of California. Second edition. University of California Press, Berkeley.

Moyle, P.B., Yoshiyama, R.M., Williams, J.E., Wikramanayake, E.D. 1995. Fish species of special concern in California. Prepared by Department of Wildlife and Fisheries Biology, University of California, Davis for California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova.

Moyle, P.B., Isreal, J.A., Purdy, S.E. 2008. Salmon, steelhead, and trout in California: status of an emblematic fauna. Prepared for California Trout by University of California Davis, Center for Watershed Sciences.

Moyle, P.B., Brown, L.R., Chase, S.D., Quiñones, R.M. 2009. Status and conservation of lamprey in California. Pages 279-292 *in* LR Brown, S.D. Chase, M.G. Mesa, R.J. Beamish, and P.B. Moyle, editors. Biology, management, and conservation of lamprey in North America. American Fisheries Society Symposium 72, Bethesda, Maryland.

Myers, J.M., Kope, R.G., Bryant, T.D., Lierheimer, L.J., Wainwright, T.C., Grant, W.S., Waknitz, F.W., Neely, K., Lindley, S.T., Waples, R.S. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. NMFS-NWFSC-35. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service. 1997a. Endangered and threatened species: threatened status for southern Oregon/northern California coast evolutionarily significant unit of coho salmon. Federal Register 62: 24588-24609.

_____. 1997b. Designated critical habitat; Central California Coast and Southern Oregon/Northern California Coast Coho Salmon. Federal Register 62: 62741-62751.

_____. 1999a. Status review update for deferred ESUs of west coast Chinook salmon (*Oncorhynchus tshawytscha*) from Washington, Oregon, California, and Idaho. Report of West Coast Biological Review Team to NOAA Fisheries Service, Seattle, Washington. Available at: http://www.nwr.noaa.gov/Publications/Biological-Status-Reviews/loader.cfm?csModule=security/getfile&pageid=21676.

_____. 1999b. Designated critical habitat; Central California Coast and Southern Oregon/Northern California Coast coho salmon. Federal Register 64: 24049-24062.

_____. 2001. Endangered and threatened species: final listing determination for Klamath Mountains Province steelhead. Federal Register 66: 17845-17856.

_____. 2002. Biological opinion: Klamath Project operations. NOAA Fisheries Service, Southwest Region. Long Beach, California.

_____. 2005. Endangered and threatened wildlife and plants: endangered status for Southern Resident Killer Whales. Federal Register 70: 69903-69912.

_____. 2006a. Endangered and threatened wildlife and plants: threatened status for Southern Distinct Population Segment of North American green sturgeon: final rule. Federal Register 71: 17757-17766.

_____. 2006b. Endangered and threatened species; designation of critical habitat for Southern Resident Killer Whale. Federal Register 71: 69054-69070.

_____. 2007. Magnuson-Stevens Reauthorization Act Klamath River coho salmon recovery. Prepared by FR Rogers, Lagomarsino IV, and Simondet JA for NOAA Fisheries Service, Southwest Region, Long Beach, California.

_____. 2009a. Endangered and threatened wildlife and plants; proposed threatened status for Southern Distinct Population Segment of eulachon. Federal Register 75 13012-13024.

_____. 2009b. Endangered and threatened wildlife and plants; final rulemaking to designate critical habitat for the threatened Southern Distinct Population Segment of North American green sturgeon. Federal Register 74: 52300-52351.

_____. 2010a. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for Bureau of Reclamation by NOAA Fisheries Service, Southwest Region. Available at: http://swr.nmfs.noaa.gov/klamath/FINAL-Klamath_Ops_031510.pdf

_____. 2010b. Endangered and threatened wildlife and plants; threatened status for Southern Distinct Population Segment of eulachon. Federal Register 75 13012-13024.

_____. 2011. Endangered and threatened species, designation of critical habitat for Southern Distinct Population Segment of eulachon. Final rule. Federal Register 76: 65324-65352.

National Research Council (NRC). 2004. Endangered and threatened fishes in the Klamath Basin: causes of decline and strategies for recovery. The National Academies Press, Washington, DC. Available at: http://www.nap.edu/openbook.php?isbn=0309090970.

_____. 2008. Hydrology, ecology, and fishes of the Klamath Basin. The National Academies Press, Washington, DC. Available at: http://www.nap.edu/catalog.php?record_id=12072#orgs.

Nawa, R. 2003. A petition for rules to list: Pacific lamprey (*Lampetra tridentata*); river lamprey (*Lampetra ayresi*); western brook lamprey (*Lampetra richardsoni*); and Kern brook lamprey (*Lampetra hubbsi*) as threatened or endangered under the Endangered Species Act. Letter to U.S. Fish and Wildlife Service, Washington, DC.

Nedeau, E., Smith, A.K., Stone, J. 2005. Freshwater mussels of the Pacific Northwest. U.S. Fish and Wildlife Service, Vancouver, Washington.

Nedeau, E.J., Smith, A.K., Stone, J., Jepsen, S. 2009. Freshwater mussels of the Pacific Northwest. Second edition. The Xerces Society for Invertebrate Conservation.

Newcombe, C.P., Jensen, J.O.T. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16: 693-727.

Nichols, K., Foott, J.S. 2005. Health monitoring of juvenile Klamath River chinook salmon. FY 2004 Investigational Report. U.S. Fish and Wildlife Service, California-Nevada Fish Health Center, Anderson, California.

North Coast Regional Water Quality Control Board (NCRWQCB). 2010. Action plan for the Klamath River Total Maximum Daily Loads addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in the Klamath River, California, and Site-specific objectives for dissolved oxygen in the Klamath River in California, and implementation plans for the Klamath and Lost River basins. NCRWQCB, Santa Rosa,

California. Available at: http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/.

Odemar, M.W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus*. California Fish and Game 50: 305–307. Available at: http://archive.org/details/californiafishga50_4cali.

Olson, A. 1996. Freshwater rearing strategies of spring Chinook salmon (*Oncorhynchus tshawytscha*) in Salmon River tributaries, Klamath Basin, California. Master's thesis. Humboldt State University, Arcata, California.

Olson, J.M. 1998. Temporal and spatial distribution patterns of sightings of southern community and transient orcas in the inland waters of Washington and British Columbia. Master's thesis, Western Washington University, Bellingham, Washington.

Oosterhout, G.R. 2005. KlamRAS results of fish passage simulations on the Klamath River. Final report. Eagle Point, Oregon.

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake drainage Total Maximum Daily Load and Water Quality Management Plan. ODEQ, Portland.

_____. 2010. Upper Klamath and Lost River Subbasins Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WPMP). DEQ 10-WQ-030. ODEQ, Portland, Oregon. Available at: http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/uklost/KlamathLostTMDLWQMP.pdf.

Oregon Department of Fish and Wildlife (ODFW). 2003. Klamath River redband trout investigations. ODFW, Klamath Falls, Oregon.

_____. 2011. Observations of spawning Chinook in the former impoundment at Gold Ray Dam. Unpublished data received from D. Van Dyke, Rogue District Fish Biologist, Oregon Department of Fish and Wildlife, Central Point, Oregon.

Osborne, R.W. 1999. A historical ecology of Salish Sea "resident" killer whales (*Orcinus orca*): with implications for management. Doctoral dissertation. University of Victoria, Victoria, British Columbia.

Pacific Fishery Management Council (PFMC). 2005. Klamath River Chinook salmon stock-recruitment analysis. PFMC, Portland, Oregon.

PacifiCorp. 2004a. Environmental Report. Final License Application, Volume 2, Exhibit E. Klamath Hydroelectric Project, FERC No. 2082. Portland, Oregon.

_____. 2004b. Water Resources. Final Technical Report. Final License Application. Klamath Hydroelectric Project, FERC No. 2082. Portland, Oregon.

_____. 2004c. Analysis of potential Klamath Hydroelectric Project effects on water quality aesthetics for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Portland, Oregon.

_____. 2005. Response to FERC AIR AR-2, Anadromous fish restoration for the Klamath Hydroelectric Project (FERC Project No. 2082). Final Technical Report. Portland, Oregon.

_____. 2006. PacifiCorp positions on important topics. Klamath Hydroelectric Project, FERC No. 2082. Portland, Oregon.

_____. 2011. PacifiCorp Klamath Hydroelectric Project interim operations habitat conservation plan for coho salmon. Portland, Oregon.

Papa, R., Israel, J.A., Nonnis, M.F., May, B. 2007. Assessment of genetic variation between reproductive ecotypes of Klamath River steelhead reveals differentiation associated with different run-timings. Journal of Applied Ichthyology 23: 142-146.

Pearsons, T.N., Temple, G.M. 2010. Changes to rainbow trout abundance and salmonid biomass in a Washington watershed as related to hatchery salmon supplementation. Transactions of the American Fisheries Society 139: 502-520.

Perkins, D.J., Kann, J., Scoppettone, G. 2000. The role of poor water quality and fish kills in the decline of endangered Lost River and shortnose suckers in the Upper Klamath Lake. Final Report. Prepared by U.S. Geological Survey, Biological Resources Division for Bureau of Reclamation, Klamath Falls Project Office, Klamath Falls, Oregon.

Perry, R.W., Risley, J.C., Brewer, S.J., Jones, E.C., Rondorf, D.W. 2011. Simulating water temperature of the Klamath River under dam removal and climate change scenarios. Open File Report. U.S. Geological Survey, Reston, Virginia.

Pess, G.R., Kiffney, .PM., Liermann, M.C., Bennett, T.R., Anderson, J.H., Quinn, T.P. 2011. The influences of body size, habitat quality, and competition on the movement and survival of juvenile coho salmon during the early stages of stream recolonization. Transactions of the American Fisheries Society 140: 883-897.

Petersen, Lewis, R.S. 2009. Yurok and Karuk traditional ecological knowledge: insights into Pacific lamprey populations of the Lower Klamath Basin. American Fisheries Society Symposium 72: 1-39.

Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B., Sparks, R., and Stromberg, J. 1997. The natural flow regime: a new paradigm for riverine conservation and restoration. BioScience 47:769-784.

Prendergast, L., Foster, K. 2010. Analysis of microcystin in fish in Copco and Iron Gate reservoirs in 2009. Technical memorandum. PacifiCorp, Portland, Oregon.

Pullen, J.D., Allen, J.~~V.~~S. 2000. Modeling studies of the coastal circulation off northern California: shelf response to a major Eel River flood event. Continental Shelf Research 20: 2213-2238.

Richter, B.D., Baumgartner, J.V., Powell, ~~DP~~J., Braun~~.~~, D.P. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10: 1163-1174.

~~Ridenhour R.L., Hofstra T.D. 1994. Fishery resources of the Redwood Creek basin (California).~~

Rieman, B.E., Beamesderfer, R.C., Vigg, S., Poe, T. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 448-458.

Rieman~~-~~, .B~~.~~E., McIntyre, J.D. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT-302. USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Rieman, B.E., McIntyre, J.D. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16: 132-141.

Rogers, J.B~~ and C.C.~~., Burley~~.~~, C.C. 1991. A sigmoid model to predict gastric evacuation rates of smallmouth bass (*Micropterus dolomieui*) fed juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences 48: 933-937.

Roninger, T. 2012. Memo to the file prepared by Trisha Roninger, July 2, 2012. U.S. Fish and Wildlife Service, Klamath Falls, Oregon.

Ryan, P.A. 1991. Environmental effects of sediment on New Zealand streams: a review. New Zealand Journal of Marine and Freshwater Research 25: 207-221.

Sartori, J.C~~.~~. 2006. Comparative otolith microstructural analysis of adult, juvenile, and fry life stages of Salmon River spring Chinook salmon of northwestern CA. Technical report. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Schabetsberger, R., Morgan, C.A., Brodeur, R.D., Potts, C.L., Peterson, W.T., Emmett, R.L. 2003. Prey selectivity and diel feeding chronology of juvenile chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Columbia River plume. Fisheries Oceanography 12: 523-540.

Scheiff, A.J., Lang, J.S., Pinnix~~ W.D.~~, WD. 2001. Juvenile salmonid monitoring on the mainstem Klamath River at Big Bar and mainstem Trinity River at Willow Creek 1997-

2000. Annual report of the Klamath River Fisheries Assessment Program. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

~~Juvenile salmonid monitoring annual report 2001~~

~~Schultz L.P., DeLacy A.C. 1935. Fishes of the American Northwest. Journal of the Pan Pacific Research Institute 10: 365-380.~~
Schrank, A.J., Rahel, F.J., Johnstone, H.C. 2003. Evaluating laboratory derived thermal criteria in the field: An example involving Bonneville cutthroat trout. Transactions of the American Fisheries Society 132: 100–109.

Scoppetone, G.G. 1988. Growth and longevity of the cui-ui and other catostomids and cyprinids in western North America. Transactions of the American Fisheries ~~Society~~ Society 117: 301-307.

Scott, W.B., Crossman, E.J~~.~~. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin No. 184.

Shaw, T.A., Jackson, C., Nehler, D., Marshall, M. 1997. Klamath River (Iron Gate Dam to Seiad Creek) life stage periodicities for Chinook, coho, and steelhead. Prepared by U.S. Fish and Wildlife Service, Coastal California Fish and Wildlife Office, Arcata, California.

Simon, D.C., Markle, D.F. 1997. Interannual abundance of non-native fathead minnows (*Pimephales promelas*) in ~~upper~~Upper Klamath Lake, Oregon. Great Basin Naturalist 57: 142–148.

Snyder, J.O~~.~~. 1931. Salmon of the Klamath River, California. Fish Bulletin No. 34: 5-22. Division of Fish and Game of California, Sacramento.

Snyder, M.A., Sloan, L.C., Bell, J.L. 2004. Modeled regional climate change in the hydrologic regions of California: a CO_2 sensitivity study. Journal of the American Waters Resources Association 40: 591–601.

Soto, T.~~A.~~, Corum, A., Voight, H., Hillemeier, D., Lestelle, L. ~~2009.~~ 2008. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (*Oncorhynchus kisutch*). Draft report to ~~U.S.~~ Bureau of Reclamation.

Starcevich, S.J., Jacobs, S.E., Tinniswood, W. 2006. Effects of dams on redband trout life history in the Upper Klamath River: a summary and synthesis of past and recent studies. Oregon Department of Fish and Wildlife, Corvallis.

State Water Resources Control Board (SWRCB). 2006. 2006 CWA Section 303(d) list of water quality limited segments.

Steward and Associates. 2007. Assessment of volitional and non-volitional fish passage systems relative to the Klamath River Hydroelectric Project. Prepared for Yurok Indian Tribe.

Stillwater Sciences. 2008. Klamath River dam removal study: sediment transport DREAM-1 simulation. Technical ~~report.~~Report. Prepared by Stillwater Sciences, Arcata, California for California Coastal Conservancy, Oakland, California.

~~Stillwater Sciences. 2009a.~~ _____. 2009a. Effects of sediment release following dam removal on the aquatic biota of the Klamath River. Technical ~~report.~~Report. Prepared by Stillwater Sciences, Arcata, California for State Coastal Conservancy, Oakland, California. Available at: http://www.Reclamation.gov/mp/kbao/kbra/docs/other/Klamath%20Dam%20Removal%20Biological%20Analysis_FINAL.pdf.

~~http://www.Reclamation.gov/mp/kbao/kbra/docs/other/Klamath%20Dam%20Removal%20Biological%20Analysis_FINAL.pdf~~

~~Stillwater Sciences. 2009b.~~ _____. 2009b. Dam removal and Klamath River water quality: A synthesis of the current conceptual understanding and an assessment of data gaps. Technical ~~report.~~Report. Prepared by Stillwater Sciences, Arcata, California for State Coastal Conservancy, Oakland, California.

~~Stillwater Sciences. 2010a.~~ _____. 2010a. Anticipated sediment release from Klamath River dam removal within the context of basin sediment delivery. Prepared by Stillwater Sciences, Arcata, California for California Coastal Conservancy, Oakland, California.

~~**Stillwater Sciences. 2010b.**~~ _____. 2010b. Potential responses of coho salmon and steelhead downstream ~~**of**~~ from Iron Gate Dam to No-Action and Dam-Removal alternatives for the Klamath Basin. Prepared by Stillwater Sciences, Arcata, California for ~~**USDI**~~ Bureau of Reclamation in support of the Biological Subgroup for the Klamath Basin Secretarial Determination. Arcata, California.

Stocking, R.W., Holt, R.A., Foott, J.S., Bartholomew, J.L. 2006. Spatial and temporal occurrence of the salmonid parasite *Ceratomyxa shasta* (Myxozoa) in the Oregon-California Klamath Basin. Journal of Aquatic Animal Health 18: 194-202.

Stocking, R.W., Bartholomew, J.L. 2007. Distribution and habitat characteristics of *Manayunkia speciosa* and infection prevalence with the parasite *Ceratomyxa shasta* in the Klamath River, Oregon-California. Journal of Parasitology 93: 78-88.

Stone, J., Pirtle, J., Barndt, S. 2002. Evaluate habitat use and population dynamics of lampreys in Cedar Creek. BPA Contract #200001400, Annual Report for 2001. ~~US~~

U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, Washington.

Strange, J. 2008. Adult Chinook salmon migration in the Klamath Basin, 2007 Biotelemetry monitoring study final report. Yurok Tribal Fisheries Program, Klamath, California and University of Washington, School of Aquatic and Fishery Science, Seattle, Washington, in collaboration with Hoopa Valley Tribal Fisheries, Hoopa, California.

~~Strange J. 2009. Adult Chinook salmon migration in the Klamath Basin, 2008 Biotelemetry monitoring study final report. Yurok Tribal Fisheries Program, Klamath, California and University of Washington, School of Aquatic and Fishery Science, Seattle, Washington, in collaboration with Hoopa Valley Tribal Fisheries, Hoopa, California.~~

Streif, B. 2009. Considering Pacific lamprey when implementing instream activities. Pages 255-268 *in* Brown ~~LR~~, L.R., Chase ~~SD~~, S.D., Mesa ~~MG~~, M.G., Beamish ~~RJ~~, R.J., Moyle ~~PB~~, P.B., editors. Biology, management, and conservation of lamprey in North America. American Fisheries Society Symposium 72, Bethesda, Maryland.

Stutzer, G.M., Ogawa, J., Hetrick, N.J., Shaw, T. 2006. An initial assessment of radio telemetry for estimating juvenile coho salmon survival, migration behavior, and habitat use in response to Iron Gate Dam discharge on the Klamath River, California. Arcata Fisheries Technical Report Number TR2006-05US. ~~US~~ U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Sullivan ~~C.M. 1989. Juvenile life history and age composition of mature fall Chinook salmon returning to the Klamath River, 1984-1986. Master's thesis. Humboldt State University, Arcata, California.~~

~~Sullivan K., Martin D.J., Cardwell R.D., Toll J.E., Duke S. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute, Portland, Oregon. http://www.mtpi.sei.org/downloads/reports/salmon2000.pdf~~

~~Sullivan~~, A.B., Deas, M.L., Asbill, J., Kirshtein, J.D., Butler, K., Vaughn, J. 2009. Klamath River water quality data from Link River Dam to Keno Dam, Oregon, 2008. Open-File Report 2009-1105. ~~US~~ U.S. Geological Survey.

~~SWRCB (State Water Resources Control Board). 2006. 2006 CWA Section 303(d) CWA SECTION 303(d) list of water quality limited segments.~~

Sullivan, C.M. 1989. Juvenile life history and age composition of mature fall Chinook salmon returning to the Klamath River, 1984-1986. Master's thesis. Humboldt State University, Arcata, California.

Sullivan, K., Martin, D.J., Cardwell, R.D., Toll, J.E., Duke, S. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute, Portland, Oregon. Available at: http://www.mtpi.sei.org/downloads/reports/salmon2000.pdf.

Sykes, G.E., Johnson, C.J., Shrimpton, J.M. 2009. Temperature and flow effects on migration timing of Chinook salmon smolts. Transactions of the American Fisheries Society 138: 1252-1265.

Thomas, A.C. 2008. Investigation of western pearlshell mussel (*Margaritfera falcata*) mortality in Bear Creek, King County, Washington: a disease ecology approach. Master's thesis. University of Washington, Seattle.

Thorp~~ JH~~, J.H., Covich~~ AP~~, A.P., editors. 2001. Ecology and classification of North American freshwater invertebrates. Second ~~Edition.~~edition. Academic Press.

Trihey and Associates. 1996. Instream flow requirements for tribal trust species in the Klamath River. Concord, California.

True~~,~~ K~~.~~., Foott, J.S., Bolick, A., Benson, S., Fogerty, R. 2010. Myxosporean parasite (*Ceratomyxa shasta* and *Parvicapsula minibicornis*) incidence and severity in Klamath Basin juvenile Chinook salmon, April-August 2009. FY 2009 Investigational Report. U.S. Fish and Wildlife Service, California–Nevada Fish Health Center, Anderson, California.

Underwood, K., Langendorf, H.D., Diviney, C., Debrick, A., Daniels, S., Crombie, W.B., Chesney, W.R. 2010. Shasta and Scott River juvenile salmonid outmigration monitoring project. Final report. Contract No. 09-62. Prepared for Pacific States Marine Fisheries Commission by California Department of Fish and Game, Anadromous Fisheries Resource Assessment and Monitoring Program.

~~USFWS (~~U.S. Environmental Protection Agency (USEPA). 1986. Ambient water quality criteria for dissolved oxygen. EPA 440/5-86-003. Office of Water Regulations and Standards, Washington, DC.

_____. 2003. EPA Region 10 guidance for Pacific Northwest State and tribal temperature and water quality standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, Washington.

U.S. Fish and Wildlife Service~~).~~ (USFWS). 1988. Endangered and threatened wildlife and plants: Determination of endangered status for the shortnose sucker and Lost River sucker. Federal Register 53: 27130-27134.

~~USFWS.~~_____. 1993. Shortnose sucker (*Chasinistes brevirostris*) and Lost River (*Deltistes luxatus*) Sucker Recovery Plan. Portland, Oregon.

~~USFWS.~~_____. 1994. Endangered and threatened wildlife and plants: proposed determination of critical habitat for Lost River sucker and shortnose sucker. Federal Register 53: 27130-27134.

~~USFWS.~~_____. 1998. Klamath River (Iron Gate Dam to Seiad Creek) life state periodicities for Chinook, coho, and steelhead. Prepared by USFWS, Coastal California Fish and Wildlife Office, Arcata.

~~USFWS.~~_____. 1999. Endangered and threatened wildlife and plants; determination of threatened status for bull trout in the coterminous United States; final rule. Federal Register 64: 58910-58933.

~~USFWS.~~_____. 2000. Endangered and threatened wildlife and plants; 12-month finding for a petition to list the Great Basin redband trout as threatened or endangered. Federal Register 65: 14932-14936.

~~USFWS.~~_____. 2002. Bull trout (*Salvelinus confluentus*) draft recovery plan. ~~USFWS,~~ Region 1, Portland, Oregon.

~~USFWS.~~_____. 2003. Klamath River fish die-off, September 2002: Report on estimate of mortality. Report No. AFWO-01-03. Arcata Fish and Wildlife Office, Arcata, California.

_____. 2004. Endangered and threatened wildlife and plants: 90-day finding on a petition to list three species of lampreys as threatened or endangered. Federal Register 69: -77158-77167.

~~USFWS.~~_____. 2007a. Lost River sucker (*Deltistes luxatus*) 5-year review summary and evaluation. USFWS, Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon.

~~USFWS.~~_____. 2007b. Shortnose sucker (*Chasmistes brevirostris*) 5-year review summary and evaluation. ~~USFWS,~~ Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon.

~~USFWS.~~_____. 2007c. Formal consultation on the proposed relicensing of the Klamath Hydroelectric Project, FERC Project No. 2082, Klamath River, Klamath

County, Oregon, and Siskiyou County, California. Biological opinion. U.S. Fish and Wildlife Service, Yreka, California.

_____. 2008. Biological/conference opinion regarding the effects of the ~~U.S.~~ Bureau of Reclamation's proposed 10-year Operation Plan (April 1, 2008–March 31, 2018) for the Klamath Project and its effects on the endangered Lost River and shortnose suckers. USFWS, Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon, and Yreka Fish and Wildlife Office, Yreka, California.

~~USFWS~~_____. 2009. Endangered and threatened wildlife and plants; 12-month finding on a
petition to list the San Francisco Bay-Delta population of the longfin smelt (*Spirinchus thaleichthys*) as Endangered. Federal Register 74: 16169-16175.

~~USFWS and ODFW (US Fish and Wildlife Service and Oregon Department of Fish and Wildlife). 2004. Letter from Oregon Department of Fish and Wildlife and US Fish and Wildlife Service to PacifiCorp regarding FERC No. 2082, Klamath River Hydroelectric Project, Klamath County, Oregon and Siskiyou County California. License Compliance - Fishway Maintenance and Operation. USFWS, Yreka, California, ODFW, Salem, Oregon. February 26, 2004.~~

~~USGS (US~~_____. 2011a. Draft revised recovery plan for the Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). Pacific Southwest Region, Sacramento, California.

_____. 2011b. Endangered and threatened wildlife and plants; designation of critical habitat for Lost River sucker and shortnose sucker. Proposed rule. Federal Register 76: 76337- 76357.

U.S. Geological Survey~~).~~ (USGS). 2010. Water-quality monitoring in the Keno Reach of the Klamath River. Available at: http://or.water.usgs.gov/proj/keno_reach/monitors.html.

VanderKooi~~ SP~~, S.P., Burdick~~ SM~~, S.M., Echols~~ KR~~, K.R., Ottinger~~ CA~~, C.A., Rosen ~~BH, and~~, B.H., Wood~~ TM~~., T.M. 2010. Algal toxins in upper Klamath Lake, Oregon: Linking water quality to juvenile sucker health. ~~U.S. Geological Survey~~ Fact Sheet 2009-3111. U.S. Geological Survey, Western Fisheries Research Center, Seattle, Washington. Available at: http://pubs.usgs.gov/fs/2009/3111/pdf/fs20093111.pdf.

Van Eenennaam~~ JP~~, J.P., Linares-Casenave, J., Deng, X., Doroshov~~ SI.~~, S.I. 2005. Effect of incubation temperature on green sturgeon embryos, *Acipenser medirostris*. Environmental Biology of Fishes 72: 145-154.

Van Eenennaam ~~JP~~, J.P., Linares-Casenave, J., Doroshov ~~SI~~, S.I., Hillemeier ~~DC~~, D.C., Willson ~~TE~~, T.E., Nova ~~AA.~~, A.A. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society 135: 151-163.

Vannote ~~RL~~, R.L., Minshall ~~GW.~~, G.W. 1982. Fluvial processes and local lithology controlling abundance, structure, and composition of mussel beds. Proceedings of the National Academy of Sciences of the United States of America 79: 4103-4107.

Vigg, S~~, TP.~~, Poe, ~~LA~~T.P., Prendergast, ~~and HC~~L.A., Hansel~~.~~, H.C. 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 421-438.

Vuori ~~KM~~,K.M., Joensuu, I. 1996. Impact of forest drainage on the macroinvertebrates of a small boreal headwater stream: do buffer strips protect lotic biodiversity? Biological Conservation 77: 87-95.

Wallace, M. 1998. Seasonal water quality monitoring in the Klamath River estuary, 1991-1994. Administrative Report No. 98−9. California Department of Fish and Game, Inland Fisheries Division, Arcata.

~~Wallace M.~~ _____. 2004. Natural vs. hatchery proportions of juvenile salmonids migrating through the Klamath River estuary and monitor natural and hatchery juvenile salmonid emigration from the Klamath Basin. July 1, 1998 through June 30, 2003. Final performance report. Federal Aid in Sport Fish Restoration Act. Project ~~no.~~No. F-51-R-6. Arcata, California.

Ward ~~EJ~~, E.J., Holmes ~~EE~~, E.E., Balcomb ~~KC.~~, K.C. 2009. Quantifying the effects of prey abundance on killer whale reproduction. Journal of Applied Ecology, 46: 632-640.

Water Quality ~~Subgroup.~~Sub Team (WQST). 2011. Assessment of long~~-~~-term water quality changes for the Klamath River basin resulting from KHSA, KBRA, and TMDL and ~~NPS~~ NPS reduction programs. ~~Technical Memorandum.~~ Final report. Prepared by the Water Quality ~~Subgroup~~Sub Team for the Secretarial Determination~~. US Department~~ regarding potential removal of the ~~Interior.~~ lower four dams on the Klamath River.

West, J.R., Dix ~~OJ~~, O.J., Olson ~~AD~~, A.D., Anderson ~~MV~~, M.V., Fox ~~SA, and~~, S.A., Power ~~JH.~~, J.H. 1990.
Evaluation of fish habitat conditions and utilization in Salmon, Scott, Shasta, and Mid-Klamath sub-basin tributaries. Annual report for interagency agreement 14-16-0001-

89508. Prepared by USDA Forest Service, Klamath National Forest, Yreka, California and Shasta Trinity National Forest, Weaverville, California.

Westover, M. 2010. Freshwater mussel distribution, abundance and habitat use in the middle Klamath River. Bachelor of Science thesis submitted to Biology Department, Whitman College.

White ~~JL~~, J.L., Harvey ~~BC.~~, B.C. 1999. Habitat separation of prickly sculpin, *Cottus asper*, and the coastrange sculpin, *Cottus aleuticus*, in the mainstream Smith River, northwestern California. Copeia, 2: 371-375.

Williams ~~JE~~, J.E., Bowman ~~DB~~, D.B., Brooks ~~JE~~, J.E., Echelle ~~AA~~, A.A., Edwards ~~RJ~~, R.J., Hendrickson ~~DA~~, D.A., Landye ~~JJ.~~, J.J. 1985. Endangered aquatic ecosystems in North American deserts with a list of vanishing fishes of the region. Journal of the Arizona-Nevada Academy of Science 20: 1-62.

Williams ~~TH~~, T.H., Bjorkstedt ~~EP~~, E.P., Duffy ~~WG~~, W.G., Hillemeier, D., Kautsky, G., Lisle ~~TE~~, T.E., McCain, M., Rode, M., Szerlong ~~RG~~, R.G., Schick ~~RS~~, R.S., Goslin ~~MN~~, M.N., Agrawal, A. 2006. Historical population structure of coho salmon in the Southern Oregon/Northern California Coasts evolutionarily significant unit. NOAA Technical Memorandum NOAA-TM-NOAA Fisheries-SWFSC-390. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Williams, T.H., Garza, J.C., Hetrick, N., Lindley, S.T., Mohr, M.S., Myers, J.M., O'Farrell, M.R., Quinones. R.M., Teel, D.J. 2011. Upper Klamath and Trinity River Chinook salmon Biological Review Team report. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California.

Willson ~~MF~~, M.F., Armstrong ~~RH~~, R.H., Hermans ~~MC~~, M.C., Koski, K. 2006. Eulachon: a review of biology and an annotated bibliography. AFSC Processed Report 2006-12. National Marine Fisheries Service, Alaska Fisheries Science Center, Juneau, Alaska.

Wood ~~TM~~, T.M., Hoilman ~~GR~~, G.R., Lindenberg~~-~~, M.K. 2006. Water-quality conditions in Upper Klamath Lake, Oregon, 2002–04. Scientific Investigations Report 2006-5209. U.S. Geological Survey.

Zaroban, D., Mulvey, M., Maret, T., Hughes, R., Merritt, G. 1999. Classification of species attributes for Pacific Northwest freshwater fishes. Northwest Science 73: 81-93.

3.4 Algae

3.4.1 Area of Analysis

This section of the Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) analyzes potential effects of the Proposed Action and alternatives on algal communities in the Klamath ~~River Watershed~~Basin, excluding the Lost River watershed, Tule Lake watershed, and most of the Trinity River.

The area of analysis for algae is generally the same as for Aquatic Resources (~~Section~~ Section 3.3, Aquatic Resources, Figure 3.3-1). Potential impacts were assessed within and across reaches of the Klamath Basin, as separated by changes in physiography (e.g~~.,~~ ., Upper and Lower Klamath Basins), the presence of the Four Facilities under analysis, and degree of marine influence. The area of analysis for algae has the following reaches:

1. Upstream of the influence of J.C. Boyle Reservoir, including the following:
   a. Upper Klamath Lake and Agency Lake
   b. Tributaries to Upper Klamath Lake (Sprague, Sycan, Wood and Williamson Rivers)
   c. Reclamation's Klamath Project facilities (e.g., Link River Dam, Keno Impoundment /Lake Ewauna)
2. Hydroelectric Reach: from the upstream end of J.C. Boyle Reservoir to Iron Gate Dam, including all sections categorized as mainstem, bypass~~ed~~, and peaking reaches and including tributaries to the Klamath River (examples include Jenny, Spencer, Slate, Shovel, and Fall creeks).
3. Lower Klamath River: downstream ~~of~~from Iron Gate Dam, including the following:
   a. Major tributaries to the Klamath River (Shasta, Scott, and Salmon Rivers)
   b. Minor tributaries to the Klamath River (examples include Bogus, Beaver, Humbug, and Cottonwood creeks)
4. Klamath Estuary
5. Pacific Ocean marine nearshore environment (see Figure 3.2-1)

3.4.2 Regulatory Framework

Beneficial uses and water quality objectives for Oregon, California, the United States Environmental Protection Agency (USEPA), and the Hoopa Valley, Yurok and Karuk Tribes provide the regulatory framework for algae listed below. These uses and objectives are described in detail in Section 3.2.2. Oregon includes a narrative nuisance algae growth objective in which impairment of beneficial uses by algal growth is not allowed. Additionally, for natural lakes that do not thermally stratify, reservoirs, rivers and estuaries, the numeric average of 0.015 mg/~~l~~L chlorophyll-*a* identifies Oregon water bodies where phytoplankton may impair the recognized beneficial uses (Table 3.2-3). California has a narrative biostimulatory water quality objective that limits nutrients to

the extent that such growths cause nuisance or adversely affect beneficial uses (~~Table~~ Table 3.2-3). Additionally, the algal concentration "targets" for the California Klamath River Total Maximum Daily Loads (TMDLs) were developed from an interpretation of the biostimulatory substances objective, using the California Nutrient Numeric Endpoint guidelines (North Coast Regional Water Quality Control Board [NCRWQCB] 2010~~a~~). For water column chlorophyll-*a* concentrations (i.e., phytoplankton) the California Klamath River TMDL target is 10 µg/L. For attached benthic algal biomass (i.e., periphyton), the target is 150 ~~µg/m²~~mg of chlorophyll-*a*/m². The Hoopa Valley Tribe also uses 150 ~~µg/m²~~mg/L of chlorophyll-*a* as the water quality objective for nuisance periphyton growth (Table 3.2-6), which is applicable for River Mile (RM) ≈45~~-~~–46 of the mainstem Klamath River.

3.4.2.1~~–~~ Federal Authorities and Regulations

- Clean Water Act (Title 33 U.S.C. §1313 [1972])
- Safe Drinking Water Act (Title 42 U.S.C. CHAPTER 6A §300f-j [1973 as amended])
- Coastal Zone Management Act

3.4.2.2~~–~~ State Authorities and Regulations

- Oregon Administrative Rules for Water Pollution Control (OAR 340-041)
- North Coast Region Basin Plan (as required by Sections 13240–13247 of California Porter-Cologne Water Quality Act)
- ~~Oregon Administrative Rules for Water Pollution Control (OAR 340-041)~~
- California Ocean Plan

3.4.2.3~~–~~ Tribal Authorities and Regulations

- Hoopa Valley Tribe Water Quality Control Plan

3.4.3 Existing Conditions/Affected Environment

Two algal communities, phytoplankton and periphyton, are ~~predominate~~predominant in the Klamath Basin. The lakes and reservoirs are dominated by phytoplankton, small algae that float in the water column. Particular phytoplankton species (i.e., blue-green algae or cyanobacteria) frequently reach nuisance levels within the lakes and reservoirs. In addition, there are portions of the riverine reaches (e.g., backwater eddies and near shore shallows) that have become inoculated with phytoplankton from upstream lakes and reservoirs, which can also support nuisance levels of blue-green algae under certain conditions. The riverine portions of the Klamath River are dominated by periphyton (i.e.~~,~~ , attached algae) or algae, fungi, and bacteria that attach to the stream bed and/or periphyton mats. Periphyton is generally dominated by diatoms and green algae. Submerged aquatic macrophytes may also be present in ~~quite~~quiet backwater areas in the Klamath River; however, no known quantitative or species-specific information has been collected. No surveys have been conducted to determine the relative distribution or biomass of aquatic macrophytes in the Klamath River. This section focuses on the

potential impacts of the Proposed Action and the alternatives on the phytoplankton and periphyton communities.

3.4.3.1 Phytoplankton

A number of different groups contribute to the phytoplankton community, including diatoms, green algae, and cyanobacteria (i.e., blue-green algae). The phytoplankton community shifts seasonally in response to changing temperature, light and nutrient levels. Phytoplankton forms form the base of the food web in the reservoirs. Phytoplankton is are consumed by zooplankton, insects and some small fish, which are fed upon by larger fish, birds, mammals, and humans. Diatoms and green algae are generally considered to be beneficial components of the phytoplankton based on their important role in the food web. When phytoplankton communities reach higher levels of concentrationbiomass in the water column (e.g., greater than 10–15 µg/L), the species composition often shifts from the more beneficial green algal species to blue-green algal species. This happens quickly as biomass in the water column begins to increase exponentially, which results in nuisance conditions including: extreme diurnal dissolved oxygen (DO) and pH fluctuations due to the effect of photosynthesis and respiration of the algal biomass, high concentrations of cyanotoxins produced by toxigenic blue-green algal species (see also Section 3.2.3.7), DOdissolved oxygen crashes due to the decomposition of decaying algal biomass, and in extreme conditions, disruption of food webs from light limitation. Typically these nuisance conditions are dominated by blue-green algae species, most notably in Upper Klamath Lake, Copco 1 Reservoir, and Iron Gate Reservoir. Nuisance blooms of green algae are less common in the Klamath Basin. Blue-green algae reach very high densities in the summer months. Some blue-green algae, *Anabaena flos-aquae*, and *Microcystis aeruginosa,* produce toxins that are harmful to fish, mammals and humans (see Section 3.2.3.7).

The stable lacustrine[1] environment created at the Four Facilities, particularly in the larger Copco 1 and Iron Gate Reservoirs, coupled with high nutrient availability and high water temperatures in summer to fall, provides ideal conditions for phytoplankton growth. Blue, including the growth of blue-green algal species. While blue-green algae can be found in a variety of lake, reservoir, river, and estuarine environments, in particular, these species thrive under warm water temperature, high nutrient, and stable water column conditions (Konopka and Brock 1978, Kann 2006), and) where they can out-compete other algal species such as diatoms in areas characterized by these conditions (Stillwater Sciences 2009).

. Huisman et al. (2004) demonstrate that *M. aeruginosa* can dominate the phytoplankton assemblage at low turbulent diffusivity (i.e., calm-stable lacustrine conditions) when their flotation velocity exceeds the rate of turbulent mixing.

[1] Pertaining to a lake or other calm water types.

In general, blooms of floating, or planktonic, algae (i.e., phytoplankton) can have important implications for water quality in freshwater systems, causing seasonal and daily fluctuations in nutrients, ~~DO~~dissolved oxygen, and pH cycles. Within the Klamath Basin, blue-green algal productivity is locally and seasonally associated with extreme daily fluctuations in ~~DO~~dissolved oxygen levels (high during the day and low at night), ~~and~~ elevated pH, and free ammonia concentrations, which do not meet Oregon water quality standards during the summer months (Section 3.2.2.3). In California, multiple reaches of the Klamath River ~~watershed was listed for nutrient and temperature impairment~~ from ~~Iron Gate Reservoir to the Scott River, and the Klamath River mainstem was listed for organic enrichment/low DO in the reaches upstream of Iron Gate Reservoir and downstream of~~ the ~~Scott River in 1998. These listings were confirmed in the Klamath River TMDL (NCRWQCB 2010b~~Oregon-California State line to the Klamath Estuary are included on the CWA Section 303(d) list of water bodies with water quality impairments for water temperature, organic enrichment/dissolved oxygen, nutrients, and microcystin concentration (see Table 3.2-8). The factors contributing to ammonia toxicity (i.e., high ammonia concentrations, high pH, and elevated temperatures) have been documented independently, but concurrent measurements of these conditions are not available to demonstrate ammonia toxicity in California (C. Creager, pers. comm., 2011). Organic enrichment and DO dissolved oxygen depressions are particularly of issue during the summer and fall months when water temperatures are relatively high.

Nuisance algal blooms that occur in the Klamath Basin are primarily composed of three species of blue-green algae: *Aphanizomenon flos-aquae*, *Anabaena flos-aquae*, and *M. aeruginosa*. Large blooms of *Aphanizomenon flos-aquae and Anabaena flos-aquae* can strongly influence pH, free ammonia, and ~~DO~~ concentrations as described above. ~~As nitrogen fixers, these species can provide a source of~~ *M. aeruginosa* requires an aquatic source of dissolved inorganic nitrogen ~~for additional primary production in reservoirs (Federal Energy Regulatory Commission [FERC] 2007),~~because it cannot make use of (fix) nitrogen gas from the atmosphere. However, *Aphanizomenon* and *Anabaena* are nitrogen fixers which allows them to outcompete other algal species when dissolved inorganic nitrogen becomes scarce in a lake or reservoir. The fixed nitrogen can subsequently become a source of nitrogen for additional primary production of phytoplankton in reservoirs (Federal Energy Regulatory Commission [FERC] 2007).

In addition to its role as a nitrogen fixer, *Anabaena flos-aquae* ~~produces a neurotoxin~~ can produce several types of toxins (i.e., anatoxin~~),~~, microcystins, and saxitoxins; Lopez et al. 2008). Anatoxin is a neurotoxin which can cause irritation, muscle twitching, paralysis, and death.

~~Although~~In contrast to *M*~~.~~. *aeruginosa* ~~is not a nitrogen fixer, there are also frequent instances of bloom densities that also create conditions that negatively influence diurnal pH and DO conditions. *M. aeruginosa* produces microcystin, a liver~~, toxin ~~that can have detrimental effects on the health of exposed vertebrates, including humans. These toxins can cause irritation, sickness, or in extreme cases, death.~~

production by some strains of *Anabaena flos-aquae* appears to be sporadic, and the circumstances under which this occurs are unknown. Anatoxin has been detected during one sampling event, at levels ranging from 20–34 ug/L in September 2005 at Iron Gate Reservoir (T. Mackie, written communication, 2005); however, the extent of anatoxin production by *Anabaena flos-aquae* in the Klamath River cannot be fully evaluated or ruled out based on the limited sampling to date. Although it is widely assumed that the severe blooms of *M. aeruginosa* in the Klamath Basin are responsible for the detected concentrations of microcystin, the relative proportion of microcystin contributions from *M. aeruginosa* vs. *Anabaena flos-aquae* has not been documented.

Studies suggest that the presence of *M. aeruginosa* blooms could result in acute and chronic effects on fish including increased mortality, reduced fertility, reduced feeding~~;~~, and habitat avoidance (Interagency Ecological Program 2007~~,~~; Fetcho 2008, ~~CH2M~~ 2009; CH2M Hill 2009~~, Fetcho 2009,~~; Teh et al. 2010~~)~~), including potential adverse ~~affects~~effects to endangered juvenile suckers in Upper Klamath Lake (VanderKooi et al. ~~2011~~2010; see Section 3.3.3.2 Physical Habitat Descriptions - Water Quality - Algal Toxins). The World Health Organization (WHO) guidelines for exposure to microcystin ~~have been~~ were exceeded in 2007–2008 in Upper Klamath Lake (VanderKooi et al. ~~2011) and the middle and lower Klamath River on several occasions (~~2010). More frequent exceedances of algal toxin guidelines have occurred since 2007 in the Middle and Lower Klamath River (Chorus and Bartram 1999~~,~~; Fetcho 2006, ~~Fetcho~~ 2007, ~~Fetcho~~ 2008~~,~~; Kann 2008~~,~~; Kann and Corum 2009), ~~and~~ the Klamath River from Copco 1 Reservoir (RM 203.1) to ~~Iron Gate Dam (RM 190.1) is~~ the confluence with the Trinity River (RM 40.0) being listed as impaired for toxicity due to the presence of microcystin in the reservoirs (Section 3.2.2.3). ~~Large *Anabaena flos-aquae* blooms occur in the Klamath Hydroelectric Project reservoirs, along with *M. aeruginosa*, and their toxin has been documented in the reservoirs and downstream (Raymond 2009).~~

3.4.3.2 Periphyton

Periphyton ~~is~~ are generally dominated by diatoms and green algae. Blue-green algae can also occur in the periphyton community, but ~~are~~they are typically a small component of the community and do not reach nuisance levels. Like phytoplankton in ~~the~~lakes and reservoirs, periphyton ~~also contributes substantially to~~are important components in the base of the food web in riverine systems. Periphyton ~~in the Klamath River~~can also play~~s~~ an important role in ~~nutrient dynamics,~~ riverine water quality, affecting nutrient ~~fluxes~~cycling and resulting in ~~short-term changes in DO and pH. Monitoring at multiple locations along the mainstem Klamath River indicates that DO and pH patterns over a 24-hour period are driven by photosynthesis and respiration of large colonies of periphyton.~~diel (24-hour cycle) fluctuations in dissolved oxygen and pH (Anderson and Carpenter 1998, Kuwabara 1992, Tanner and Anderson 1996). Excessive swings in ~~DO~~dissolved oxygen and pH can be stressful to aquatic biota, ~~thus~~ such that too much periphyton can adversely affect ~~water quality and aquatic resources.~~ designated beneficial uses related to fish and other aquatic organisms (see Section 3.2.2.1, Table 3.2-2). In the Upper Klamath Basin, excessive periphyton growth in the Sprague River has been reported to negatively affect summertime dissolved oxygen in this tributary to

Upper Klamath Lake (Oregon Department of Environmental Quality [ODEQ] 2002; see also Appendix C, Section C.4.1.1). Monitoring at multiple locations along the mainstem Lower Klamath River indicates that dissolved oxygen and pH patterns over a 24-hour period are driven primarily by photosynthesis and respiration of periphyton (Ward and Armstrong 2010). The repeatable and consistent diel cycling of dissolved oxygen is characteristic of a stream metabolism dominated by benthic photosynthesis and respiration (Odum 1956). However, planktonic algae transported through the system likely exert some influence on the dissolved oxygen signal in the Klamath River, as does demand from organic matter (Pogue and Anderson 1995) exported from the reservoirs. The exact amount of this influence has not been quantified for the Lower Klamath River downstream from the reservoirs.

~~Benthic[2]~~Periphytic algae documented within the Klamath Basin include nuisance filamentous green algae species such as *Cladophora* (FERC 2007), which can form dense mats in some places in the ~~lower~~Lower Klamath River. These mats tend to be patchy and occur in lower velocity areas. They are not a dominant feature of the river, but in some locations are an important habitat for the polychaete worm that is the intermediate host of the important fish parasites~~,~~ *Ceratomyxa shasta* and *Parvicapsula minibicornis.* ~~Periphyton~~ The factors influencing periphyton abundance and community composition ~~appears to be controlled in large part by nutrient~~ are complex and include abiotic factors such as nutrients, substrate, flow velocity, shading, light availability ~~and flow rates, with high flow rates frequently corresponding to low periphyton abundance, and nutrient enrichment corresponding to an increased abundance of *Cladophora*. However,~~ , and water temperature (Biggs 2000), as well as ecological factors such as macroinvertebrate grazing that interact with abiotic factors (Power et al. 2008). However, data regarding the distribution, community composition, and biomass of periphyton in the Klamath River is limited.

3.4.3.3~~.~~ Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir

3.4.3.3.1 Phytoplankton

~~Sediment~~ Multiple peer-reviewed sediment core studies indicate that Upper Klamath Lake was ~~likely a~~ historically a biologically productive lake (i.e., the lake produced abundant fish and ~~blue-green~~ algae blooms) as indicated by high nutrient concentrations (particularly phosphorus) in the sediments ~~for the last thousand years (~~and algal cell remains, including remains of blue-green algae species (Eilers ~~et~~ et al. 2001~~). Additional analysis~~ , Eilers et al. 2004, Bradbury et al. 2004, Colman et al. 2004). Results from these studies describe a progression from naturally eutrophic conditions in Upper Klamath Lake prior to Euro-American settlement to anthropogenically-exacerbated

[2] ~~Relating to the bottom of a sea, stream, or lake or to the organisms that live there.~~

hypereutrophic[3] conditions in the lake following Euro-American settlement (see also Appendix C, Section C.3).

Interpretation of sediment cores collected by Eilers et al. (2004) suggests that Upper Klamath Lake water quality has changed substantially over the past 100 years as consumptive water use practices (e.g., irrigation, municipal uses, wetland diking and draining [i.e., for conversion of wetlands to agricultural land]) and accompanying changes in land use practices throughout the upper Klamath and Lost River watersheds have increased (Walker 2001). Specifically, it appears that mobilization of phosphorus (e.g., from agriculture and other nonpoint sources) has pushed the lake from a naturally eutrophic state into its current hypereutrophic[4]-[3] state, allowing algal blooms to reach or approach their theoretical maximum (Walker 2001).

Evaluation of temporal and spatial patterns of algal community composition in Upper Klamath Lake reveals annual shifts between blue-green algae and diatom-dominated communities. Phytoplankton biovolumes in Upper Klamath Lake are dominated by beneficial diatoms in the spring (Kann 1997, Oregon Department of Environmental Quality [ODEQ] 2002, Sullivan et al. 2009), while summer and fall (June–October) algal blooms in Upper Klamath Lake are strongly dominated by noxious blue-green algal species (primarily *Aphanizomenon flos-aquae* but also including *Anabaena flos-aquae*, and *M. aeruginosa*) (Eilers et al. 2004, FERC 2007). *M. aeruginosa* is believed to be responsible for the production of microcystin toxin in the lake, which at times has exceeded the World Health Organization (WHO) limit for drinking water (1 µg/L) and the Oregon Department of Public Health guidelines for issuing public health advisories (Section 3.2.3.7). Health advisories are generally issued for recreational contact with water. Additional microcystin data collection in Upper Klamath Lake is ongoing (Vanderkooi et al. 2010, see Section 3.3, Aquatic Resources for more detail).

Downstream from the Link River to Keno Dam, temporal and spatial patterns of algal community composition are driven by blooms originating in Upper Klamath Lake. In 2008, a total of 141 algae species were identified in this reach, with most of these algae (98.8 percent) belonging to one of four algal groups: blue-green, cryptophytes, diatoms, and green (Sullivan et al. 2009). *Aphanizomenon flos-aquae* possessed the highest average density (61 percent) when present. As in Upper Klamath Lake, algal group composition in this reach is dominated by diatoms in the spring (56 percent of the total algal biovolume at mainstem sites), while in summer and fall blue-green algae represent

[3] Hypereutrophic: a state of water quality characterized by excessive concentrations of nutrients such as nitrogen and phosphorous and resulting in extremely high productivity. Such waters are often shallow, with intense algal blooms and periods of oxygen deficiency and high pH.

[4] Hypereutrophic: a state of water quality characterized by excessive concentrations of nutrients such as nitrogen and phosphorous and resulting in extremely high productivity. Such waters are often shallow, with intense algal blooms and periods of oxygen deficiency and high pH.

the dominant species (76~~-~~–80 percent of the total algae biovolume) (Sullivan et al. 2009). High mean algal abundances have been documented in the Klamath River at the Keno Bridge (Highway 66), Link River, and Upper Klamath Lake (at Freemont St. Bridge) (Raymond 2005, Sullivan et al. 2009). The prevalence of beneficial diatoms increases relative to noxious blue-green algal species (including nitrogen-fixing and bloom-forming blue-green algae) ~~moving~~in the river downstream from Keno Dam (Kann and Asarian 2006). However, farther downstream within the Copco/Iron Gate Reservoir complex, diatoms decrease again in abundance relative to blue-green algae ~~within the Copco/Iron Gate Reservoir complex,~~ as described further in ~~the~~ Section 3.4.3.4.

The reach from Link River to Keno Dam has extremely poor water quality, especially during summer months, with water ~~temperature~~ temperatures exceeding 25ºC, pH approaching 10 units, dense algal blooms, and ~~DO~~dissolved oxygen concentrations below 4 mg/L (National Research Council 2004, Deas and Vaughn 2006, Kann and Smith 1999). Decomposition of the algae and organic matter transported from Upper Klamath Lake to this reach is largely responsible for the low ~~DO concentration~~dissolved oxygen concentrations measured during summer and early fall (see Section 3.2.3.5 and Appendix C, Section C.4.1.3 for more detail). The large-scale settling of algal-derived (organic) suspended materials in the Keno Impoundment/Lake Ewauna is one of the primary physical mechanisms responsible for the removal of dense seasonal blue-green algal blooms that originate in Upper Klamath Lake and are transported into the upper reaches of the Klamath River. Further breakdown and loss occurs as algal cells are exposed to turbulent mixing in the river from Keno Dam to J.C. Boyle Reservoir (see also Section 3.2.3.3 and Appendix C, C.2.1.3).

3.4.3.3.2 Periphyton

Periphyton ~~is~~ are abundant in portions of the upper Klamath River. In the Klamath Basin, one periphyton species that can reach nuisance levels is *Cladophora*, which are common in nutrient enriched waters (Dodds 1991, FERC 2007), particularly with abundant inorganic nitrogen. Periphyton ~~is~~are of particular concern in the Sprague River, tributary to Upper Klamath Lake, where the dominance of these species results in dramatic diurnal fluctuations in ~~DO~~dissolved oxygen and pH (ODEQ 2002). Because *Cladophora* provide an ideal habitat for the polychaete host of both *C. shasta* and *P. minibicornis*, the presence of these species may result in an increased abundance of the polychaete host populations, potentially resulting in increased exposure to and incidence of fish disease (see Section 3.3.3.3).

3.4.3.4 ~~Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam~~Hydroelectric Reach

3.4.3.4.1 Phytoplankton

Excluding patterns of seasonal algal growth within the reservoirs, blue-green algae dominance and biovolume in riverine sections of the Hydroelectric Reach generally decrease ~~from sites upstream of J.C. Boyle Reservoir (RM 224.7 to 228.3)~~with distance downstream ~~through this area of analysis~~ (Kann and Asarian 2006~~).~~ , Kann and Corum

2009). In addition to the large degree of settling of suspended algal materials in the upstream Keno

Impoundment/Lake Ewauna and turbulent break-down of algal cells in the river reach from Keno Dam to J.C. Boyle Reservoir (see previous section), dilution from groundwater springs in the J.C. Boyle Bypass Reach can further decrease concentrations of algal cells and associated toxins (i.e., microcystin) in the Upper Klamath River (see also Section 3.2.3.3 and Appendix C, C.2.1.4).

However~~; this~~, the decreasing riverine trend is interrupted by large summer and fall blooms ~~of~~ of blue-green algae in Copco 1 and Iron Gate Reservoirs (Kann and Asarian 2006~~,~~; Raymond 2009; Asarian et al. 2009, Kann and Asarian 2011). In these two reservoirs, a bloom of diatoms generally occurs in ~~March~~spring to early summer, followed by a period of low chlorophyll-*a* concentrations (FERC 2007~~). Blue-green algae dominate the algal community during the late~~ ; Raymond 2008, 2009, 2010) (see also Appendix C, Section C.6.1). Large algae blooms occur again in the reservoirs in mid-summer to fall months, ~~with large blooms of *Anabaena*~~dominated by *Aphanizomenon flos-aquae* and *M. aeruginosa* ~~in the reservoirs (~~(Asarian and Kann 2011; Kann 2006~~,~~; FERC 2007~~). The incidence and magnitude of *M. aeruginosa* in the reservoirs is high relative to stations upstream, where blooms of *Aphanizomenon flos-aquae* are more prevalent~~; Raymond 2008, 2009, 2010). During these blooms, *M. aeruginosa* typically constitutes a higher proportion of the overall biomass than it does when it occurs upstream in Upper Klamath Lake and the Keno Impoundment/Lake Ewauna (Kann and Asarian 2006~~).~~) (see Section 3.4.3.3).

Copco 1 and Iron Gate Reservoirs provide ideal habitat conditions during late summers for the proliferation of large blooms of toxigenic *M. aeruginosa*, which subsequently become the source of *M. aeruginosa* in the Lower Klamath River. This pattern is robust and repeatable in most years. Figure 3.4-1, modified from Kann and Asarian (2007), illustrates the pattern in 2005. At the river station just upstream of Copco 1 Reservoir ("KRAC" in Figure 3.4-1), *M. aeruginosa* was never detected during multiple summer samplings, despite the fact that other, nitrogen-fixing cyanobacteria such as *Aphanazominon flos-aquae* were detected at KRAC during the same period (Kann and Asarian 2007). During the same period, blooms of *M. aeruginosa* within the reservoirs (Copco Reservoir stations CR02 and CR01, and Iron Gate Reservoir stations IR03 and IR01) were pronounced. Among all reservoir samplings in 2005, *M. aeruginosa* comprised 20–60% of sample biovolume and during some periods it was 60–100% of sample biovolume, particularly in Iron Gate Reservoir. Significant export of the *M. aeruginosa* bloom to downstream reaches is evident by the relatively high biovolume observed at the station downstream from Iron Gate Dam (KRBI). Nearly identical patterns were documented for other years, such as 2006 (Kann and Corum 2007), and 2008 (Kann and Corum 2009), and aggregated over longer time period such as 2001–2004 (Kann 2006) and from 2005–2011 (Asarian and Kann 2011), demonstrating the repeatable nature of this phenomenon.

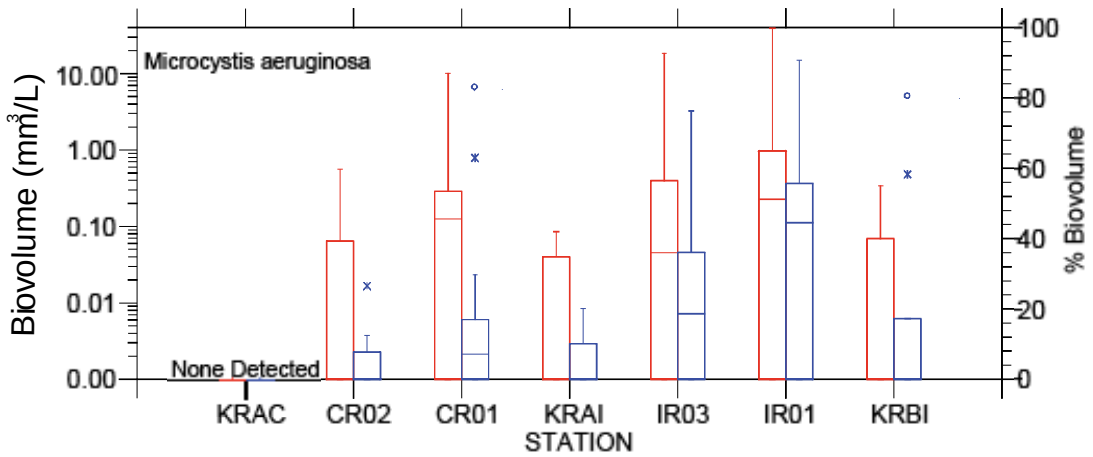


Figure 3.4-1. Biovolume (in red) and percent biovolume (in blue) of Microcystis aeruginosa above, within, and downstream from Copco 1 and Iron Gate Reservoirs during 2005. Station definitions: KRAC, Klamath River above Copco Reservoir; CR01, Copco Reservoir Station 1; CR02, Copco Reservoir Station 2; KRAI, Klamath River above Iron Gate Reservoir; IR03, Iron Gate Reservoir Station 3; IR01, Iron Gate Reservoir Station 1; KRBI, Klamath River below Iron Gate Reservoir. Source: modified from Kann and Asarian (2007).

Of note is that the phytoplankton composition of the river site just upstream of Copco 1 Reservoir does not merely reflect downstream transport of intact algal blooms from Upper Klamath Lake. As described above, seasonal phytoplankton blooms dominated by *Aphanizomenon flos-aquae* occur annually in Upper Klamath Lake and are transported into the Keno Impoundment/Lake Ewauna where they largely settle out of the water column (see Section 3.2.3.3 and Appendix C, Section C.2.1.3), although some colonies are occasionally detected at the inflow to Copco Reservoir (KRAC) (Kann and Asarian 2007). Although *M. aeruginosa* also occurs in Upper Klamath Lake, but generally at relatively low proportions, it rarely survives the journey through Keno Impoundment/ Lake Ewauna and into Copco and Iron Gate Reservoirs, as evidenced by only a few detections at the KRAC site (Asarian and Kann 2011).

The documented presence of algal toxins in water and fish tissue in the reach from upstream of J.C. Boyle Reservoir to Iron Gate Reservoir corresponds with spatial and temporal patterns in the distribution of blue-green algal blooms within ~~this~~ the reach. Recent data indicate that while microcystin ~~toxin occurs at~~ toxins occur in Upper Klamath Lake, their concentrations decrease downstream to undetectable or very low levels in the Klamath River directly upstream of J.C. Boyle Reservoir ~~and reaches high concentrations~~. This pattern reverses, however, as water is impounded in ~~the~~ Copco 1 and Iron Gate Reservoirs, creating ideal growing conditions for blue-green algae, and producing high microcystin concentrations from July through October (Kann and Corum

2006, 2009). Since ~~2007~~2005, high levels of microcystin have prompted the posting of public health advisories around the ~~reservoirs~~Copco and Iron Gate Reservoirs, and during certain years, along ~~the length~~reaches of the Klamath River downstream from Iron Gate Dam during late summer months (see Appendix C, Section C.6.1.4 for more detail). In 2010, the Klamath Hydroelectric Project reservoirs and the entire river downstream ~~of~~from Iron Gate Dam (including the estuary) were posted to protect public health due to elevated cyanobacteria cell counts and cyanotoxin concentrations. High cell counts and toxin concentrations in the water column ~~have significant implications for~~ can result in bioaccumulation of microcystin ~~toxin~~ in muscle and/or liver tissues of resident (i.e., yellow perch~~,~~) and anadromous fish (i.e., juvenile hatchery Chinook, adult Chinook salmon, steelhead) and in freshwater mussels (Kann 2008, Kann and Corum 2009~~).~~, Kann et al. 2011). Section 3.3.3.3 Algal Toxins presents a discussion of algal toxins ~~as related to fish health~~in fish and mussel tissue.

~~Moreover, the reservoirs serve as the primary source of blue-green algae and associated toxins for the areas downstream of Iron Gate Dam, as described in Section~~ 3.4.3.~~5 and Appendix C, Section C.6.~~

4.2 Periphyton

Nuisance blooms ~~among the~~of periphyton have not been documented in the riverine portions of this reach. In the J.C. Boyle ~~peaking reach~~Peaking Reach, it has been noted that periphyton tends to be absent from the margins of the river that are alternately dried and wetted during peaking operations (E. Asarian, pers. comm., 2011).

3.4.3.5 Klamath River ~~downstream of~~Downstream from Iron Gate Dam

3.4.3.5.1 Phytoplankton

Although both ~~*Anabaena*~~*Aphanizomenon flos-aquae* and *M. aeruginosa* have been observed just downstream ~~of~~from Iron Gate Dam, and as far downstream as the Klamath Estuary, this ~~area~~ reach of the river is more suitable for the growth of periphytic algae, and does not provide ~~suitable~~optimal habitat for phytoplankton species that ~~generally only~~ typically thrive in reservoir and lake environments. ~~Accordingly, these species~~ As discussed above, data collected in 2005 and 2007–2010, suggest that the phytoplankton composition of river sites immediately downstream from Copco 1 and Iron Gate Reservoirs can become dominated by blue-green algae on a seasonal basis, when large blooms occurring in the upstream reservoirs are transported downstream. Further downstream in the, *Aphanizomenon flos-aquae* and *M. aeruginosa* are generally documented at lower abundances ~~in this area relative to the diatom species observed in the middle and lower Klamath River (Kann and Asarian 2006). Despite this relatively low abundance, however, algal toxins are a critical concern in this reach because they are released from the reservoirs in dissolved phase, as well as in intact algal colonies that~~Lower Klamath River (Kann and Asarian 2006, Raymond 2008). In general, turbulent mixing, increased velocity, and tributary dilution result in the gradual removal of suspended algal materials and chlorophyll-*a* from the water column as the river travels downstream (Armstrong and Ward 2008, Ward and Armstrong 2010) (see also discussion in Appendix C.2.2.1 and C.6.2.1). Occasionally (e.g., 2007), *M. aeruginosa* transported

downstream from Copco 1 and Iron Gate Reservoirs can become trapped and accumulate in quiescent pools along the margins of the Lower Klamath River (Kann and Corum 2006), resulting in localized cell abundances greater than those measured immediately downstream from Iron Gate Dam (Kann and Corum 2009, Raymond 2008, Fetcho 2008). At times, accumulations of blue-green algae, including *M. aeruginosa*, along shorelines and in protected coves and backwaters in the Lower Klamath River can result in exceedances to the SWRCB/OEHHA Public Health Threshold (40,000 cells/mL) and WHO guidelines for *M. aeruginosa* cell density (20,000 cells/mL). These thresholds and guidelines are issued for safe recreational water contact (not drinking water).

Despite these localized accumulations of blue-green algae along shorelines and in backwaters, data collected during June through November from 2005–2009 indicate that the majority of *M. aeruginosa* cell density measurements at river sites in the Lower Klamath River are less than the SWRCB/OEHHA Public Health Threshold of 40,000 cells/mL, while the vast majority of *M. aeruginosa* cell densities in Copco 1 and Iron Gate Reservoir sites are greater than the SWRCB/OEHHA threshold (Appendix C, Figure C-30; see also Kann et al. 2010, Kann and Bowman 2012). A similar pattern exists with respect to the lower WHO guidelines for *M. aeruginosa* cell density (20,000 cells/mL) during June through November 2005–2009 (i.e., the majority of river station measurements are less than the WHO guidelines, while the majority of reservoir station measurements during late summer and fall are greater than the WHO guidelines). There is no documentation of river occurrences of blue-green algae prior to the larger reservoir blooms, although sampling of blue-green algae (and algal toxins) does not occur in the Lower Klamath River until after large-scale summer and fall blooms in Copco 1 and Iron Gate Reservoirs have been observed.

Algal toxins are a critical concern in the Klamath River downstream from Iron Gate Dam because they can remain viable along the low-velocity margins of the river where little mixing occurs (Kann and Corum 2009). ~~This creates problems associated with toxin bioaccumulation and toxicity in areas beyond those that provide suitable conditions for growth of blue-green algae (Kann and Corum 2009). Data collected from 2004 through 2009 indicate high levels of microcystin in Copco 1 and Iron Gate Reservoirs, with measured concentrations exceeding the California State Water Resources Control Board (SWRCB)/Office of Environmental Health and Hazard Assessment (OEHHA) public health threshold of 8 µg/L by over 1000 times in Copco Reservoir in 2006, 2007, 2008, and 2009 (see Appendix C, Section C.6.1.4) (Kann 2007a–2007d, Kann and Corum 2007 and 2009, Kann et al. 2010, Jacoby and Kann 2007) (see Appendix C, Section C.6.1.4~~Concentrations of microcystin toxin in the Klamath River downstream from the Hydroelectric Reach are typically 1 to 3 orders of magnitude lower than observed in Copco 1 and Iron Gate Dam reservoirs (Appendix C, Figure C-32; see also Raymond 2008, Kann et al. 2010, Kann and Bowman 2012); however, the SWRCB/OEHHA Public Health Threshold (8 ug/L) and WHO guidelines for exposure to microcystin (i.e., < 4 µg/L) have been exceeded downstream from Iron Gate Dam on numerous occasions (Kann 2004, Kann and Corum 2009, Kann et al. 2010, Fetcho 2011, Kann and Bowman 2012), including late-summer/early-fall *M. aeruginosa* blooms in September 2007, 2009,

and 2010 from Iron Gate Dam (RM 190.1) to the mouth of the Klamath River (RM 0.0). Overall, the 2005–2009 dataset indicates that while Lower Klamath River exceedances do occur, they are far less in number than exceedances in Copco 1 and Iron Gate Reservoirs (Appendix C, Figure C-32; see also Raymond 2008, Kann et al. 2010, Kann and Bowman 2012). Data from 2007 also indicate that microcystin ~~bioaccumulation~~can bioaccumulate in juvenile salmonids reared in Iron Gate hatchery (Kann 2008; see Section 3.3.3.3 Algal Toxins for a discussion of algal toxins as related to fish health). ~~Annual peaks in *M. aeruginosa* biovolume occur in the late summer to fall months (e.g., August and September) of most recent years directly downstream of Iron Gate Dam (Kann and Asarian 2006). The degree to which reservoir production of nitrogen-fixing blue-green algae contribute to overall nitrogen levels in the middle and lower Klamath River remains poorly understood (Stillwater Sciences 2009).~~

Overall, the literature and studies to date overwhelmingly support the conclusion that algal blooms in Copco 1and Iron Gate Reservoirs are the primary source of *M. aeruginosa* and microcystin toxin that are detected seasonally in the river downstream from the Hydroelectric Reach. The relatively high turbulence and velocity of the Lower Klamath River makes it poor habitat for these algal species to thrive in most reaches. Some colonies of *M. aeruginosa* do appear to accumulate and may actually persist in the localized quiescent waters and pools of the lower river, but there is no evidence to indicate that these algal colonies would accumulate or propagate in these types of areas without Copco 1 and Iron Gate Reservoirs as an upstream source. That the reservoirs themselves receive excessive nutrients and potentially a small amount of viable algal cells transported from Upper Klamath Lake and/or the Keno Impoundment/Lake Ewauna, while well documented, does not diminish the fundamental role of Copco 1 and Iron Gate reservoirs in fostering excessive growth of *M. aeruginosa*, the production of high concentrations of microcystin, and the downstream transport of both to the Lower Klamath River

3.4.3.5.2 Periphyton

Sampling of periphyton in the Klamath River downstream ~~of~~ from Iron Gate Dam revealed a shift in community composition, where nitrogen-fixing species are not present directly downstream ~~of~~from Iron Gate Dam but begin to appear by Seiad Valley and then make up an increasing percent of periphyton biomass at sites further downstream. Nitrogen-fixing species are dominant at sites between Orleans and Turwar (Asarian et al. 2010; E~~.~~. Asarian, pers. comm., 2011). The increased prevalence of nitrogen-fixing periphyton coincides with very low levels of inorganic nitrogen (ammonia and nitrate) concentrations in water samples.

In a single survey downstream ~~of~~from Iron Gate Dam, Eilers (2005) ~~documented~~documented relatively high periphyton coverage (near 80 percent) on stream rocks and periphyton chlorophyll-*a* content (near 50 micrograms per square centimeter [$\mu g/cm^2$]) immediately downstream ~~of~~ from Iron Gate Dam (RM 189.7), and relatively low periphyton coverage (near 10 percent) on stream rocks several miles downstream near the Collier Rest Area at the I-5 bridge (RM 178).

Downstream ~~of~~from the Collier Rest Area, both periphyton coverage and chlorophyll content increased gradually to peak levels ~~in the Klamath River~~ near the ~~mouth of~~confluence with the Salmon River (RM 67). ~~*Cladophora* dominated the Shasta River site, where it made up one half of the~~While periphyton ~~community by biovolume; however, these species were not documented at any of the other tributary or mainstem Klamath River sites surveyed (Eilers 2005). As discussed previously, *Cladophora* provide suitable habitat for the polychaete worm that is the intermediate host for fish parasites. Periphyton~~ biomass was generally found to be low to moderate ~~in this study; however,~~ during the survey (with the exception of the site immediately downstream from Iron Gate Dam), it is believed that increased discharge (i.e., a doubling of flow from ~~about~~approximately 600 cfs around August 15 to ~~about~~approximately 1,200 cfs near the end of ~~the month, settling at about~~August, and decreasing to approximately 800 cfs by September 1, the start of the ~~study~~survey) may have dislodged filamentous algae that had proliferated under the previous lower flow regime (Eilers 2005, FERC 2007). *Cladophora* dominated the Shasta River (tributary) site, where it made up one half of the periphyton community by biovolume; however, these species were not documented at any of the other tributary or mainstem Klamath River sites surveyed (Eilers 2005). As discussed previously, *Cladophora* provide suitable habitat for the polychaete worm that is the intermediate host for fish parasites. However, data regarding *Cladophora* biomass ~~is~~ are limited, making it difficult to determine the primary factors that control the biomass and distribution of these species (E. Asarian, pers. comm., 2011). Periphyton studies are ongoing under KHSA Interim Measure 15 to better document periphyton biomass in this reach of the Klamath River.

~~*3.4.3.6 Klamath Estuary*~~

~~*The algal community in the*~~ _____*Klamath Estuary*

The algal community in the Klamath Estuary is dominated by phytoplankton, but ~~has~~ has more periphyton in the upstream areas where the estuary has more riverine characteristics. The presence of brackish water ~~in the estuary~~ influences the types of algae present in different areas of the estuary. Like the ~~lower~~Lower Klamath River, the Klamath Estuary has an algal community composed primarily of diatoms and blue-green algae (Fetcho 2007, ~~Fetcho~~ 2008, 2009). Phytoplankton densities are generally lower in this area than those measured concurrently in the ~~lower~~Lower Klamath River~~.~~. On one occasion, in September 2007, estuary concentrations of *M. aeruginosa* twice exceeded the Yurok Tribe posting action level (40,000 cells/mL). On a separate occasion, in September 2005, ~~-~~concentrations exceeded the WHO guidelines for low risk recreational use (20,000 cells/mL) (Fetcho 2006, ~~Fetcho~~ 2008). These instances of elevated levels of *M. aeruginosa* corresponded with elevated levels measured at upstream locations in the ~~lower~~Lower Klamath River~~, suggesting that *M. aeruginosa* is transported from the Klamath Hydroelectric Project reservoirs into the lower river and subsequently into the estuary.~~ .

Although periphyton data for the estuary ~~is~~ are unavailable, in part due to the difficulty of sampling in deeper areas, abundant periphyton cover has been documented in the south slough (Hiner 2006).

3.4.3.7~~–~~ Marine Nearshore Environment

The algal community of the near shore Pacific Ocean is dominated by marine algae, including attached red and brown seaweeds, as well as many marine planktonic species. The freshwater algae discussed above are not expected to ~~grow~~thrive in this turbulent, saline environment, but may be carried into the ocean with the current and survive for limited periods. Toxins can also be washed into the ocean, but are expected to be rapidly diluted~~, and there~~. There have been no reports of problems relating to freshwater algal toxins in the Pacific Ocean near the mouth of the Klamath River; however, algal toxins have been reported as the cause for numerous sea otter deaths in the area of Monterey Bay, California (Miller et al. 2010).

3.4.4 Environmental Consequences

3.4.4.1~~–~~ Environmental Effects Determination ~~Methodology~~

Methods

Existing information regarding blue-green algal blooms in the Klamath Basin suggests that several critical factors ~~determine~~affect the frequency and toxicity of such blooms in Upper Klamath Lake and the Klamath Hydroelectric Project reservoirs: water temperature, light levels (FERC 2007), flow rates (Kann 2006), nutrient availability/ratios (Chorus and Bartram 1999, Fetcho 2008, Moisander et al. 2009) and wind-induced turbulence and mixing. In this nutrient-rich system, elevated temperatures and increased light levels that occur during the summer and early fall result in seasonal blue-green algal blooms in Upper Klamath Lake and the Klamath River, and especially the reservoir reaches. ~~Upstream areas in or~~ In addition to Upper Klamath Lake and Copco 1 and Iron Gate Reservoirs, riverine reaches in close proximity to the reservoirs generally ~~have larger blooms relative to the downstream river reaches~~experience high abundance of *M. aeruginosa* (Kann 2006, Kann and Corum 2009), and with the highest ~~*M. aeruginosa* cell density~~ cell densities and microcystin toxin concentrations ~~occur~~ occurring within and directly below the reservoirs (Kann and Corum 2009). This information indicates that the reservoirs provide ideal conditions (see Section 3.4.3.1) for proliferation of blue-green algal species, and likely also serve as a source of algal cells and their toxins to downstream areas. While blue-green algae can occur in riverine and estuarine environments (Christian et al. 1986, Lehman et al. 2005, Lehman et al. 2008), the rate of turbulent mixing in the water column relative to algal flotation velocity is a critical factor controlling the size of blue-green algal blooms (Huisman et al. 2004).

~~The Lead Agencies assessed~~The assessment of the effects of the Proposed Action and ~~alternatives' effects on~~ alternatives on toxic algal blooms in the area of analysis is based on the expected effects of the alternatives on water temperature, hydrodynamic conditions (water movement potential~~), and~~ nutrient availability. ~~The Lead Agencies~~

~~used modeling~~Existing model output and empirical data describing the expected effects of dam removal on water quality~~, as well as~~ (see Section 3.2.4.1) provide the basis for the anticipated effects on water temperature, suspended sediment concentrations, and nutrients. In combination with existing literature regarding the biology and ecology of blue-green algal species, the water temperature and nutrient information is used to determine whether the Proposed Action and the alternatives would alter the spatial extent of ~~the river that provides suitable growing conditions for blue-green algae.~~

optimal habitat for blue-green algae or periphyton in the area of analysis.

~~The Lead Agencies evaluated~~ The following specific metrics ~~including the~~ are evaluated:

- The extent to which monthly mean and maximum water temperatures would be within the range ~~from~~ of 18 to 25 °C ~~and~~or exceed 28 °C~~, total~~;
- Total suspended sediment and nutrient concentrations~~,~~; and ~~the~~,
- The presence or absence of lacustrine (i.e., lake-like) conditions. ~~Nutrient and suspended sediment concentration data came from the TMDL and SRH-1D model output, respectively. The Lead Agencies obtained benthic chlorophyll-*a* data for evaluation of potential changes in periphyton biomass from the Nutrient Numeric Endpoint Analysis (NCRWQCB 2010a, Appendix 2). Mass balance nutrient budgets presented in Asarian et al. (2010) were also used to evaluate potential effects of the Proposed Project on periphyton. The Lead Agencies~~

The water temperature thresholds are selected ~~the temperature thresholds~~ based on information regarding required temperatures for growth and toxicity of blue-green algae provided in the ~~blue-green~~Blue-Green Algae Work Group assessment (SWRCB et al. 2010) and Van Der Westhuizen and Eloff (1985). ~~The Lead Agencies assessed~~Suspended sediment and nutrient concentrations data are based on output from the SRH-1D model and the California Klamath River TMDLs model, respectively (see Section 3.2.4.1 and Appendix D for descriptions of these numeric models). Mass balance nutrient budgets presented in Asarian et al. (2010) are also used to evaluate the potential effects of the Proposed Project on periphyton growth. Benthic chlorophyll-*a* data for evaluation of potential changes in periphyton biomass are obtained from the Nutrient Numeric Endpoint Analysis conducted for development of the California Klamath River TMDLs (see NCRWQCB 2010, Appendix 2). Anticipated changes in water quality (i.e., water temperature, ~~nutrient and~~ suspended sediment concentrations, and nutrients) during the growth season (i.e., summer and early fall~~,~~) in the reservoirs at the Four Facilities and at various in-river locations throughout the project area~~. The Lead Agencies~~ are also used ~~this information~~ to evaluate Project-induced changes on other algal groups such as diatoms and periphyton.

3.4.4.2 Significance Criteria

For purposes of the EIS/EIR, impacts would be significant if they were to result in the following:

- An increase in the spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious phytoplankton blooms, including blue-green algae.
- An increase in the spatial extent, temporal duration, or biomass of nuisance periphyton (i.e.~~g.~~, *Cladophora*) growth.

3.4.4.3 Effects Determinations

3.4.4.3.1 Alternative 1: No Action/No Project Alternative

Phytoplankton

Continued impoundment of water in the reservoirs at the Four Facilities could support the long-term growth of seasonal nuisance and/or noxious phytoplankton blooms in the reservoirs and subsequent transport to downstream reaches of the Klamath River. Under the No Action/No Project Alternative, none of the actions under consideration would be implemented. The Klamath Hydroelectric Project would continue current operations under the terms of an annual license until a long-term license is finalized. Annual licenses would not include the actions associated with the Klamath Hydroelectric Settlement Agreement (KHSA) and Klamath Basin Restoration Agreement (KBRA). Some KBRA actions have already been initiated and would continue under the No Action/No Project Alternative. These include the Williamson River Delta Project, the Agency Lake and Barnes Ranch Project, fish habitat restoration work, and ongoing climate change assessments. Implementation of several Oregon and California TMDLs (Section 3.2.2.4) within the period of analysis is a reasonably foreseeable action associated with water quality under the No Action/No Project Alternative as the TMDLs are an unrelated regulatory action. ~~Hydroelectric~~Because changes to hydroelectric operations resulting from the relicensing process cannot be definitively predicted, it is assumed for the purposes of this analysis that operation of the reservoirs would continue as ~~they have been~~in recent years, providing peaking power generation during the summer as demand requires and conditions allow. However, increased water temperatures and nutrient loading associated with climate change could increase the spatial extent, temporal duration, toxicity, or concentration of blue-green algal blooms.

Continued impoundment of water at the Four Facilities could support long-term ~~(>2 years following dam removal)~~ growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach. Under existing conditions, nuisance phytoplankton blooms occur during summer and fall in Copco 1 and Iron Gate Reservoirs, with the most intense blooms generally occurring in the late summer (Section 3.4.3.4). High seasonal levels of algal toxins (microcystin) in the Project reservoirs are ~~linked to~~ caused by these intense blue-green algae blooms (~~Section~~Sections 3.2.3.7~~).~~ and 3.4.3.4.1).

TMDLs for the Upper Klamath Lake drainage, the Upper Klamath River and Lost River in Oregon, the Lower Lost River in California, and the Klamath River in California include allocations and/or targets for nutrients and/or chlorophyll-*a* (Section 3.2.2.4); full and successful implementation of these TMDLs would result in a decreased spatial extent, duration, and concentration of phytoplankton blooms in the Upper and Lower Klamath Basin (see also analysis for chlorophyll-*a* under the No Action/No Project Alternative, Section 3.2.4.3.1.6). As discussed in Section 3.2, Water Quality, the timeframes for achieving water quality objectives with respect to the TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full implementation would require decades to achieve.

Climate change is projected to result in increased water temperatures due to median annual increases in air temperatures of 3°C and decreases in snowpack (Snyder et al. 2004). The projected decreases in snowpack are associated with increased air temperatures and higher levels of rainfall relative to snowfall. Water temperature increases are generally expected to be more dramatic in the Lower Klamath Basin than in the Upper Basin over the next 50 years due to the cooling influence of ground water in the Upper Basin during the summer months (Hamilton et al. 2010). Between J.C. Boyle Reservoir and Iron Gate Dam, the benefits of substantial groundwater resources would not be realized because they are inundated by reservoirs or occur in bypass reaches (Hamilton et al. 2010). Higher intensity rainfall events are also expected to occur. Runoff from such events could increase the frequency with which the river exhibited high suspended sediment concentrations, which could increase the delivery of nutrients, such as phosphorous, to the reservoir system (Stillwater Sciences 2009). Increased summer temperatures and nutrient inputs would likely result in an increase in the magnitude, duration, and spatial extent of summer blooms of toxic blue-green algae.

Additionally, research conducted in the San Francisco Bay-Delta system indicates that increased temperatures could result in elevated toxicity of *M. aeruginosa* (i.e., increased microcystin concentrations produced by a bloom) (Mioni and Payton 2010). Under the No Action/No Project Alternative, an increase in the toxicity of seasonal phytoplankton blooms due to climate change, if it occurred, would be a significant impact. The anticipated effects of climate change would also occur over a timescale of decades and may offset improvements expected from successful TMDL implementation throughout the Upper and Lower Klamath Basin, particularly in the case of potential elevated toxicity of *M. aeruginosa*. However, overall, the benefits of nutrient reductions under the TMDLs are anticipated to be of greater relative importance than climate change with respect to phytoplankton blooms under the No Action/No Project Alternative.

Existing seasonal nuisance and/or noxious phytoplankton blooms in the Upper and Lower Klamath Basin are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease these blooms. Continued impoundment of water at the Four Facilities would result in no change from existing conditions.

Periphyton

Continued impoundment of water at the Four Facilities could support the growth of nuisance periphyton such as Cladophora downstream from Iron Gate Dam. Under existing conditions, periphyton coverage is relatively high immediately downstream from Iron Gate Dam, with coverage decreasing further downstream near the I-5 Bridge (RM 178), and increasing again to peak levels near the mouth of the Salmon River (RM 67) (Section 3.4.3.5). Because *Cladophora* provide suitable habitat for the polychaete worm that is the intermediate host for fish parasites, the presence of large seasonal periphyton mats immediately downstream from the Hydroelectric Reach have been linked to the potential for increased exposure to and incidence of fish disease.

As described above for phytoplankton (i.e., blue-green algae), full and successful implementation of Oregon and California TMDLs would decrease nutrients in the Klamath River and would result in decreased spatial extent, temporal duration, and/or biomass of periphyton mats. As discussed in Section 3.2, Water Quality, the timeframes for achieving water quality objectives with respect to the TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full implementation would require decades to achieve.

Conversely, increases in water temperature with climate change are likely to result in increased growth of periphyton in the Klamath River. Increased temperature through climate change may exacerbate biostimulatory conditions through increased periphyton metabolic and growth rates. As with phytoplankton, the benefits of nutrient reductions under the TMDLs are anticipated to be of greater relative importance than climate change with respect to periphyton spatial extent, bloom duration, and biomass under the No Action/No Project Alternative. **Existing seasonal nuisance periphyton growth in the Upper and Lower Klamath Basin is potentially adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease periphyton growth. Continued impoundment of water at the Four Facilities would result in no change from existing conditions.**

The implications of potential changes in periphyton biomass and community composition for dissolved oxygen and the spread of fish disease are described in Water Quality Section 3.2.4.3 and Aquatics Section 3.3.3.3, respectively.

3.4.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

Under the Proposed Action, the four major dams in the Klamath Hydroelectric Project (J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) would be removed along with the ancillary facilities of each installation. This includes the entire dam, the powerhouses, spillways, and other infrastructure associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to the United States Department of the Interior (DOI) and the implementation of the KBRA.

Upper Klamath Basin Upstream of the influence of J.C. Boyle Reservoir

Phytoplankton

The Proposed Action could decrease the long-term spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious phytoplankton in the area of analysis. Dam removal activities would not affect the Klamath River upstream of J.C. Boyle Reservoir. Effects of KBRA in this reach are discussed in Section 3.4.4.3.2.9 Alternative 2: Full Removal of Four Dams – KBRA – Programmatic Measures. **There would be no change from existing conditions for nuisance and/or noxious phytoplankton.**

Periphyton

The Proposed Action could decrease the long-term spatial extent, temporal duration, or biomass of nuisance periphyton in the area of analysis. Dam removal activities would

not affect the Klamath River upstream of J.C. Boyle Reservoir. Effects of KBRA in this reach are discussed in Section 3.4.4.3.2.9 KBRA – Programmatic Measures. **There would be no change from existing conditions for nuisance periphyton.**

Hydroelectric Reach

Phytoplankton

Sediment release associated with the Proposed Action could cause short-term increases in sediment-associated nutrients downstream from J.C. Boyle Dam that could stimulate nuisance and/or noxious phytoplankton growth in the Hydroelectric Reach. Under the Proposed Action, the short-term increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact due to the timing of reservoir drawdown (i.e., in the wintertime when rates of primary productivity and microbially mediated nutrient cycling are relatively low) and light limitation from high concentrations of suspended sediments in the water (see corresponding discussion in Section 3.2.4.3.2.3). The minimum bioavailability of nutrients in sediments mobilized during dam removal would be unlikely to affect phytoplankton in the short term. Further, by mid-to late- spring when phytoplankton would begin to bloom again, reservoir drawdown would be nearly complete and little to no quiescent habitat would remain in the Hydroelectric Reach. Thus, phytoplankton blooms, and in particular nuisance and/or noxious phytoplankton blooms, would be very limited if not absent from the Hydroelectric Reach. **There would be no effect of short-term (<2 years following dam removal) increased nutrients due to sediment releases in the Hydroelectric Reach.**

Under the Proposed Action, removal of the reservoirs at the Four Facilities would eliminate lacustrine habitat behind the dams and could decrease the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms. This change, particularly within the larger Copco 1 and Iron Gate Reservoirs, would decrease or eliminate the system's support for excessive growth of blue-green algae over the long term by eliminating large areas of quiescent habitat where these algal species currently thrive. This dramatic decrease in the amount of optimal habitat available for nuisance and/or noxious phytoplankton species would occur even if relatively high nutrient concentrations were to remain in the Klamath River system. This would substantially reduce seasonal phytoplankton bloom occurrence and the associated production of algal toxins in these reservoirs that are potentially harmful to animals and humans. This would be a major benefit of the Proposed Action. The Proposed Action would provide a substantial long-term benefit with regard to phytoplankton in the Hydroelectric Reach. **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton due to the elimination of the reservoirs in the Hydroelectric Reach would be beneficial.**

Periphyton

Sediment release associated with the Proposed Action could cause short-term increases in sediment-associated nutrients downstream from J.C. Boyle Dam that could stimulate nuisance periphyton growth in the Hydroelectric Reach. While quiescent habitat for phytoplankton would be eliminated in the short term by reservoir drawdown and dam removal (see above), periphyton growth in the riverine reaches of the Hydroelectric Reach could occur during the initial summer and fall months following drawdown. However, although increased short-term (<2 years following dam removal) nutrient availability may occur under the Proposed Action, it is unlikely to result in substantial

increases in periphyton growth because the effects of increased nutrients in the Hydroelectric Reach would be minimized by the timing of reservoir drawdown (i.e., in the wintertime when rates of primary productivity and microbially mediated nutrient cycling are relatively low) and light limitation from high concentrations of suspended sediments in the water (see also Section 3.2.4.3.2.3.). Additionally, higher flows during drawdown and late spring storm events would result in greater bed turnover (see Section 3.3.4.3, Bedload Sediment) and scouring, which would greatly limit, if not eliminate, short-term establishment of periphyton in the Hydroelectric Reach. **Thus, there would be no effect of short-term increased nutrients on periphyton blooms in the Hydroelectric Reach.**

Under the Proposed Action, conversion of the reservoir areas to a free-flowing river and the elimination of hydropower peaking operations could cause long-term slight increases in nutrients and increases in low-gradient channel margin habitat available for nuisance periphyton in the Hydroelectric Reach downstream from J.C. Boyle Dam. Periphyton growth in low-gradient channel margin areas in the Hydroelectric Reach could increase on a seasonal basis following dam removal. While nutrient increases in this reach would be less than significant following full attainment of the Oregon and California TMDLs (Section 3.2.4.3.2.3), removal of the reservoirs and elimination of hydropower peaking operations in the J.C. Boyle Peaking Reach would immediately provide additional low-gradient habitat suitable for periphyton. The particular periphyton species that may become abundant in these areas are unknown (E. Asarian, pers. comm., 2011). Thus, the difference between the long-term significance calls for nutrients and periphyton in the Hydroelectric Reach is due to the increase in habitat availability for periphyton, rather than the relatively small increase in already elevated nutrient concentrations, which, as noted in Section 3.2.4.3.2.3, would be less than significant. The increase in nutrient inputs from the Upper Klamath Basin are expected to decrease over time with implementation of the Oregon and California TMDLs and KBRA projects, minimizing future potential for heavy colonization of periphyton mats. Potential increases in periphyton growth in the Hydroelectric Reach could also be disrupted by more frequent river bed turnover (see Section 3.3.3.6.2.1.2) and increased flow variability during storm flow under the Proposed Action, which may result in increased scouring of periphyton during late spring storm events and a lower overall biomass later in the growth season. However, the overall effect of the Proposed Action would likely be to increase periphyton in the re-exposed margins of low gradient river channels in the Hydroelectric Reach until full attainment of the Oregon and California TMDLs can be achieved. **Under the Proposed Action, long-term increases in nuisance periphyton growth due to increases in available habitat along channel margin areas of the Hydroelectric Reach downstream from J.C. Boyle Dam would be a significant impact.**

The above "significant impact" determination represents a conservative assessment of the effects of the Proposed Action on periphyton growth. The response of periphyton in the river is subject to many competing processes that could either accelerate or hinder improvements. Improvements (i.e., reductions in biomass) are expected from several processes such as scour, long term nutrient reductions stemming from TMDL or KBRA-

related actions (see WQST [2011] and below subsection on KBRA under Alternative 2 – Proposed Action), and in-stream retention processes, whereas improvements could be hindered by processes such as reduced nutrient retention from the reservoirs or climate change. Additional research prior to the facilities removal would help resolve these uncertainties. Monitoring could also be conducted after dam removal which would help identify the actual changes in the periphyton community resulting from dam removal. The implications of potential changes in periphyton biomass and community composition for dissolved oxygen and the spread of fish disease are described in Sections 3.2.4.3.2.4 and 3.3.3.3, respectively.

Under the Proposed Action, construction/deconstruction activities would include the demolition of various recreation facilities. The existing recreational facilities located along the banks of the reservoirs will be removed once the reservoirs are drawn down. Facilities such as campgrounds and boat ramps, currently located on the reservoir banks will need to be relocated down slope to be near the new river channel once the reservoir is removed. Impacts specific to the deconstruction of the Recreation Facilities are discussed in Section 3.20, Recreation. Once the reservoirs are drawn down, the existing recreational facilities would be well above the new river channel. The removal of the facilities is not expected to impact algae biomass or lifecycles. The potential for impacts during the facilities removal will minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **There would be no effect on algae (phytoplankton or periphyton) levels in the Hydroelectric Reach or the Klamath River downstream from Iron Gate Dam as a result of the removal of the recreational facilities.**

Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in increased bedload mobility and increased scour of nuisance periphyton in the Hydroelectric Reach. The Proposed Action includes seven years of gravel placement; the first year would be before the Secretary makes a determination, and would therefore be included in the No Action/No Project Alternative (Note: since there is no nuisance periphyton growth in the Hydroelectric Reach under current conditions [see Algae Section 3.4.3.4.2], IM 7 would not affect periphyton under the No Action/No Project Alternative). The following seven years would be part of the Proposed Action prior to dam removal. Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches using a passive approach before high flow periods, or to provide for other habitat enhancement in the Klamath River upstream of Copco 1 Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal (see also Aquatics Section 3.3.3.6.2.3). Increased mobility of streambed material due to pre-dam removal gravel augmentation may also result in increased scouring of periphyton and a lower overall biomass in this reach following dam removal, although the effects may be small. Work on IM 7 began in fall 2010 with the contracting,

planning, and permitting phase. **Under the Proposed Action, the effect of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, on nuisance periphyton growth in the Hydroelectric Reach would be beneficial.**

Klamath River Downstream from Iron Gate Dam

Phytoplankton

Under the Proposed Action, removal of the reservoirs would eliminate lacustrine habitat behind the dams and could substantially reduce or eliminate the long-term transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River downstream from Iron Gate Dam. Existing data indicate that large seasonal blue-green algae blooms (i.e., *M. aeruginosa*) and associated algal toxins (i.e., microcystin) in Copco 1 and Iron Gate Reservoirs and the Klamath River downstream from Iron Gate Dam are not the result of algal transport from Upper Klamath Lake; rather, these blooms occur in the two largest Project reservoirs and are transported to Klamath River sites downstream from Iron Gate Dam (see Figure 3.4-1). The following physical mechanisms are responsible for the removal of large seasonal blue-green algal blooms that originate in Upper Klamath Lake and are transported into the upper reaches of the Klamath River:

1. Large-scale settling in the Keno Impoundment/Lake Ewauna (see Section 3.2.3.3 and Appendix C, Section C.2.1.3);
2. Turbulent mixing and associated algal cell breakdown in the river from Keno Dam to J.C. Boyle Reservoir (see Section 3.2.3.3 and Appendix C, C.2.1.3); and,
3. Dilution from springs in the J.C. Boyle Bypass Reach (see Section 3.2.3.3 and Appendix C, C.2.1.4).

Further, under current conditions, microcystin toxin rarely persists through steps 1 to 3, occurring at low (very infrequently) to non-detectable (primarily) concentrations at the Klamath River station just upstream of Copco 1 Reservoir ("KRAC") (see also Figure 3.4-1). The aforementioned removal mechanisms for algal cells (and microcystin) would still occur under the Proposed Action, and additional removal could occur in the Hydroelectric Reach due to turbulence and relatively high velocities in the free-flowing river reaches that were previously occupied by Copco 1 and Iron Gate Reservoirs. The primary lacustrine habitat for supporting seasonal nuisance and/or noxious phytoplankton blooms in the Hydroelectric Reach would be eliminated and there is little reason to suspect that large blooms of *M. aeruginosa* from Upper Klamath Lake would be successfully transported into the Klamath River downstream from Iron Gate Dam. Therefore, the overall occurrence of nuisance and/or noxious phytoplankton and associated toxins in the Klamath River downstream from Iron Gate Dam would be substantially reduced or eliminated.

Increases in nutrient availability associated with delivery and deposition of sediments from the upper watershed could occur over the long term as a result of dam removal (Reclamation 2012; Section 3.3.4.3). However, possible summer through fall increases in nutrient concentrations, particularly directly downstream from Iron Gate Dam, following dam removal (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin) would

not substantially contribute to blue-green algal blooms downstream from the dam due to the lack of the suitable hydrodynamic conditions required for extensive planktonic algal growth in the Klamath River. While some phytoplankton growth could occur along shorelines and protected coves and backwaters in the lower Klamath River Lower Klamath River during low-flow periods, *M. aeruginosa* cell density and microcystin concentrations are not expected to exceed current levels, which are typically 1 to 3 orders of magnitude lower relative to those measured in Copco 1 and Iron Gate Reservoirs (Appendix C, Figure C-32; see also Kann et al. 2010).

This analysis suggests that the Proposed Action would have a positive effect on aquatic resources in the Klamath River downstream from Iron Gate Dam in the long term based on reductions in downstream transport and concentrations of phytoplankton and microcystin toxins to this area. **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton in the reservoirs in the Hydroelectric Reach would reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins (i.e., microcystin) into the Klamath River downstream from Iron Gate Dam and would be beneficial.**

Periphyton

~~*Continued impoundment of water at the Four Facilities could support the growth of nuisance periphyton such as Cladophora spp. downstream of Iron Gate Dam.* Under existing conditions, periphyton coverage is relatively high immediately downstream of Iron Gate Dam, with coverage decreasing further downstream near the I-5 Bridge (RM 178), and increasing again to peak levels near the mouth of the Salmon River (RM 67) (Section 3.4.3.5). Because *Cladophora* provide suitable habitat for the polychaete worm that is the intermediate host for fish parasites, the presence of large seasonal periphyton mats immediately downstream of the Hydroelectric Reach have been linked to the potential for increased exposure to and incidence of fish disease.~~

~~As described above for phytoplankton (i.e., blue-green algae), full and successful implementation of Oregon and California TMDLs would decrease nutrients in the Klamath River and would result in decreased spatial extent, temporal duration, and/or biomass of phytoplankton mats. As discussed in Section 3.2, Water Quality, the timeframes for achieving water quality objectives with respect to the TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full implementation would require decades to achieve.~~

~~Conversely, increases in water temperature with climate change are likely to result in increased growth of periphyton in the Klamath River. Increased temperature through climate change may exacerbate biostimulatory conditions through increased periphyton metabolic and growth rates. Increases in nutrient availability under climate change may also cause a shift in periphyton community composition from that dominated by nitrogen-fixing periphyton species to that dominated by non-nitrogen fixers. It remains uncertain whether this change in community composition would result in a change in periphyton biomass. As with phytoplankton, the benefits of nutrient reductions under the TMDLs~~

are anticipated to be of greater relative importance with respect to periphyton spatial extent, bloom duration, and biomass under the No Action/No Project Alternative.

Existing seasonal nuisance periphyton growth in the Upper and Lower Klamath Basin is potentially adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease periphyton growth. Continued impoundment of water at the Four Facilities would result in no change from existing conditions.

The implications of potential changes in periphyton biomass and community composition for DO and the spread of fish disease are described in Sections 3.2.4.3 and 3.3.3.3, respectively.

Alternative 2: Proposed Action: Full Removal of Four Dams (Proposed Action)
Under the Proposed Action, the four major dams in the Klamath Hydroelectric Project (J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) would be removed along with the ancillary facilities of each installation. This includes the entire dam, the powerhouses, spillways, and other infrastructure associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to the United States Department of the Interior (DOI) and the implementation of the KBRA.

Upper Klamath Basin upstream of the influence of J.C. Boyle Reservoir
Phytoplankton
The Proposed Action could decrease the spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious phytoplankton in the area of analysis. Dam removal activities would not affect the Klamath River upstream of J.C. Boyle Reservoir. Effects of KBRA in this reach are discussed in Section 3.4.4.3. Alternative 2: Full Removal of Four Dams—KBRA. **There would be no change from existing conditions from nuisance and/or noxious phytoplankton.**

Periphyton
The Proposed Action could decrease the spatial extent, temporal duration, or biomass of nuisance periphyton in the area of analysis. Dam removal activities would not affect the Klamath River upstream of J.C. Boyle Reservoir. Effects of KBRA in this reach are discussed in Section 3.4.4.3. Alternative 2: Full Removal of Four Dams—KBRA. **There would be no change from existing conditions from nuisance periphyton.**

Hydroelectric Reach
Short-Term Effects
Phytoplankton—Under the Proposed Action, the short-term (<2 years following dam removal) increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact (Section 3.2.4.3.2.3.). Additionally, by mid to late spring following reservoir drawdown (assuming drawdown Scenario 8), little to no reservoir habitat would be left, and blue-green algal blooms would be very limited if not eliminated from the Hydroelectric Reach. Thus, potential effects of increased nutrients on phytoplankton blooms in the Hydroelectric Reach are not considered further.

Periphyton- While quiescent habitat for phytoplankton would be eliminated in the short-term by reservoir drawdown and dam removal (see above), periphyton growth in the riverine reaches of the Hydroelectric Reach could occur during the initial summer and fall months following drawdown. However, this is unlikely to occur due to increased short-term (<2 years following dam removal) nutrient availability under the Proposed Action since in the short-term, the increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact (Section 3.2.4.3.2.3.). Additionally, higher flows during drawdown and late spring storm events would result in greater bed turnover (see Section 3.3.4.3, Bedload Sediment) and scouring, which would greatly limit, if not eliminate, short-term establishment of periphyton in the Hydroelectric Reach. Thus, potential effects of increased nutrients on short-term periphyton establishment in the Hydroelectric Reach is not considered further. The potential long-term effects of scour on periphyton biomass are discussed in greater detail below.

Long-Term Effects

Phytoplankton- *Under the Proposed Action, removal of the reservoirs at the Four Facilities would eliminate lacustrine habitat behind the dams and could decrease the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms.* This change, particularly within the larger Copco 1 and Iron Gate Reservoirs, would decrease or eliminate the system's support for excessive growth of blue-green algae over the long-term by eliminating quiescent habitat where these algal species can thrive. This change in suitable habitat would occur even if relatively high nutrient concentrations were to remain in the Klamath River system. This would substantially reduce the production of toxins from these reservoirs that are harmful to animals and humans. This would be a major benefit of the Proposed Action. Moreover, dam removal would allow the substantial groundwater resources within this area of analysis to cool water temperatures during the summer months (Hamilton et al. 2010). This would further reduce the suitability of conditions for blue-green algae growth and mitigate for the effects of climate change. The Proposed Action would provide a substantial long-term benefit with regard to phytoplankton in the Hydroelectric Reach. **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton due to the elimination of the reservoirs in the Hydroelectric Reach would be beneficial.**

Periphyton- *Under the Proposed Action, dam removal and the elimination of hydropower peaking operations could result in long-term increased biomass of nuisance periphyton in low-gradient channel margin areas downstream of J.C. Boyle Dam.* Periphyton growth in the Hydroelectric Reach downstream of J.C. Boyle Dam could be quite high on a seasonal basis following dam removal. This is because until full attainment of the Oregon and California TMDLs can be achieved, high nutrient inputs from the Upper Klamath Basin would continue to support periphyton growth and removal of the reservoirs and the hydropower peaking reaches would create suitable physical habitat suitable for periphyton. Thus, the overall effect of the Proposed Action could be to eliminate blooms of toxic blue-green algae in the reservoirs and replace them with

colonies of periphyton in the newly created margins of low gradient river channels in the Klamath Hydroelectric Project Reach. However, the particular periphyton species that may become abundant in these areas is unknown (E. Asarian, pers. comm., 2011). Although there is potential for nutrient concentrations to increase in these areas, these increases are expected to be less than significant (see Section 3.2.4.3.2.3). Moreover, these nutrient inputs would be expected to decrease over time with implementation of the Oregon and California TMDLs and KBRA projects (see Section 3.4.4.3 Alternative 2: Full Removal of Four Dams – KBRA).

Potential increases in periphyton growth could also be disrupted by more frequent river bed turnover (see Section 3.3.4.3) and increased flow variability during storm flow, which may result in increased scouring of periphyton during late spring storm events, following dam removal (See NCRWQCB 2010a, Appendix 2). This potential outcome is supported by results from the Nutrient Numeric Endpoint Benthic Biomass Predictor for the "natural conditions" (i.e., point sources eliminated, large reductions in nutrient input from Upper Klamath Lake and Straits Drain, and dams out) scenario. The model predicts that periphyton growth in the Klamath River downstream of Iron Gate Dam can achieve the proposed 150 mg/m^2 maximum benthic chlorophyll-*a* target under the "natural conditions" scenario when more frequent scouring events are allowed to occur, a condition that would be supported if the dams were not in place (see NCRWQCB 2010a, Appendix 2). However, the benthic chlorophyll-*a* predictions are subject to uncertainty because of a lack of data regarding relationships between nutrient concentrations, flows, periphyton biomass and chlorophyll-*a* concentrations and between dam removal and the frequency of scouring events. In addition, these model results include the effect of large reductions in nutrient loading based on compliance with the Upper Klamath Lake TMDL, and do not provide information regarding the isolated effects of the Proposed Project on periphyton abundance. **Under the Proposed Action, long-term increases in nuisance periphyton growth due to increases in available habitat along channel margin areas of the Hydroelectric Reach downstream of J.C. Boyle Dam would be a significant impact.**

The above "significant impact" determination represents a conservative assessment of the effects of the Proposed Action on periphyton growth since there is inherent uncertainty in the Nutrient Numeric Endpoint predictions and it is possible that excessive periphyton growth would not be supported in the Hydroelectric Reach. Additional research prior to the time of dam removal would help resolve these uncertainties. Monitoring could also be conducted after dam removal which would help identify the actual changes in the periphyton community resulting from dam removal. The implications of potential changes in periphyton biomass and community composition for DO and the spread of fish disease are described in Sections 3.2.4.3 and 3.3.3.3, respectively. If projects were well-designed and implemented at a large enough scale, reductions in nutrient loading resulting from implementation of TMDL and KBRA projects (see Section 3.4.4.3 Alternative 2: Full Removal of Four Dams – KBRA) proposed to reduce nutrient loading from the Upper Klamath Basin could fully mitigate for potential increases periphyton biomass associated with changes in nutrient concentrations under the Proposed Action (E. Asarian, pers. comm., 2011).

Yreka Pipeline Relocation and Recreational Facilities Removal

Under the Proposed Action, removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline. The water supply pipeline for Yreka will have to be relocated from its present location under Iron Gate Reservoir. Once the reservoir is drawn down, the existing pipeline would be exposed to higher velocity water flow, debris during flood events, and other potentially damaging situations that it is currently not exposed to at the bottom of the reservoir. To address this, the pipeline will be suspended from a pipe bridge across the Klamath River. Potential impacts to algae from the installation of the pipe bridge will be minimized or eliminated through the implementation of Best Management Practices (BMPs) for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **There will be no change from existing conditions from algae in the Hydroelectric Reach or the Klamath River downstream of Iron Gate Dam as a result of the Yreka water supply pipeline relocation.**

Under the Proposed Action, construction/deconstruction activities would include the demolition of various recreation facilities. The existing recreational facilities located along the banks of the reservoirs will be removed once the reservoirs are drawn down. Facilities such as campgrounds and boat ramps, currently located on the reservoir banks will need to be relocated down slope to be near the new river channel once the reservoir is removed. Impacts specific to the deconstruction of the Recreation Facilities are discussed in Section 3.20, Recreation. Once the reservoirs are drawn down, the existing recreational facilities would be well above the new river channel. The removal of the facilities is not expected to impact algae biomass or lifecycles. The potential for impacts during the facilities removal will minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **There would be no change from existing conditions from algae in the Hydroelectric Reach or the Klamath River downstream of Iron Gate Dam as a result of the removal of the recreational facilities.**

Klamath River Downstream of Iron Gate Dam

Long-Term Effects

Phytoplankton *Under the Proposed Action, removal of the reservoirs would eliminate lacustrine habitat behind the dams could substantially reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River downstream of Iron Gate Dam.* Reduced inputs of *M. aeruginosa* and *Anabaena flos-aquae* to the mainstem river downstream of Iron Gate Dam would result in a substantial reduction in the presence of toxic algal cells.

Increases in nutrient availability associated with delivery and deposition of sediments from the upper watershed could occur over the long term as a result of dam removal (DOI 2011; Section 3.3.4.3). However, possible summer through fall increases in nutrient concentrations, particularly directly downstream of Iron Gate Dam, following

dam removal (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin) would not contribute significantly to blue-green algal blooms downstream of Iron Gate Dam due to the lack of the suitable hydrodynamic conditions required for extensive planktonic algal growth following implementation of the Proposed Action. This analysis suggests that the Proposed Action would have a positive effect on aquatic resources in the Klamath River downstream of Iron Gate Dam in the long-term based on reductions in downstream transport and concentrations of phytoplankton and microcystin toxins to this area. **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton in the reservoirs in the Hydroelectric Reach would reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River downstream of Iron Gate Dam and would be beneficial.**

Periphyton *Under the Proposed Action, dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and biomass of nuisance periphyton biomass in the Klamath River downstream of from Iron Gate Dam.* Periphyton growth could continue to be relatively high downstream of from Iron Gate Dam on a seasonal basis following dam removal because of continuing nutrient inputs from the Upper Klamath Basin, as described for the J.C. Boyle to Iron Gate Dam reach. DespiteHowever, despite the overall increases in absolute nutrient concentrations anticipated under the Proposed Action (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin), the relatively greater increases in Total Nitrogen (TN) may not result in significant biostimulatory effects on periphyton growth. Existing data indicate that the Klamath River is generally N-limited (TN: because it will be accompanied by only a relatively minor increase in Total Phosphorus (TP)). Existing data regarding TN:TP ratios in the Klamath River suggest the potential for N-limitation (TN:TP <10), with some periods of co-limitation by N and P (see also Section 3.2.3.4 and Appendix C, Section C.3.2.1). However, concentrations of both nutrients are high enough in the river from Iron Gate Dam (RM 190.1) to approximately Seiad Valley (RM 129.4) (and potentially further downstream) that algal growth is nutrient saturated, and nutrients are not likely to be limiting primary productivity (i.e., periphyton growth) in this portion of the Klamath River (FERC 2007, Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008, Asarian et al. 2010). In addition, N-fixing species currently dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010). Since these species can fix their own nitrogen from the atmosphere, increases in TN due to dam removal may alter the composition of the periphyton community but it may not significantly increase theiralgal biomass, particularly if in these reaches because it will be accompanied by only relatively minor increases in TP. In addition, overall TN and TP increases are could be less than those predicted by existing models due to implementation of TMDLs and general nutrient reductions in the Klamath Basin.

This potential outcome is supported by results from the Nutrient Numeric Endpoint Benthic Biomass Predictor for the "natural conditions" (i.e., point sources eliminated, large reductions in nutrient input from Upper Klamath Lake and Straits Drain, and dams

out) scenario. The model predicts that periphyton growth in the Klamath River downstream from Iron Gate Dam can achieve the proposed 150 mg chlorophyll-*a*/m^2 maximum benthic target when nutrient concentrations approach TMDL compliance targets (NCRWQCB 2010, Appendix 2).

In addition to the effects of changes in nutrient concentrations, periphyton community composition and biomass may be affected by light levels and substrate stability. ~~Light penetration would decrease following dam removal below Iron Gate Dam due to removal of the reservoirs, which serve as sediment catchment areas. This would have a reducing effect on periphyton growth downstream of Iron Gate Dam. In addition, potential~~Potential increases in periphyton growth could be counteracted by more frequent river bed turnover (see Section 3.3.~~4.~~3.6.2.1.2 Bedload Sediment and 3.3.3.6.2.1.5 Fish Disease and Parasites) and increased flow variability during storm flow, which could result in increased scouring of periphyton during late spring storm events, following dam removal (FERC 2007, NCRWQCB 2010~~a~~, Appendix 2). The magnitude of the effect of bed turnover and scouring on periphyton would ~~likely~~ decrease with distance downstream, with increased scour occurring from Iron Gate Dam to approximately the Shasta River (RM 177). As described for the Hydroelectric Reach, TMDL model results suggest that increased scouring may somewhat limit long-term periphyton biomass following dam removal (NCRWQCB 2010~~a~~, Appendix 2). Overall, these processes would reduce periphyton growth downstream from Iron Gate Dam.

Because of these many competing factors, some that may favor enhanced periphyton growth downstream ~~of~~from Iron Gate Dam (i.e., increased nutrients transport and recycling), and some that counteract this response (increased uptake and retention of nutrients by periphyton in the Hydroelectric Reach, increased frequency and intensity of scouring events, decreasing nutrient concentrations due to TMDL implementation and KBRA nutrient reduction programs [see KBRA discussion below]), it is likely that increases in periphyton growth below Iron Gate Dam would be less than significant. ~~Moreover, the biological significance of potential increases in periphyton biomass is unknown due to uncertainty regarding the magnitude of increase in biomass required to generate a significant reduction in habitat quality for aquatic resources (NCRWQCB 2010a, Appendix 2).~~ **Under the Proposed Action, long-term increases in nuisance periphyton in the Klamath River downstream from Iron Gate Dam would be a less than significant impact.**

~~**Under the Proposed Action, long-term increases in nuisance periphyton in the Klamath River downstream of Iron Gate Dam would be a less than significant impact.**~~

Klamath Estuary

~~Long-term Effects~~

Phytoplankton

Under the Proposed Action, removal of the reservoirs would eliminate lacustrine habitat behind the dams and could substantially reduce or eliminate the long-term transport of

nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath Estuary. Information regarding current conditions of algal biomass, population dynamics, and the likelihood of nutrient limitation on algal growth in the Klamath Estuary is limited (Fetcho 2006, 2007, 2008). Consequently, it is difficult to determine the potential long-term effects that the Proposed Action would have on algae in the estuary. Existing information ~~suggests~~indicates that ~~the~~instances of elevated levels of *M. aeruginosa* in the Klamath Estuary correspond with elevated levels measured at upstream locations in the Lower Klamath River (Section 3.4.3.6). Since removal of the

Four Facilities would reduce or eliminate elevated *M. aeruginosa* levels ~~within the estuary, because *M. aeruginosa* that is transported downstream originates in the reservoirs (Fetcho 2006, Fetcho 2008). **Under the Proposed Action, long-term reductions in the growth of nuisance and nuisance and/or noxious phytoplankton in the Hydroelectric Reach would reduce or eliminate the transport of algal cells and their associated toxins into the Klamath Estuary and would be beneficial.**~~ in the Lower Klamath River (see prior section), levels in the Klamath Estuary are also likely to be reduced or eliminated.

~~**Periphyton**~~As discussed for the Klamath River downstream from Iron Gate Dam, increases in nutrient transport from the upper watershed could occur over the long term as a result of dam removal (Reclamation 2012; Section 3.3.4.3). However, possible summer through fall increases in nutrient concentrations, particularly directly downstream from Iron Gate Dam, following dam removal (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin) would not contribute significantly to blue-green algal blooms downstream from the dam due to the lack of the suitable hydrodynamic conditions required for extensive planktonic algal growth following implementation of the Proposed Action. Thus, while some phytoplankton growth could occur in the Klamath Estuary during summer and fall
low-flow periods, *M. aeruginosa* cell density and microcystin concentrations would not be expected to exceed current levels, which are typically 1 to 3 orders of magnitude lower relative to those measured in Copco 1 and Iron Gate Reservoirs (Appendix C, Figure C-32; see also Kann et al. 2010). **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton in the Hydroelectric Reach would reduce or eliminate the transport of algal cells and their associated toxins into the Klamath Estuary and would be beneficial.**

Periphyton

Under the Proposed Action, dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath Estuary. ~~-~~As discussed for the ~~lower~~Lower Klamath River downstream ~~of~~from Iron Gate Dam, periphyton growth under the Proposed Action could be affected by increased nutrient availability following dam removal. However,~~ since~~ the long-term increase in nutrients in the Klamath Estuary would be ~~a less-than-significant impact due to the implementation of TMDLs and KBRA (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin), it is likely that increases in periphyton growth would also be less than significant~~relatively small due to the effects of tributary dilution and nutrient retention in the 190 miles between Iron Gate Dam and the Estuary (Asarian et al. 2010). In addition, N-fixing species dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low and these species can fix their own nitrogen from the atmosphere (Asarian et al. 2010). Thus, increases in total nitrogen (TN) due to dam removal are not likely to significantly increase periphyton biomass in the Klamath Estuary (see also Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin). Moreover, the biological significance of potential increases in periphyton biomass in the Klamath estuary is unknown due to uncertainty regarding the magnitude

of increase in biomass required to generate a significant reduction in habitat quality for aquatic resources (NCRWQCB 2010~~a~~, Appendix 2). **Under the Proposed Action, long-term increases in the growth of nuisance periphyton in the Klamath Estuary would be a less than significant impact.**

Marine Nearshore Environment

~~*Under the Proposed Action, dam removal and conversion of the reservoir areas could cause long-term increases in freshwater phytoplankton and periphyton species of concern.*~~ The marine nearshore environment is not a suitable habitat for the freshwater phytoplankton species of concern (i.e., *Aphanizomenon flos-aquae*, *Anabaena flos-aquae*, *M. aeruginosa*) or the freshwater periphyton species of concern (i.e., *Cladophora*~~).~~ ~~**While other marine algal species would occur in the marine near shore environment, because of short-term (< 2 years following dam removal) increases in both rates of sediment deposition (Section 3.2.4.3.2.2 Suspended Sediments – Lower Klamath Basin) and sediment-associated nutrient levels, (Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin) the marine nearshore environment would be a less-than-significant impact**~~) therefore effects on these species under the Proposed Action ~~**and are not expected to effect marine algal species**~~are not considered further.

Keno Transfer

Implementation of the Keno Transfer could cause adverse effects to algae. The Keno Transfer would be a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in new impacts on algae compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion ~~**and**~~ and canal maintenance consistent with agreements and historic practice (KHSA ~~**Section**~~ Section 7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and ~~West Side~~Westside Facilities – Programmatic Measure

Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse effects to algae. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA ~~will redirect~~would eliminate water ~~flows currently diverted~~diversions at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there ~~will~~would be no change in algae conditions in the Klamath River. **Therefore, implementation of the East and ~~West Side~~Westside Facility Decommissioning action would result in no change from existing conditions.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Under the Proposed Action, relocation of the Yreka Water Supply Pipeline required as part of the removal of Iron Gate Dam would not affect algae. The water supply pipeline for Yreka would have to be relocated from its present location under Iron Gate Reservoir. Once the reservoir is drawn down, the existing pipeline would be exposed to higher velocity water flow, debris during flood events, and other potentially damaging situations that it is currently not exposed to at the bottom of the reservoir. To address this, the pipeline would be suspended from a pipe bridge across the Klamath River. Potential impacts to algae from the installation of the pipe bridge would be minimized or eliminated through the implementation of Best Management Practices (BMPs) for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **There would be no effect on algae (phytoplankton or periphyton) levels in the Hydroelectric Reach or the Klamath River downstream from Iron Gate Dam as a result of the Yreka Water Supply Pipeline relocation.**

KBRA – Programmatic Measures

The KBRA, which is a ~~component~~connected action of the Proposed Action, encompasses several programs that could affect nuisance and/or noxious phytoplankton and periphyton blooms in the Klamath Basin through improvements to water quality, including:

- Phases I and II Fisheries Restoration Plans
- Wood River Wetland Restoration
- Water Use Retirement Program
- Interim Flow and Lake Level Program
- Upper Klamath Lake and Keno Nutrient Reduction

Beneficial effects of these projects on nutrients in the Klamath Basin would also be beneficial for nuisance and/or noxious phytoplankton and periphyton blooms.

Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin (with the exception of the Trinity Basin) including KHSA implementation (i.e., dam removal) and reduce nuisance and/or noxious phytoplankton blooms through their beneficial effects on flow and water quality. Specific projects are addressed below.

Phase I Fisheries Restoration Plan

Implementation of the Phase I Fisheries Restoration Plan could result in a long-term reduction in nutrients and associated decreases in nuisance and/or noxious phytoplankton and periphyton blooms. Several ongoing resource management actions related to nutrient reductions may be amplified under the Phase I Plan (Section 3.2.4.3.2.10). Ongoing actions and types of new programs that could be implemented are described at a programmatic level for water quality. Anticipated benefits with respect to phytoplankton and periphyton are the same as those described for any Phase I project that would decrease nutrient levels in the Klamath Basin (Section 3.2.4.3.2.10).

The improvements in nuisance and/or noxious phytoplankton and periphyton blooms generated by implementation of the Phase I Fisheries Restoration Plan would contribute to the long-term water quality improvements in the Klamath Basin, supplementing those anticipated from hydroelectric facility removal. **Resource management actions implemented under the KBRA Phase I Fisheries Restoration Plan would accelerate long-term decreases in nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton and periphyton blooms in the Klamath Basin and would be beneficial.**

Phase II Fisheries Restoration Plan

Implementation of the Phase II Fisheries Restoration Plan under the KBRA (KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same impacts as Phase I. Anticipated benefits with respect to phytoplankton and periphyton are the same as those described for any Phase II project that would decrease nutrient levels in the Klamath Basin (Section 3.2.4.3.2.10). The improvements in nuisance and/or noxious phytoplankton and periphyton blooms generated by implementation of the Phase II Fisheries Restoration Plan would contribute to the long-term water quality improvements in the Klamath Basin, supplementing those anticipated from hydroelectric facility removal. **Resource management actions implemented under the KBRA Phase II Fisheries Restoration Plan would accelerate long-term decreases in nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton and periphyton blooms in the Klamath Basin and would be beneficial.**

Wood River Wetland Restoration

Implementation of Wood River Wetland Restoration could result in reduced nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms. This project may decrease overall nutrient inputs to Upper Klamath Lake by inundating wetland (peat) soils and creating anaerobic conditions that support nutrient retention, particularly in the case of phosphorus (Snyder and Morace 1997). Specific options still need to be developed and studied as part of a separate project-level National Environmental Policy Act (NEPA) evaluation and Federal Endangered Species Act (ESA) consultation. The improvements in nuisance and/or noxious phytoplankton blooms generated by implementation of the Wood River Wetland Restoration Project would contribute to the long-term water quality improvements in the Klamath Basin, supplementing those anticipated in the Klamath Basin from hydroelectric facility removal. **Under the KBRA, the Wood River Wetland Restoration Project would accelerate ongoing long-term improvements in nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton blooms in Agency Lake and would be beneficial.**

Water Use Retirement Program

Implementation of the Water Use Retirement Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or

noxious phytoplankton blooms. Anticipated benefits with respect to phytoplankton are the same as those described for this project under water quality, because it would decrease nutrient levels (i.e., decrease irrigation and fallowing of crop land and would decrease fertilizer [nutrient] inputs) in Upper Klamath Lake (see Section 3.2.4.3.2.10). The decreases in nutrient inputs to Upper Klamath Lake generated by implementation of the Water Use Retirement Program would contribute to the long-term water quality improvements in the Klamath Basin, supplementing those anticipated from hydroelectric facility removal. **The KBRA Water Use Retirement Program would decrease long-term nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton blooms in Upper Klamath Lake and would be beneficial.**

Interim Flow and Lake Level Program

Implementation of the Interim Flow and Lake Level Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms. Anticipated benefits with respect to phytoplankton are the same as those described for this project under water quality, because the project would decrease nutrient levels in the Upper Klamath Lake (see Section 3.2.4.3.2.10). The decreases in nutrient inputs to Upper Klamath Lake generated by implementation of the Interim Flow and Lake Level Program would contribute to the long-term water quality improvements in the Klamath Basin, supplementing those anticipated from hydroelectric facility removal. **The KBRA Interim Flow and Lake Level Program would decrease long-term nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton blooms in Upper Klamath Lake and would be beneficial.**

Upper Klamath Lake and Keno Nutrient Reduction

Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program ~~could~~ could result in decreases in nutrient inputs to Upper Klamath Lake and Keno Impoundment/Lake Ewauna and associated decreases in nuisance and/or noxious phytoplankton blooms. KBRA (Appendix C-2, line 11) includes a program to study and reduce nutrient concentrations in the Keno Impoundment/Lake Ewauna and Upper Klamath Lake in order to reduce dissolved oxygen and nuisance algal problems in both water bodies. Restoration actions to control nutrients have not been developed, and there are many possible actions that could require construction of treatment wetlands, construction of facilities, or chemical treatments of bottom sediment, among other possibilities. A nutrient reduction program in the Keno Impoundment/Lake Ewauna and Upper Klamath Lake would be designed to improve water quality (increasing seasonally low dissolved oxygen and reducing seasonal algal blooms) and fish passage through the Keno Impoundment/Lake Ewauna in summer and fall months, however implementation of this nutrient reduction program will require future environmental compliance investigations and a determination on significance cannot be made at this time.

3.4.4.3.3 Alternative 3: Partial Facilities Removal of Four Dams

This alternative proposes to remove enough of the material from each dam to allow the river to retain a free-flowing condition and volitional fish passage under all river stages and flow conditions. Some portion of each dam and much of the appurtenant infrastructure could remain, such as the dam foundations, power houses, buildings, tunnels, and pipes. All tunnel openings would be sealed with concrete, remaining buildings would be fenced, and all hazardous materials would be removed from the site. This alternative would include the transfer of the Keno Facility to the DOI and implementation of the KBRA. **The Partial Facilities Removal of Four Dams Alternative effects on algae would be the same as those described for the Proposed Action.**

3.4.4.3.4 Alternative 4: Fish Passage at Four Dams

This alternative would provide upstream and downstream fish passage at the Four Facilities, but would not include implementation of the KBRA. The ongoing restoration actions, described in the No Action/No Project Alternative, would continue. The alternative would incorporate the prescriptions from the Departments of the Interior and Commerce imposed during the FERC relicensing process, including fishway installation for both upstream and downstream migrations at all facilities and barriers to prevent juvenile salmonid entrainment into turbines. In addition to the fishways, there are a series of flow-related measures, including a condition that requires at least 40 percent of the inflow to the J.C. Boyle Reservoir to be released downstream. This alternative would limit generation of peaking power at J.C. Boyle Power Plant to one day per week as water supplies allow, and would include recreation flows one day a week. The flow requirements would reduce the overall power generation.

The Fish Passage at Four Dams Alternative effects on ~~algae~~phytoplankton would be similar to those described for the No Action/No Project Alternative. Nuisance blooms of periphyton do not currently occur in the Hydroelectric Reach (Section 3.4.3.4.2). Under Alternative 4, increases in J.C. Boyle Dam flow releases and associated increases in summer and early fall water temperatures in the Bypass Reach (Section 3.2.4.3.4), as well as decreases in peaking flows and less flow and water temperature variation in the Peaking Reach, could result in small amounts of periphyton colonization in the Klamath River downstream from J.C. Boyle Dam and upstream of Copco 1 Dam. Slight overall decreases in water temperature in the Peaking Reach are not expected to have an effect on periphyton. However, it is assumed that the periphyton biomass increases would be less-than-significant because the generally high gradient and velocity in this reach of the Klamath River do not currently support excessive periphyton mats. As described under the No Action/No Project Alternative, full and successful implementation of Oregon and California TMDLs would decrease nutrients in the Klamath River and would further minimize colonization of periphyton mats in free-flowing river portions of the Hydroelectric Reach (i.e., downstream from J.C. Boyle Dam and upstream of Copco 1 Reservoir). Since Copco 1 and Iron Gate Reservoirs would remain in place under this alternative, there would be no effect on periphyton in the stretches of river covered by reservoirs. **Overall, small potential increases in**

periphyton establishment in the Klamath River downstream from J.C. Boyle Reservoir under the Fish Passage at Four Dams Alternative would be less than significant.

3.4.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Phytoplankton

Removal of Copco 1 and Iron Gate Dams would eliminate lacustrine habitat in the two largest reservoirs in the Hydroelectric Reach and could decrease or eliminate the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms in the Hydroelectric Reach and subsequent transport to the Klamath River from downstream ~~of~~ from Iron Gate Dam to the Klamath Estuary. Dam removal activities under Alternative 5 would not affect the Klamath River upstream of J.C. Boyle Reservoir. The removal of quiescent reservoir habitat in Copco 1 and Iron Gate Reservoirs would decrease or eliminate conditions in the Hydroelectric Reach that support excessive growth of blue-green algae. This change in ~~suitable~~optimal habitat would occur even if relatively high nutrient concentrations were to remain in the Klamath River system. The reduction in growth of nuisance and/or noxious phytoplankton in the Hydroelectric Reach would reduce the transport of algal cells and their associated toxins to the Klamath River downstream ~~of~~ from Iron Gate Dam and the Klamath Estuary. This would substantially reduce the production of toxins from these reservoirs that are harmful to animals and humans. **Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, long-term reductions in the growth of nuisance and/or noxious phytoplankton due to the elimination of the two largest reservoirs in the Hydroelectric Reach would decrease or eliminate levels of nuisance and ~~nuisance and~~/or noxious phytoplankton and concentrations of algal toxins from the Hydroelectric Reach to the Klamath Estuary, and would be beneficial.**

Periphyton

Removal of Copco 1 and Iron Gate Dams and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Hydroelectric Reach, the Klamath River downstream ~~of~~ from Iron Gate Dam, and the Klamath Estuary. ~~The~~ Dam removal activities under Alternative 5 would not affect the Klamath River upstream of J.C. Boyle Reservoir. With the exception of the short reach from J.C. Boyle Dam to the upstream end of Copco 1 Reservoir, the effects ~~of~~ of removing the two largest dams in the Hydroelectric Reach, Copco 1 and Iron Gate Dams, on nutrients and available habitat for periphytic algal growth under this alternative would be similar to removing all four dams under the Proposed Action (Section 3.2.4.3.5.3). Long-term increases in periphyton growth in the Klamath River downstream ~~of~~ from Iron Gate Dam and in the Klamath Estuary could also occur and ~~would~~ would be the same as those described under the Proposed Action. **Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, long-term increases in the growth of nuisance periphyton in the Hydroelectric Reach~~,~~ from Copco 1 Reservoir to Iron Gate Reservoir would be a significant impact[5]. Long-term increases in the growth of nuisance periphyton in the Klamath River downstream ~~of~~from Iron Gate Dam, and the Klamath Estuary would be a less than significant impact.**

City of Yreka Water Supply Pipeline Relocation ~~and Recreational Facilities Removal~~ – Programmatic Measure

Removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline. Under Alternative 5, Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate, the water supply pipeline for Yreka ~~will~~would have to be relocated from its present location under Iron Gate Reservoir. Once the reservoir is drawn down, the existing pipeline would be exposed to higher velocity water flow, debris during flood events, ~~and~~ and other potentially damaging situations that it is currently not exposed to at the ~~bottom~~ bottom of the reservoir. To address this, the pipeline ~~will~~would be suspended from a pipe bridge across the Klamath River. **There ~~will~~would be no impact to algae in the Hydroelectric Reach or the Klamath River downstream ~~of~~from Iron Gate Dam as a result of the Yreka ~~water supply pipeline~~Water Supply Pipeline relocation.**

3.4.4.4 Mitigation Measures

3.4.4.4.1 Mitigation Measure by Consequences Summary

The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects (i.e., dam removal during the winter would minimize the potential for large blooms of nuisance and/or noxious phytoplankton to be transported downstream [see Section 3.4.4.3.2 Klamath River Downstream from Iron Gate Dam] and would correspond to normal high-flow conditions with scour, light

[5] This revision reflects an editorial clarification. As indicated by the analysis under the Proposed Action, the determination for Alternative 5 in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir should also have been a significant effect.

limitation, and high flow velocity that would inhibit periphyton growth). **No mitigation measures are proposed beyond those described for water quality protection in Section 3.2, Water Quality.**

3.4.4.5 Summary of Impacts on Algae

Table 3.4-1 summarizes the impacts of the Proposed Action and alternatives on algae.

~~**Table 3.4.1 Summary of Algae Impacts**~~

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation (1)	Significance After Mitigation Pursuant to CEQA
Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir				
Dam removal activities ~~could decrease the spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious~~would not affect phytoplankton in the ~~area of analysis.~~Klamath River upstream of J.C. Boyle Reservoir	2, 3, 5	NCFEC	None	NCFEC
Dam removal activities ~~could decrease the spatial extent, temporal duration, or biomass of nuisance~~would not affect periphyton in the ~~area of analysis~~Klamath River upstream of J.C. Boyle Reservoir	2, 3, 5	NCFEC	None	NCFEC
~~***Hydroelectric Reach***~~				
Hydroelectric Reach				
Continued impoundment of water in the reservoirs could support the long-term growth of seasonal nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach.	1, 4	NCFEC	None	NCFEC
~~Removal of the reservoirs would eliminate lacustrine habitat behind the dams and could decrease the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms in the Hydroelectric Reach.~~ Sediment release associated with dam removal could cause short-term increases in sediment-associated nutrients downstream from J.C. Boyle Dam that could stimulate nuisance and/or noxious phytoplankton growth in the Hydroelectric Reach.	2, 3~~, 5~~	~~B~~NCFEC	None	~~B~~NCFEC
~~Dam removal and the elimination of hydropower~~	~~2, 3~~	~~S~~	~~None~~	~~S~~

Table 3.4.1 Summary of Algae Impacts

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation [1]	Significance After Mitigation Pursuant to CEQA
peaking operations could result in long-term increased biomass of nuisance periphyton in low-gradient channel margin areas within the Hydroelectric Reach.	5	LTS	None	LTS
Removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline which could impact algae.Removal of the reservoirs would eliminate lacustrine habitat behind the dams and could decrease or eliminate the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms.	2, 3, 5	B	None	B
Sediment release associated with the Proposed Action could cause short-term increases in sediment-associated nutrients downstream from J.C. Boyle Dam that could stimulate nuisance periphyton growth in the Hydroelectric Reach.	2, 3	NCFEC	None	NCFEC
Dam removal and the elimination or reduction of hydropower peaking operations could result in long-term increases in nuisance periphyton growth due to increases in available habitat along low-gradient channel margin areas downstream from J.C. Boyle Dam.	2, 3, 5 [2]	NCFECS	None	NCFECS
Construction and deconstruction activities would include the demolition of various recreation facilities that could affect algae.Increased water temperatures and decreased peaking flows could result in long-term small amounts of nuisance periphyton colonization in the Klamath River downstream from J.C. Boyle Reservoir and upstream of Copco 1 Reservoir.	2, 3, 54	NCFECLTS	None	NCFECLTS
Klamath River Downstream of Iron Gate Dam Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in increased	2 ,3	B	None	B

~~**Table 3.4.1 Summary of Algae Impacts**~~

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation (1)	Significance After Mitigation Pursuant to CEQA
bedload mobility and the potential for increased scour of nuisance periphyton in the Hydroelectric Reach.				
~~Continued impoundment of water in the reservoirs could support long-term growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach and subsequent transport into the Klamath River downstream of Iron Gate Dam.~~	~~1, 4~~	~~NCFEC~~	~~None~~	~~NCFEC~~
Klamath River Downstream from Iron Gate Dam				
Continued impoundment of water ~~at~~in the ~~Four Facilities~~reservoirs could support long-term growth of nuisance ~~periphyton~~and/or noxious phytoplankton such as ~~*Cladophora spp.*~~*M. aeruginosa* in the Hydroelectric Reach and subsequent transport into the Klamath River downstream ~~of~~from Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
~~Removal of the reservoirs would eliminate lacustrine habitat behind the dams could substantially reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River~~Continued impoundment of water at the Four Facilities could support long-term growth of nuisance periphyton such as *Cladophora spp.* downstream ~~of~~from Iron Gate Dam.	~~2, 3, 5~~1, 4	~~B~~NCFEC	None	~~B~~NCFEC
~~Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath River downstream of Iron Gate Dam.~~Removal of the reservoirs would eliminate lacustrine habitat behind the dams and could substantially reduce or eliminate the long-term transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River downstream from Iron	2, 3, 5	~~LTS~~B	None	~~LST~~B

~~**Table 3.4.1 Summary of Algae Impacts**~~

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation [1]	Significance After Mitigation Pursuant to CEQA
Gate Dam.				
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and biomass of nuisance periphyton in the Klamath ~~*Estuary*~~River downstream from Iron Gate Dam.	2, 3, 5	LTS	None	LTT

~~**Table 3.4.1 Summary of Algae Impacts**~~

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation (1)	Significance After Mitigation Pursuant to CEQA
Klamath Estuary				
Continued impoundment of water in the reservoirs could support long-term growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach and subsequent transport into the Klamath Estuary.	1, 4	NCFEC	None	NCFEC
Removal of the reservoirs would eliminate lacustrine habitat behind the dams and could substantially reduce or eliminate the long-term transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath Estuary.	2, 3, 5	B	None	B
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath Estuary.	2, 3, 5	LTS	None	LTS
~~***Marine Nearshore Environment***~~				
~~Dam removal and conversion of the reservoir areas could cause long-term increases in freshwater phytoplankton and periphyton species of concern.~~	~~2, 3, 5~~	~~LTS~~	~~None~~	~~LTS~~
~~***Keno Transfer***~~				
Keno Transfer				
Implementation of the Keno Transfer could cause adverse algae effects.	2, 3	NCFEC	None	NCFEC
~~***East and Westside Facilities***~~				
***East and Westside Facilities* - Programmatic Measure**				
Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse ~~algae~~ effects to algae.	2~~,~~, 3	NCFEC	None	NCFEC

Table 3.4.1 Summary of Algae Impacts

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation (1)	Significance After Mitigation Pursuant to CEQA
KBRA				
Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin and reduce nuisance and/or noxious phytoplankton blooms through their beneficial effects on flow and water quality. ***City of Yreka Water Supply Pipeline Relocation* - Programmatic Measure**				
Under the Proposed Action, relocation of the Yreka Water Supply Pipeline required as part of the removal of Iron Gate Dam would not affect algae.	2, 3, 5	BNCFEC	None	BNCFEC

~~Table 3.4.1 Summary of Algae Impacts~~

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation [1]	Significance After Mitigation Pursuant to CEQA
***KBRA* – Programmatic Measures**				
Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin (with the exception of the Trinity Basin) including KHSA implementation (i.e., dam removal) and reduce nuisance and/or noxious phytoplankton blooms through their beneficial effects on flow and water quality.	2, 3	B	None	B
Implementation of the Phase I Fisheries Restoration Plan could result in a long-term reduction in nutrients and associated decreases in nuisance and/or noxious phytoplankton and periphyton blooms.	2, 3	B	None	B
Implementation of the Phase II Fisheries Restoration Plan under the KBRA (KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same impacts as Phase I.	2, 3	B	None	B
Implementation of Wood River Wetland Restoration could result in reduced nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms.	2, 3	B	None	B
Implementation of the Water Use Retirement Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms.	2, 3	B	None	B

~~**Table 3.4.1 Summary of Algae Impacts**~~

Table 3.4-1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation [1]	Significance After Mitigation Pursuant to CEQA
Implementation of the Interim Flow and Lake Level Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms.	2, 3	B	None	B
Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program could result in decreases in nutrient inputs to Upper Klamath Lake and Keno Impoundment/Lake Ewauna and associated decreases in nuisance and/or noxious phytoplankton blooms.	2,3	B	None	B

[1] The timing of reservoir drawdown under the Proposed Action was optimally developed to minimize environmental effects (Section 3.4.4.4.1).
[2] This revision reflects an editorial clarification. As indicated by the analysis under the Proposed Action, the determination for Alternative 5 in the Hydroelectric Reach from Copco 1 Reservoir to Iron Gate Reservoir should also have been a significant effect

Key:
NCFEC = No change from existing conditions; B = Beneficial; LTS = Less than significant; S = Significant

3.4.5 References

Anderson, C.W., and Carpenter, K.D. 1998. Water quality and algal conditions in the North Umpqua River Basin, Oregon, 1992–95, and implications for resource management. U.S. Geological Survey Water-Resources Investigations Report 98-4125.

Armstong, N., and Ward, G. 2008. Coherence of nutrient loads and AFWO Klamath River grab sample water quality database. Technical Report. Prepared for USFWS, Arcata Fish and Wildlife Office, Arcata, California.

Asarian, E~~,~~., and Kann, J. 2011. Phytoplankton and nutrient dynamics in Iron Gate and Copco reservoirs, 2005–2010. Technical Memorandum. Prepared by Kier Associates, Eureka, California and Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Klamath Basin Tribal Water Quality Work Group.

Asarian, E., Kann, J., and Walker, W.W. 2009. Multi-year nutrient budget dynamics for Iron Gate and Copco Reservoirs, California. Prepared by Riverbend Sciences and Kier Associates, Eureka, California, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon, and William Walker, Concord, Massachusetts for the Karuk Tribe, Department of Natural Resources, Orleans, California.

Asarian, E., Kann, J., and Walker, W.W. 2010. Klamath River nutrient loading and retention dynamics in free-flowing reaches, 2005–2008. Final Technical Report to the Yurok Tribe Environmental Program, Klamath, California.

Asarian, E. 2011. Personal communication to E. Floyd on 22 February ~~22,~~ 2011.

~~Blue-green Algae Work Group of the State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment. 2010. Cyanobacteria in California recreational water bodies: providing voluntary guidance about harmful algal blooms, their monitoring, and public notification. Draft. July 2010.~~

~~CH2MHill. 2009. Occurrence of microcystin in tissues of chinook salmon and steelhead in the Klamath River in 2007, Appendix E. Report on histopathological examination of fish livers. Prepared for PacifiCorp Energy, http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Klamath_River/2007_FishTissueRpt.pdf~~

~~Chorus I, and Bartram J. 1999. Toxic cyanobacteria in water: a guide to public health consequences, monitoring and management. Für WHO durch E & FN Spon /Chapman & Hall, London,~~

~~Coleman ME, and McGie AM. 1988. Evaluate causes for the decline of the shortnose and Lost River suckers in Klamath Lake, Oregon. Oregon Department of Fish and Wildlife, Fish Division. Portland, Oregon.~~

Creager, C. 2011. NCRWQCB. Personal communication to Emily Floyd on 15 March 2011.

Deas M, and Vaugh J. 2006. Characterization of organic matter fate and transport in the Klamath River below Link Dam to assess treatment/reduction potential. Prepared for U.S. Biggs, B.J.F. 2000. New Zealand periphyton guideline: detection, monitoring, and managing enrichment of streams. Prepared for Ministry of Environment, NIWA, Christchurch. http://www.mfe.govt.nz/publications/water/nz-periphyton-guide-jun00.pdf. Accessed on: November 4, 2008.

Bradbury, J.P., Colman, S.M., and Reynolds, R.L. 2004. The history of recent limnological changes and human impact on Upper Klamath Lake, Oregon. Journal of Paleolimnology 31: 151–161.

Bureau of Reclamation Klamath Area Office by Watercourse Engineering, Inc. Davis, California.

Department of the Interior (DOI). 2011. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's(Reclamation). 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restorationdam removal and basin restoration, Klamath River, Oregon and California, Prepared for Mid-Pacific Region,. Technical Report No. SRH-2011-02. Prepared for Bureau of Reclamation, Mid-Pacific Region, Technical Service Center, Denver, CO.Colorado.

CH2M Hill. 2009. Occurrence of microcystin in tissues of Chinook salmon and steelhead in the Klamath River in 2007, Appendix E. Report on histopathological examination of fish livers. Prepared for PacifiCorp Energy, http://pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Klamath_River/2007_FishTissueRpt.pdf.

Chorus, I., and Bartram, J. 1999. Toxic cyanobacteria in water: a guide to public health consequences, monitoring and management. Chapman & Hall, London England.

Christian, R.R., Jr., Bryant, W.L., and Stanley, D.W. 1986. The relationship between river flow and *Microcystis aeruginosa* blooms in the Neuse River, North Carolina. Project No. WRRI 85-02-70037. Prepared by Biology Department and Institute for Coastal and Marine Resources, East Carolina University, Greenville, North Carolina.

Colman, S.M., Bradbury, J.P., and Rosenbaum, J.G. 2004. Paleolimnology and paleoclimate studies in Upper Klamath Lake, Oregon. Journal of Paleolimnology 31: 129–138.

Creager, C. 2011. NCRWQCB. Personal communication to Emily Floyd on March 15, 2011.

Deas, M., and Vaughn, J. 2006. Characterization of organic matter fate and transport in the Klamath River below Link Dam to assess treatment/reduction potential. Prepared for Bureau of Reclamation Klamath Area Office by Watercourse Engineering, Inc., Davis, California.

Dodds, W.K. 1991. Factors associated with the dominance of the filamentous green alga *Cladophora glomerata*. Water Research 25: 1,325–1,332.

Eilers ~~JM~~, J.M., Kann, J., Cornett, J., Moser ~~KL~~, K.L., St. Amand, A., Gubala, C. 2001. Recent paleolimnology of Upper Klamath Lake, Oregon. Prepared by J.C. Headwaters, Inc. for the ~~U.S.~~ Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon. ~~March~~ March 16.

Eilers ~~JM~~, J.M., Kann, J., Cornett, J., Moser, K., and St. Amand, A. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon~~, USA~~. Hydrobiologia 520: 7–18.

Eilers, J.M. 2005. Periphyton in selected sites of the Klamath River, California. Prepared for Tetra Tech, Inc. January 2005.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental ~~Impact~~ Impact Statement for hydropower license. Klamath Hydroelectric Project (FERC Project No. 2082-027). ~~http://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp~~ http://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp.

Fetcho, K. 2006. Klamath River blue-green algae bloom report. Water Year 2005. Yurok Tribe Environmental Program. January 2006.

~~Fetcho K~~ _____. 2007. 2006 Klamath River blue-green algae summary report. Prepared by the Yurok Tribe Environmental Program, Klamath, California.

~~Fetcho K~~ _____. 2008. 2007 Klamath River blue-green algae summary report. Final Report. Prepared by the Yurok Tribe Environmental Program, Klamath, California.

~~Fetcho K.~~ _____. 2009. 2008 Klamath River blue-green algae summary report. Final Report. Prepared by the Yurok Tribe Environmental Program, Klamath, California.

_____. 2011. 2009 Klamath River blue-green algae summary report. Final Report. Prepared by the Yurok Tribe Environmental Program, Klamath, California.

Hamilton J, Hampton M, Quinones R, Rondorf D, Simondet J, and Smith T. 2010. Synthesis of the effects on fish species of two management scenarios for the Secretarial Determination on removal of the Lower Four Dams on the Klamath River. Final Draft. Prepared by the Biological Subgroup (BSG) for the Secretarial Determination (SD) regarding potential removal of the Lower Four Dams on the Klamath River. 23 November 2010.

Hiner, M. 2006. Seasonal water quality in the Klamath River estuary and surrounding sloughs, 2001–2003. Final Report. March 2006.

Hoopa Valley Tribe Environmental Protection Agency. 2008. Water quality control plan Hoopa Valley Indian Reservation. Approved 11 September 2002, Amendments Approved 14 February 2008. Hoopa Valley Tribal Environmental Protection Agency, Hoopa, California.

Huisman, J., Sharples, J., Stroom, J.M., Visser, P.M., Kardinaal, W.E.A., Verspagen, J.M.H., and Sommeijer, B. 2004. Changes in turbulent mixing shift competition for light between phytoplankton species. Ecology 85: 2,960–2,970.

Interagency Ecological Program. 2007~~-~~. Interagency Ecological Program 2006–2007 work plan to evaluate the decline of pelagic species in the upper San Francisco estuary. 12 January 2007. http://science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2006-7_Workplan_011207.pdf.

~~Jacoby JM, and~~ Kann ~~J. 2007. The occurrence and response to toxic cyanobacteria in the Pacific Northwest, North America. Lake and Reservoir Management 23: 123–143.~~

~~Kann,~~ J. 1997. Ecology and water quality dynamics of a shallow hypereutrophic lake dominated by cyanobacteria (*Aphanizomenon flos-aquae*). Ph~~.~~D~~.~~ Dissertation. Chapel Hill, University of North Carolina.

_____. 2004. Memo: Copco Lake analysis. Letter to Kier and Associates from J. Kann J., Aquatic Ecologist, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon. 7 December.

_____. 2006. *Microcystis aeruginosa* occurrence in the Klamath River system of southern Oregon and northern California. Technical Memorandum. Prepared for the Yurok Tribe Environmental and Fisheries Program, Klamath, California.

Kann J. 2007a. Toxic cyanobacteria results for Copco/Iron Gate reservoirs: 31 May and 12–13 June 2007. Technical memorandum from J. Kann, Aquatic Ecologist, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon. 19 June.

Kann J. 2007b. Toxic cyanobacteria results for Copco/Iron Gate reservoirs: 26–27 June. Technical memorandum from J. Kann, Aquatic Ecologist, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon. 29 June.

Kann J. 2007c. Toxic cyanobacteria results for Copco/Iron Gate reservoirs: 10–11 July 2007. Technical memorandum from J. Kann, Aquatic Ecologist, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon. 16 July.

Kann J. 2007d. Toxic cyanobacteria results for Copco/Iron Gate reservoirs: 7–8 August 2007. Technical memorandum from J. Kann, Aquatic Ecologist, Aquatic Ecosystem Sciences, LLC, Ashland, Oregon. 15 August.

Kann J. _____. 2008. Microcystin bioaccumulation in Klamath River fish and freshwater mussel tissue: preliminary 2007 results. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon for the Karuk Tribe of California, Orleans, California.

Kann, J., and Asarian, E. 2006. Longitudinal analysis of Klamath River phytoplankton data 2001–2004. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and Kier Associates, Blue Lake and Arcata, California for the Yurok Tribe Environmental Program, Klamath, California.

Kann J, and Asarian E. _____. 2007. Nutrient budgets and phytoplankton trends in Iron Gate and Copco reservoirs, California, May 2005–May 2006. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and Kier Associates, Arcata, California and by the Karuk Tribe of California, Department of Natural Resources, Orleans, California for the State Water Resources Control Board.

Kann, J., and Bowman, C. 2012. Middle Klamath River toxic cyanobacteria trends, 2010. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and Karuk Tribe Department of Natural Resources, Orleans, California for the Karuk Tribe Department of Natural Resources, Orleans, California.

Kann, J., and Corum, S. 2006. Summary of 2005 toxic *Microcystis aeruginosa* trends in Copco and Iron Gate reservoirs on the Klamath River, California. Technical

Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

_____. 2007. Summary of 2006 toxic *Microcystis aeruginosa* and microcystin trends in Copco and Iron Gate reservoirs, California. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

~~Kann J, and Corum S.~~_____. 2009. Toxigenic *Microcystis aeruginosa* bloom dynamics and cell density/chlorophyll a relationships with microcystin toxin in the Klamath River, 2005–2008. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

Kann, J., and Smith, V.H. 1999. Estimating the probability of exceeding elevated pH values critical to fish populations in a hypereutrophic lake. Canadian Journal of Fisheries and Aquatic Sciences 56: 2,262–2,270.

Kann, J., Bowater, L., and Corum, S. 2010. Middle Klamath River toxic cyanobacteria trends, 2009. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

Kann, J., Bowater, L., Johnson, G., and Bowman, C. 2011. Preliminary 2010 microcystin bioaccumulation results for Klamath River salmonids. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences LLC for the Karuk Tribe Department of Natural Resources, Orleans California.

Konopka, A., and Brock, T.D. 1978. Effect of temperature on blue-green algae (Cyanobacteria) in Lake Mendota. Applied and Environmental Microbiology 36~~(4)~~: 572–576.

Kuwabara, J.S. 1992. Associations between benthic flora and diel changes in dissolved arsenic, phosphorus, and related physico-chemical parameters. Journal of the North American Benthological Society 11: 218–228.

Lehman, P.W., Boyer, G., Hal, C., Waller, S., and Gehrts, K. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541: 87–99.

Lehman, P.W., Boyer, G., Satchwell, M., and Waller, S. 2008. The influence of environmental conditions on the seasonal variation of *Microcystis* cell density and microcystins concentration in San Francisco Estuary. Hydrobiologia 600: 187–204.

Lopez, C.B., Jewet,t E.B., Dortch, Q., Walton, B.T., and Hudnell, H.K. 2008. Scientific assessment of freshwater harmful algal blooms. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology.

Mackie, T. 2005. Written communications with attachments from T. Mackie, Research Scientist, California Department of Health Services, Environmental Health Sciences Division, UC Berkeley, California to G. Louis, U.S. Environmental Protection Agency, Region 9, San Francisco, California. 3 November and 31 October.

Miller, M.A., Kudela, R.M., Mekebri, A., Crane, D., Oates, S.C., and et al. 2010. Evidence for a novel marine harmful algal bloom: cyanotoxin (microcystin) transfer from land to sea otters. PLoS ONE 5: e12576. doi:10.1371/journal.pone.0012576.

Mioni ~~CE~~, C.E., and Payton, A. 2010. What controls microcystis bloom and toxicity in the San Francisco estuary? (Summer/Fall 2008 & 2009). Delta Science Program Brownbag Series. Sacramento, California. ~~12 May 2010.~~

Moisander, P.A., Ochiai, M., and, Lincoff, A. 2009. Nutrient limitation of *Microcystis aeruginosa* in northern California Klamath River reservoirs. Harmful Algae doi:10.1016/j.hal.2009.04.005.

National Research Council ~~(NRC)~~. 2004. Endangered and threatened fishes in the Klamath River Basin. The National Academies Press, Washington, D~~.~~C.

North Coast Regional Water Quality Control Board (NCRWQCB). 2010~~a~~. Klamath River total maximum daily loads (TMDLs) addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in California, the proposed site specific dissolved oxygen objectives for the Klamath River in California, and the Klamath River and Lost River implementation plans. Final Staff Report with Appendices. North Coast Regional Water Quality Control Board, Santa Rosa, California.

~~NCWQCB. 2010b. Action plan for the Klamath River TMDLs addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in the Klamath River in California and Lost River implementation plan. September 2010.~~Odum, H.T. 1956. Primary production in flowing water. Limnology and Oceanography 1: 102–117.

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake drainage total maximum daily load (TMDL) and water quality management plan (WQMP). Portland, Oregon.

Pogue, T.R., and Anderson, C.W. 1995. Processes controlling dissolved oxygen and pH in the Upper Willamette River Basin, Oregon, 1994. U.S. Geological Survey Water-Resources Investigations Report 95-4205. http://or.water.usgs.gov/pubs_dir/Abstracts/95-4205.html.

Power, M.E., Parker, M.S., and Dietrich, W.E. 2008. Seasonal reassembly of a river food web: floods, droughts, and impacts of fish. Ecological Monographs 78: 263–282.

Raymond, R. 2005. Methods and data for PacifiCorp phytoplankton sampling in the Klamath River system, 2001–2005. Technical Memorandum. E&S Environmental Chemistry, Inc.

~~Raymond R. 2009 . Results of cyanobacteria and microcystin monitoring~~_____. 2008. Results of 2007 phytoplankton sampling in the Klamath River and Klamath Hydroelectric Project (FERC Project No. 2082). Final Report. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon, for PacifiCorp, Portland, Oregon.

_____. 2009. Phytoplankton species and abundance observed during 2008 in the vicinity of the Klamath Hydroelectric Project. ~~Technical Memorandum. 8 June~~Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon, for CH2M Hill, Portland, Oregon and PacifiCorp Energy, Portland, Oregon.

_____. 2010. Phytoplankton species and abundance observed during 2009~~.~~ ~~Prepared for T. Hemstreet and L. Prendergast (Pacificorp). 12 June 2009~~ in the vicinity of the Klamath Hydroelectric Project. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon for PacifiCorp Energy, Portland, Oregon.

Snyder~~ MA~~, D.T., and Morace, J.L. 1997. Nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath and Agency Lakes, Oregon. Water-Resources Investigations Report 97-4059. U.S. Department of the Interior, U.S. Geological Survey, Denver, Colorado, in cooperation with the Bureau of Reclamation.

Snyder, M.A., Sloan~~ LC~~, L.C., and Bell, J.L. 2004. Modeled regional climate change in the hydrologic regions of California: a CO^2 sensitivity study. Journal of the American Waters Resources Association 40: 591–601.

State Water Resources Control Board, California Department of Public Health and Office of Environmental Health and Hazard Assessment (SWRCB et al.). 2010. Cyanobacteria in California recreational water bodies: providing voluntary guidance about harmful algal blooms, their monitoring, and public notification. Blue Green Algae Work Group of the State Water Resources Control Board, the California Department of Public Health, and Office of Environmental Health and Hazard Assessment.

Stillwater Sciences. 2009. Dam removal and Klamath River water quality: a synthesis of the current conceptual understanding and an assessment of data gaps. Technical Report. Prepared by Stillwater Sciences, Berkeley, California for State Coastal Conservancy, Oakland, California.

Sullivan~~ AB~~, A.B., Deas~~ ML~~, M.L., Asbill, J., Kirshtein~~ JD~~, J.D., Butler, K., and Vaughn, J. 2009. Klamath River water quality data from Link River Dam to Keno Dam, Oregon, 2008. U.S.~~-~~ Geological Survey Open File Report 2009-1105. Prepared by the U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.

~~Teh SJ~~Tanner, D.Q., and Anderson, C.W. 1996. Assessment of water quality, nutrients, algal productivity, and management alternatives for low-flow conditions, South Umpqua River Basin, Oregon, 1990–92. U.S. Geological Survey Water-Resources Investigations Report 96-4082.

The, S.J., Baxa~~ DV~~, D.V., and Acuña, S. 2010. Effects of *Microcystis aeruginosa* in threadfin shad (*Dorosoma petenense*). Final Report. Contract No. 4600008137. Prepared for California Department of Water Resources.

~~U. S. Environmental Protection Agency (USEPA). 2008. USEPA's notification of availability regarding reconsideration of its decision to approve the omission of microcystin toxins in the Klamath river as part of California's 2005 3030(d) List and request for public comment. Federal Register 8547-7.~~

Van Der Westhuizen~~ AJ~~, A.J., and Eloff, J.N. 1985. Effect of temperature and light on the toxicity and growth of the blue-green alga *Microcystis aeruginosa* (UV-006)*. Planta 163: 55–59.

VanderKooi, S.P., Burdick, S.M., Echols, K.R., Ottinger, C.A., Rosen, B.H., and Wood, T.M. 2010. Algal toxins in Upper Klamath Lake, Oregon: linking water quality to

juvenile sucker health. U.S. Geological Survey Fact Sheet 2009-3111. U.S. Geological Survey, Western Fisheries Research Center, Seattle, Washington. http://pubs.usgs.gov/fs/2009/3111/pdf/fs20093111.pdf.

Walker~~ WW.~~, W.W. 2001. Development of a phosphorus TMDL for Upper Klamath Lake, Oregon. Oregon Department of Environmental Quality. ~~7 March.~~

Ward, G., and Armstrong, N. 2010. Assessment of primary production and associated kinetic parameters in the Klamath River. Draft Report. Prepared for the USFWS, Arcata Fish and Wildlife Office, Arcata, California.

WQST (Water Quality SubTeam). 2011. Assessment of Long Term Water Quality Changes for the Klamath River Basin Resulting from KHSA, KBRA, and TMDL and NPS Reduction Programs. Prepared by the Water Quality Sub Team for the Klamath Facilities Removal Secretarial Determination regarding potential removal of the lower four dams on the Klamath River. http://www.klamathrestoration.gov/keep-me-informed/secretarial-determination/fole-of-science/secretarial-determination-studies.

3.5 Terrestrial Resources

3.5.1 Area of Analysis

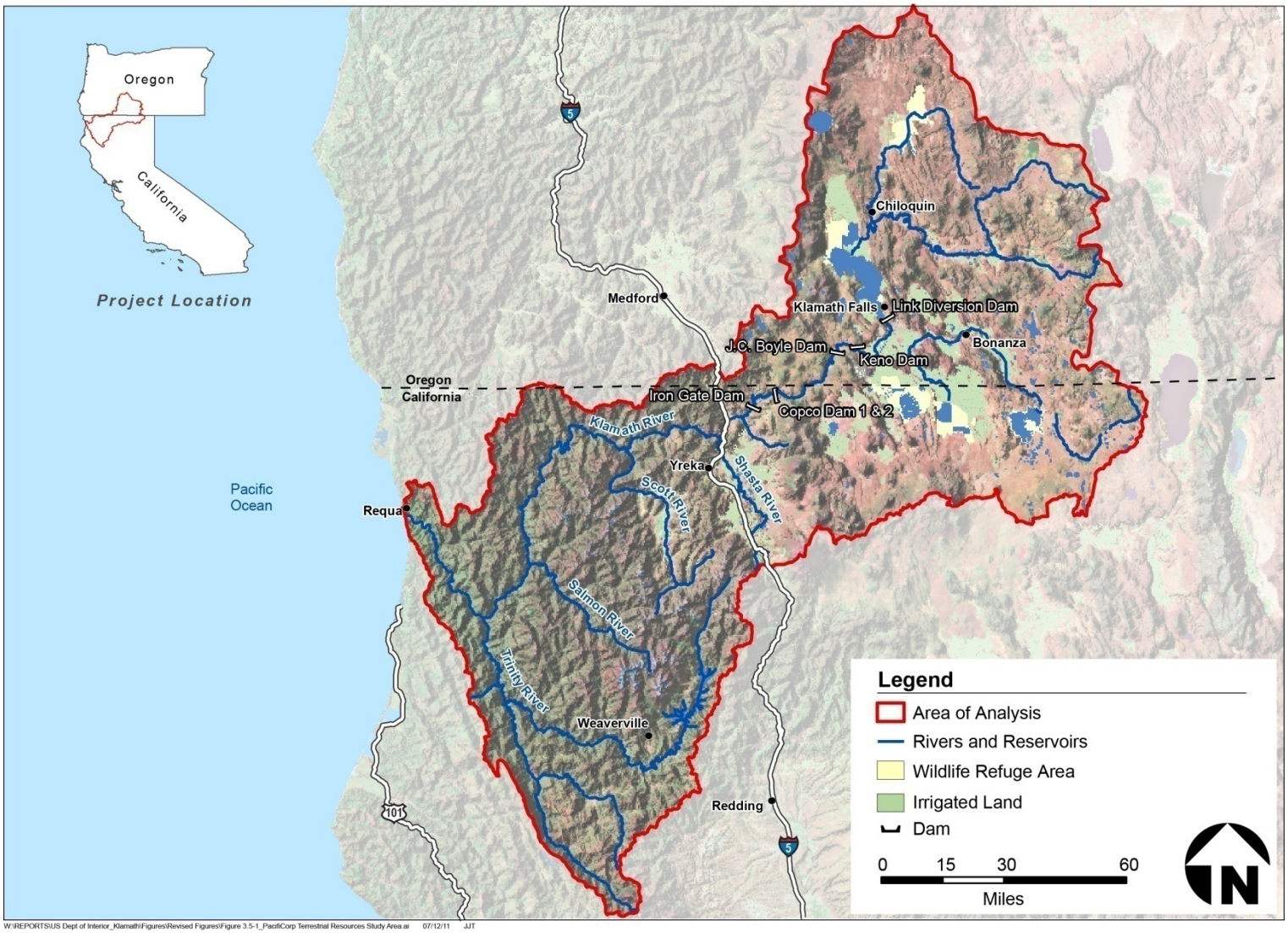
The Klamath Hydroelectric Settlement Agreement (KHSA) area of analysis or "project area" for terrestrial resources impacts includes vegetation communities and habitats of the Klamath River watershed currently influenced by the presence of the Four Facilities. Both the riparian vegetation communities downstream from these dams and the associated reservoirs upstream are influenced by the presence of the dams and have the potential to be affected by their removal. Thus, the project area extends along the Klamath River from Keno Dam to the Pacific Ocean and includes the river channel and riparian zone. Upland habitats occurring in construction areas are also included in the project area. This would include areas potentially affected by changes in land use and water supply patterns caused by the KHSA. In addition, the area of analysis includes areas where Klamath Basin Restoration Agreement (KBRA) actions would occur, particularly the Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges (NWR) in the Klamath Basin National Wildlife Refuge System (Figure 3.5-1). Most KBRA actions would occur within the Upper Klamath Basin, but some would also occur in the Lower Klamath Basin (excluding the Trinity River watershed), and are included in the area of analysis.

3.5.2 Regulatory Framework

Terrestrial resources within the area of analysis are regulated by several ~~federal~~Federal, state, and local laws and policies, which are listed below.

3.5.2.1 Federal Authorities and Regulations

- Endangered Species Act (ESA) (7 USC § 136; 16 USC § 1531 et seq.)
- Fish and Wildlife Coordination Act (16 USC § 661 et seq.)
- Migratory Bird Treaty Act (16 USC § 703 et seq.)
- Clean Water Act (CWA) (33 USC § 1251 et seq.)
- Executive Order 11990- Protection of Wetlands (42 FR 26961)
- Executive Order 11988- Floodplain Management (42 FR 26951)
- Bald and Golden Eagle Protection Act (16 CFR 668)
- National Wildlife Refuge Administration Act, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 USC § 668dd et seq.)
- United States Fish and Wildlife Service (USFWS) Biological Opinion
- Northwest Forest Plan
- Noxious Weed Act (7 USC § 2801 et seq.) and Executive Order 13112 Invasive Species (64 FR 6183)



W:\REPORTS\US Dept of Interior_Klamath\Figures\Revised Figures\Figure 3.5-1_PacifiCorp Terrestrial Resources Study Area.ai 07/12/11 JJT

Figure 3.5-1. PacifiCorp Terrestrial Resources Study Area.

3.5.2.2 State Authorities and Regulations

- California Endangered Species Act (ESA) (California Fish and Game Code [FGC] Section 2050 et seq.)
- Migratory Bird Protection (FGC Sections 3500 - 3705)
- Streambed Alterations (FGC Section 1600)
- Exotic Species Introductions (California Food and Agriculture Code Section 403)
- Oregon Endangered Species Act (ESA) (Oregon Revised Statutes [ORS] 496 et seq.)
- Oregon Removal-Fill Law (ORS 196 et seq.)
- Oregon Noxious Weed Control Law (ORS 561)

3.5.2.3 Local Authorities and Regulations

- Siskiyou County General Plan (1973)
- Humboldt County General Plan (1984)
- Del Norte County General Plan (2003)
- Klamath County Comprehensive Plan (2010)

3.5.3 Existing Conditions/Affected Environment

The project area is within the Klamath Ecological Province and the Klamath Bioregion, characterized by forested mountains and a fairly wet climate that supports large river systems. Vegetation communities include wetter forests near the coast, including white fir and Douglas fir, transitioning to drier mixed conifer-pine and mixed conifer-fir in the mountain ranges of Siskiyou County. Sagebrush and interior valley vegetation communities also exist within lower elevation areas. In Oregon, the project area is within the East Slope Cascades and the West Slope Cascades eco-regions. In California, the project area is within the Southern Cascades and the Modoc Plateau physiographic provinces and is also within the Cascade-North Sierra floristic region of the California floristic province (Federal Energy Regulatory Commission [FERC] 2007).

The Klamath-Siskiyou mountain ranges are recognized for their biological diversity, with more than 3,000 known plant species, including 30 temperate conifer tree species, more than any other ecosystem in the world (California Department of Fish and Game [CDFG] 2006). The Klamath River Canyon is a mosaic of pine, oak, juniper, and mixed conifer forest communities, with ponderosa pine and Oregon white oak being the dominant tree species. Riparian habitats are dominated by oak, birch, and white alder (FERC 2007).

3.5.3.1 Vegetation Communities and Habitat Types

The majority of the information in this section was obtained from the PacifiCorp Final Technical Report (FTR) on terrestrial resources prepared for the Klamath Hydroelectric Project (PacifiCorp 2004a). The “primary study area” for the terrestrial resources technical report included the Klamath River from the Link River Dam to the Shasta River and the area within 0.25 mile of all PacifiCorp facilities, reservoirs, and river reaches. PacifiCorp also identified a “secondary study area” that included the area between the

canyon rims from J.C. Boyle Dam to the eastern end of Copco Reservoir and all PacifiCorp-owned lands near the PacifiCorp facilities (Figure 3.5-2).

"Study area" in this section refers to the area covered by the terrestrial resources FTR, whereas "project area" refers to the area of analysis defined in Section 3.5.1. The terrestrial resources FTR study area does not include the Klamath River downstream ~~of~~ from Shasta River, and information on vegetation communities is not available to the level of detail presented in the terrestrial FTR for the downstream reaches of the Klamath River.

Unless specified, information on terrestrial resources in the ~~lower~~Lower Klamath River was obtained from the following sources:

- Draft Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration (Greimann ~~et~~ et al. 2010), which discusses the general physical characteristics of the Klamath River reaches;
- *Green Diamond Resource Company Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances* (Green Diamond Resource Company 2006), which provides information on habitat and occurrence of southern torrent salamander and tailed frog in the ~~lower~~tributaries of the Lower Klamath River ~~reaches~~;
- *Mid-Klamath Subbasin Fisheries Resource Recovery Plan* (Karuk Tribe of California 2003), which covers the Klamath River between Iron Gate Dam and the Trinity River;
- *The Lower Klamath River Sub-Basin Watershed Restoration Plan* (Yurok Tribal Watershed Restoration Program 2000), which covers the Klamath River between the Trinity River and the Pacific Ocean; and
- *Klamath River Estuary Wetlands Restoration Prioritization Plan* (Yurok Tribe Environmental Program 2009), which covers the Klamath River Estuary.

The study area for the PacifiCorp FTR includes 11 river reaches of the Klamath River upstream ~~from~~of the Shasta River, as listed in Table 3.5-1.

~~**Table 3.5-1. River Reaches in the PacifiCorp Study (2004a)**~~

Table 3.5-1. River Reaches in the PacifiCorp Study (2004a)

River Reach	River Mile
Link River	253.3 to 254.8
Keno Impoundment	233.3 to 253.3
Keno Canyon	228.2 to 233.3
J.C. Boyle Reservoir	224.6 to 228.2
J.C. Boyle Bypass	220.2 to 224.6
J.C. Boyle Peaking Reach	203.9 to 220.2
Copco 1 Reservoir	198.7 to 203.9

Fall Creek	0 to 1.5*
Copco 2 Bypass	196.8 to 198.7
Iron Gate Reservoir	188.9 to 196.8
Iron Gate-Shasta	176.8 to 188.9

Source: PacifiCorp 2004a
Notes:
*River Mile of Fall Creek

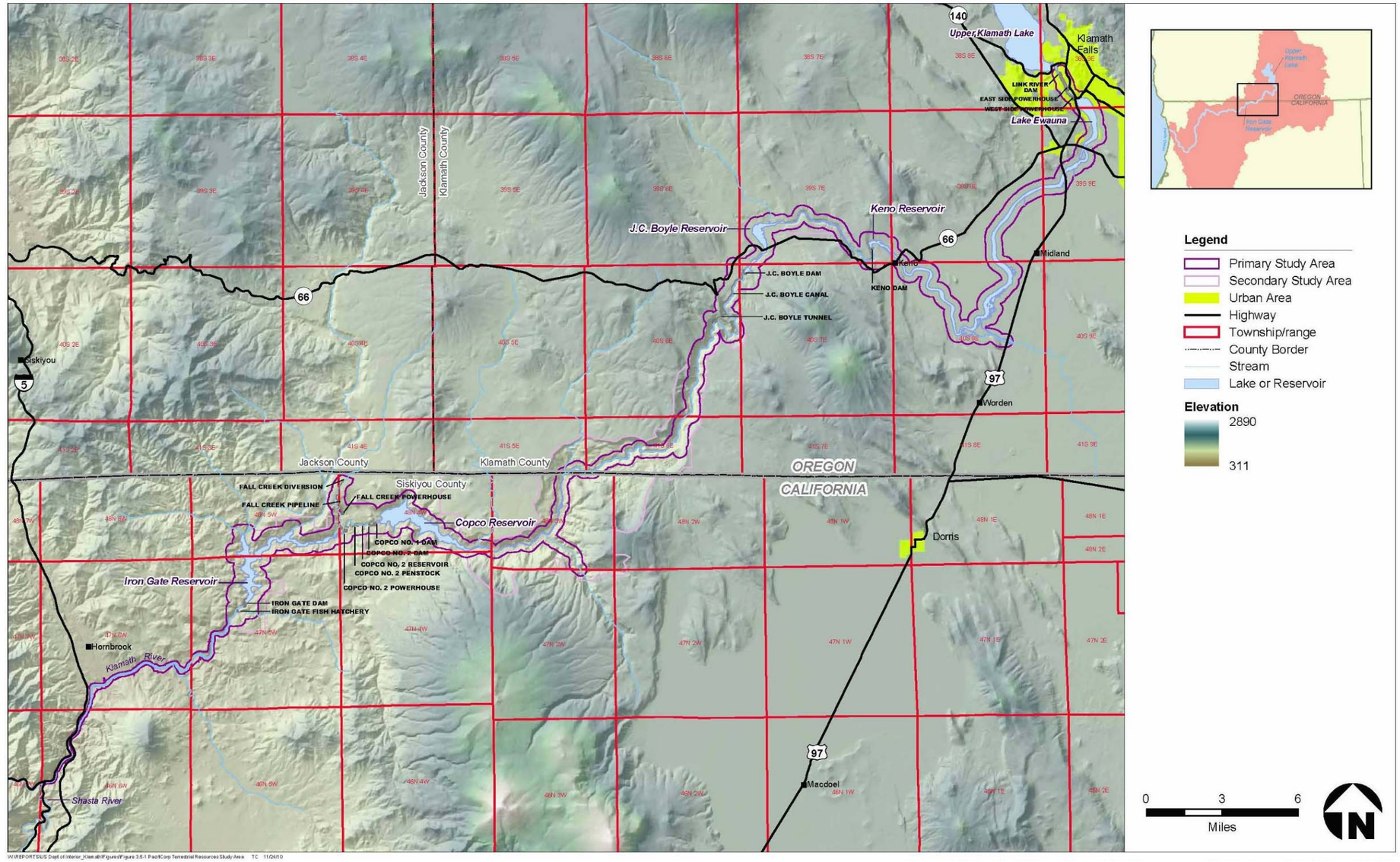


Figure 3.5-2. PacifiCorp Terrestrial Resources Study Area (PacifiCorp 2004a).

Eight vegetation cover types were mapped by PacifiCorp (2004a), with each cover type further sub-classified. Appendix G includes a series of 18 vegetation maps covering the PacifiCorp study reaches. These figures and a description of each cover type are included in Appendix G. Table 3.5-2 lists the major cover types and their relative distribution and acreage among the river reaches and Table 3.5-3 lists the sub-classifications of each cover type. PacifiCorp considered Copco 1 and Copco 2 as one reservoir during their study, and collectively referred to them as Copco reservoir (PacifiCorp 2004a). The methods used by PacifiCorp to map vegetation communities in the study area are summarized in Appendix H.

As shown in Table 3.5-2, upland tree habitat occupies 54 percent of the study area and is the most abundant cover type in all locations except at Keno Impoundment and along the Klamath River, from the Iron Gate development to the Shasta River, where aquatic and wetland cover types dominate at Keno Impoundment and upland herbaceous cover types dominate at Klamath River from Iron Gate Dam to Shasta River. Upland shrub habitat occupies 9.5 percent of the study area and is particularly abundant near the Copco 2 bypass reach. Upland herbaceous habitat occupies 9.2 percent of the study area and is common along the Klamath River between the Iron Gate development and the Shasta River (25.5 percent) and at the Iron Gate (21 percent) and Copco Reservoirs (16 percent).

Barren habitat, consisting of rock talus (rubble at the bottom of a slope or cliff) or exposed rock, occupies 1.7 percent of the study area. Agricultural and developed habitat (excluding general grazing allotment areas) occupies 11 percent of the study area, primarily along Link River, at Keno Impoundment, and along the Klamath River from Iron Gate development to the Shasta River. Developed and agricultural lands dominate the area near Keno Impoundment (48 percent), and consist primarily of pasture or irrigated hayfields.

~~Wetland and riparian vegetation in the project area is influenced by water flow and level in the river and reservoirs and sediment flow and deposition through the system. Wetland habitat consists of emergent marsh, shrub-scrub wetlands, and forested wetlands and occupies only 4.2 percent of the study area. Wetland habitat occurs primarily at the Keno Impoundment (19.5 percent of wetland habitat in the study area), the J.C. Boyle Reservoir (5.5 percent of wetland habitat), and Copco Reservoir (1.3 percent of wetland habitat). Iron Gate Reservoir contains 60 acres of wetland habitat, or only 0.9 percent of total wetland habitat. Aquatic habitat (open water habitat largely devoid of vegetation) occupies 9.6 percent of the study area, with the highest percentage (22.4 percent or 2,136.6 acres) occurring at the Keno Impoundment.~~

~~Riparian habitat occurs along the river and reservoir shorelines in some areas and consists of deciduous, shrub, and grassland vegetation. Riparian habitat occupies only 1.1 percent of the study area. Along the river reaches, reed canarygrass is a common riparian plant species in high flow areas. Reed canarygrass may outcompete other riparian species due to its ability to better use abundant nutrients and withstand frequently fluctuating peaking flows. Along the banks above high flow areas, most river reaches have even distribution~~

~~of coyote willow/reed canarygrass/colonial bentgrass, perennial ryegrass, and Oregon ash/colonial bentgrass/woolly sedge (PacifiCorp 2004a).~~

~~Wetland and riparian vegetation occurs to varying degrees along the project reservoirs. The majority of this habitat is limited to small patches in protected locations and near inlets/tributaries. However, several large wetland and riparian habitats are associated with the Keno Impoundment and J.C. Boyle Reservoir. Both the Copco Reservoir and Iron Gate Reservoir have steep slopes that generally lack extensive, near-shore riparian and wetland habitat. Emergent vegetation within the wetland and riparian communities of the reservoirs includes sedge, rush, bentgrass, bulrush, and cattail. Coyote willow is the dominant shrub layer of the wetlands at reservoirs in the project area (PacifiCorp 2004a).~~

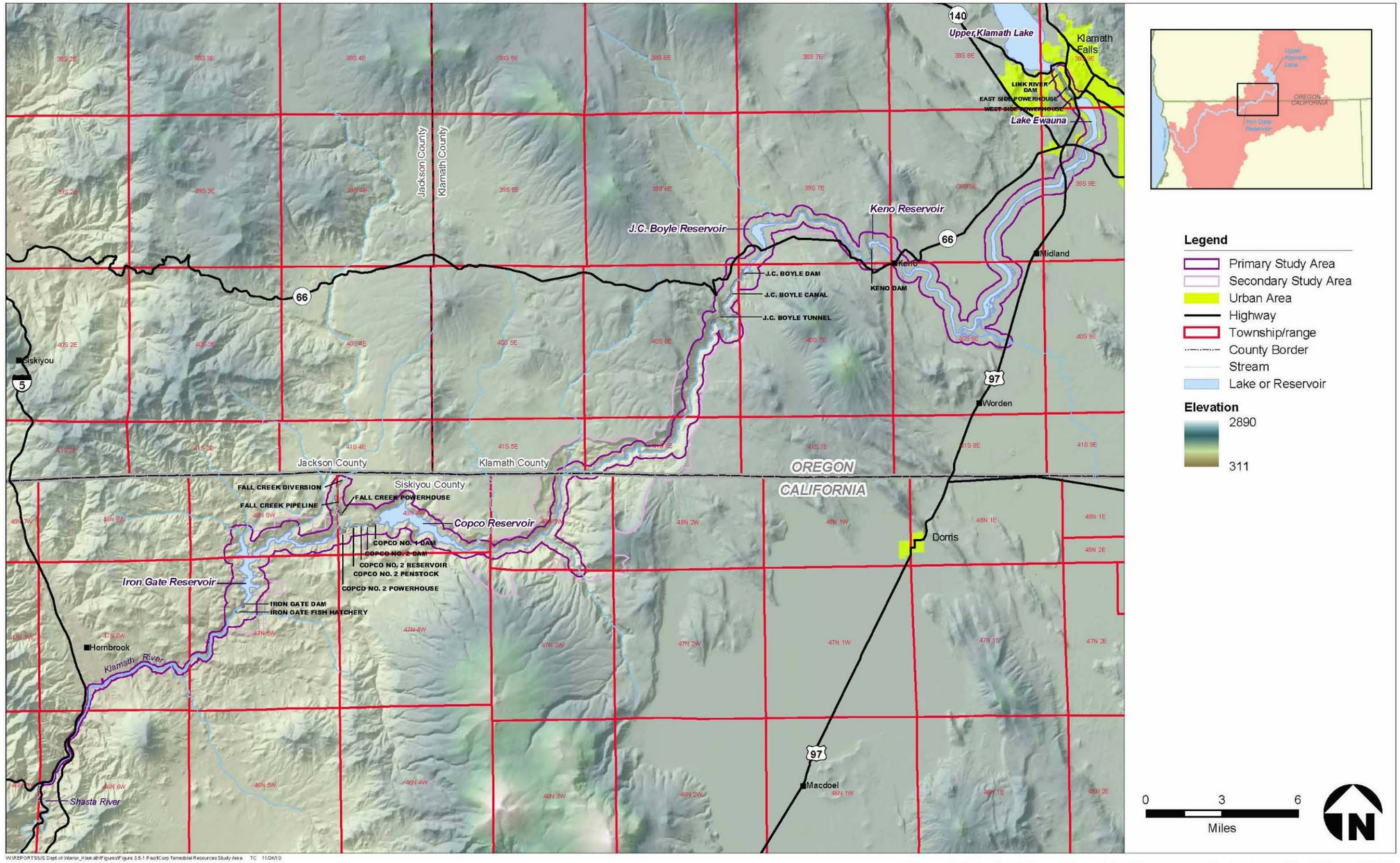
~~Noxious Weeds and Invasive Plant Species~~

~~During biological surveys conducted in 2002, 2003, and 2004, 17 species of noxious weeds were identified within the study area. The noxious weed inventory fieldwork emphasized areas around PacifiCorp facilities, roads, transmission lines, and at reservoirs, riverine shorelines, and riparian areas from the Link River to the mouth of the Shasta River. In addition, data from resource agencies on noxious weeds was obtained to supplement surveys for a 0.25-mile wide (0.4-km-wide) buffer around PacifiCorp structures, reservoirs, and river reaches (PacifiCorp 2004a).~~

~~During the surveys, the following 17 noxious weed species were found in the study area:~~

- ~~Bull thistle (*Cirsium vulgare*)~~
- ~~Canada thistle (*Cirsium arvense*)~~
- ~~Cheatgrass (Bromus tectorum)~~
- ~~Diffuse knapweed (*Centaurea diffusa*)~~
- ~~Dalmatian toadflax (*Linaria dalmatica*)~~
- ~~Dyer's woad (Isatis tinctoria)~~
- ~~Hoary Cress (*Cardaria draba*)~~
- ~~Mediterranean sage (*Salvia aethiopsis*)~~
- ~~Medusahead (Taeniatherum caput-medusae)~~
- ~~Perennial pepperweed (*Lepidium latifolium*)~~
- ~~Puncture vine (Tribulus terrestris)~~
- ~~Russian knapweed (*Acroptilon repens*)~~
- ~~Scotch thistle (Onopordum acanthium)~~
- ~~Scotch broom (Cytisus scoparius)~~
- ~~Spiny cocklebur (*Xanthium spinosum*)~~
- ~~St. John's wort (Hypericum perforatum)~~
- ~~Yellow starthistle (*Centaurea solstitialis*)~~

~~In addition to the species listed above, reed canarygrass is an invasive plant species found throughout the project area.~~



~~Figure 3.5-2. PacifiCorp Terrestrial Resources Study Area (PacifiCorp 2004a)~~

Wetland and riparian vegetation in the project area is influenced by water flow and level in the river and reservoirs and sediment flow and deposition through the system. Wetland habitat consists of palustrine aquatic bed, palustrine emergent, palustrine forested, and palustrine shrub-scrub wetlands. PacifiCorp (2004a) describes these wetland habitat types as follows:

- Palustrine Aquatic Bed: Dominant species are pondweeds (*Potamogeton* spp.) and coontail (*Ceratophyllum demersum*). Occurs primarily at J.C. Boyle Reservoir (37.6 acres).

- Palustrine Emergent: Dense herbaceous layer, often with a weedy zone immediately upslope of the bulrush (*Scirpus* spp.) zone. Occurs at J.C. Boyle Reservoir (63.2 acres), Copco Reservoir (18.9 acres), and Iron Gate Reservoir (11.2 acres).

- Palustrine Forested: Dense tree cover includes the primarily hydrophilic tree species coyote willow (*Salix exigua*) and shining willow (*Salix lucida*). Occurs at Copco Reservoir (57.1 acres) and Iron Gate Reservoir (38.8 acres).

Table 3.5-2. Distribution of Vegetation Cover Types Mapped in 2002 in the PacifiCorp Study Area (2004a)

Vegetation Cover Type	Iron Gate-Shasta	Iron Gate Reservoir	Copco 2 Bypass	Fall Creek	Copco Reservoir	J.C. Boyle Peaking Reach	J.C. Boyle Bypass	J.C. Boyle Reservoir	Keno Canyon	Keno Impound-ment	Link River	Grand Total
Upland Tree												
Subtotal	135.1	3,472.5	714.4	692.1	3,159.0	15,400.9	1,465.2	1,136.8	1,599.4	304.6	237.3	28,316.9
Percent of Reach	9.7%	52.7%	59.4%	74.6%	51.2%	75.3%	70.6%	59.1%	78.0%	3.2%	42.2%	53.6%
Upland Shrub												
Subtotal	205.8	478.4	251.7	102.6	791.2	1,851.2	285.9	120.0	259.3	607.5	88.7	5,042.2
Percent of Reach	14.8%	7.3%	20.9%	11.1%	12.8%	9.1%	13.8%	6.2%	12.6%	6.4%	15.8%	9.5%
Upland Herbaceous												
Subtotal	353.5	1,383.8	80.4	28.7	962.5	1,675.8	109.6	171.6	24.7	46.8	3.4	4,840.6
Percent of Reach	25.5%	21.0%	6.7%	3.1%	15.6%	8.2%	5.3%	8.9%	1.2%	0.5%	0.6%	9.2%
Wetland												
~~Subtotal~~Palustrine	~~0.6~~	~~60.1~~ 0.9	~~4.5~~	~~13.5~~	~~79.2~~	~~89.9~~ 0.1	~~14.1~~	~~105.1~~	~~5.1~~	~~1,860.8~~	~~5.6~~	~~2,238.5~~
Aquatic Bed				0.6				37.6		254.1		293.3
Palustrine Emergent	0.4	11.2	1.4	8.0	18.9	89.8	8.3	63.2	5.1	1,589.4	0.2	1,795.9
Palustrine Forested		38.8	3.1	2.2	57.1		5.0			9.5	2.9	118.6
Palustrine Scrub-Shrub	0.2	9.2		2.7	3.2		0.8	4.2		7.8	2.5	30.6
Subtotal	0.6	60.1	4.5	13.5	79.2	89.9	14.1	105.1	5.1	1,860.8	5.6	2,238.5
Percent of Reach	0.0%	0.9%	0.4%	1.5%	1.3%	0.4%	0.7%	5.5%	0.2%	19.5%	1.0%	4.2%
Aquatic												
Subtotal	218.5	964.9	10.0	0.9	999.6	277.1	45.5	299.4	92.3	2,136.6	32.3	5077.1
Percent of Reach	15.8%	14.7%	0.8%	0.1%	16.2%	1.4%	2.2%	15.6%	4.5%	22.4%	5.7%	9.6%
Riparian												
Subtotal	151.1	41.8	23.1	39.9	25.6	228.3	32.1	0.8	20.3	0.8	33.9	597.5
Percent of Reach	10.9%	0.6%	1.9%	4.3%	0.4%	1.2%	1.6%	0.0%	1.0%	0.0%	6.0%	1.1%
Barren												
Subtotal	17.4	63.1	82.6	38.3	61.4	545.0	96.0	10.2	12.3	0.0	0.0	926.2
Percent of Reach	1.3%	1.0%	6.9%	4.1%	1.0%	2.7%	4.6%	0.5%	0.6%	0.0%	0.0%	1.7%
Agricultural/ Developed												
Subtotal	304.4	120.3	35.5	11.7	96.3	379.6	28.0	80.7	37.2	4,575.8	161.0	5,830.5
Percent of Reach	22.0%	1.8%	3.0%	1.3%	1.6%	1.8%	1.3%	4.2%	1.8%	48.0%	28.6%	11.0%
Total Acres	**1,386.4**	**6,585.1**	**1,202.2**	**927.7**	**6,174.7**	**20,447.8**		**1,924.5**	**2,050.6**	**9,532.9**	**562.1**	

							2,076.1					**52,869.5**
Percent of Total	**2.6%**	**12.5%**	**2.3%**	**1.8%**	**11.7%**	**38.7%**	**3.9%**	**3.6%**	**3.9%**	**18.0%**	**1.1%**	**100.0%**

Table 3.5-3. Sub-Classification of Vegetation Cover Types Mapped in 2002 in the PacifiCorp Study Area (2004a)

Upland Tree Habitats	**Wetland Habitats**	**Barren Habitat**
Montane Hardwood Oak	Palustrine Emergent	Rock Talus
Montane Hardwood Oak-Conifer	Palustrine Scrub-Shrub	Exposed Rock
Montane Hardwood Oak-Juniper	Palustrine Forested	
Juniper	Palustrine Aquatic Bed	**Agricultural/Developed**
Mixed Conifer		
Lodgepole Pine	**Riparian Habitats**	
Ponderosa Pine	Riparian Grassland	
	Riparian Shrub	
Upland Shrub Habitats	Riparian Deciduous	
Mixed Chaparral	Riparian Mixed Deciduous-Coniferous	
Rabbitbrush		
Sagebrush	**Aquatic Habitat**	
	Riverine and Lacustrine Unconsolidated Bottom	
Upland Herbaceous Habitats	Riverine and Lacustrine Unconsolidated Shore	
Annual Grassland		
Perennial Grassland		

- Palustrine Scrub-Shrub: Open canopy with moderate shrub layer. Coyote willow and arroyo willow (*Salix lasiolepis*) are the primary hydrophilic shrubs. Occurs at J.C. Boyle Reservoir (4.2 acres), Copco Reservoir (3.2 acres), and Iron Gate Reservoir (9.2 acres).

Wetland habitat occupies only 4.2 percent of the study area. Wetland habitat occurs primarily at the Keno Impoundment (19.5 percent of wetland habitat in the study area), the J.C. Boyle Reservoir (5.5 percent of wetland habitat), and Copco Reservoir (1.3 percent of wetland habitat). Iron Gate Reservoir contains 60 acres of wetland habitat, or only 0.9 percent of total wetland habitat. Aquatic habitat (open water habitat largely devoid of vegetation) occupies 9.6 percent of the study area, with the highest percentage (22.4 percent or 2,136.6 acres) occurring at the Keno Impoundment.

Riparian habitat occurs along the river and reservoir shorelines in some areas and consists of deciduous, shrub, and grassland vegetation. Riparian habitat occupies only 1.1 percent of the study area. Along the river reaches, reed canarygrass is a common riparian plant species in high flow areas. Reed canarygrass may outcompete other riparian species due to its ability to better use abundant nutrients and withstand frequently fluctuating peaking flows. Along the banks above high flow areas, most river reaches have even distribution of coyote willow/reed canarygrass/colonial bentgrass, perennial ryegrass, and Oregon ash/colonial bentgrass/woolly sedge (PacifiCorp 2004a).

Wetland and riparian vegetation occurs to varying degrees along the project reservoirs and river reaches. Vegetation maps prepared by PacifiCorp (2004a) are provided in Appendix G. The majority of wetland and riparian habitat is limited to small patches in protected locations and near inlets/tributaries. However, several large wetland and riparian habitats are associated with the Keno Impoundment and J.C. Boyle Reservoir. Both the Copco Reservoir and Iron Gate Reservoir have steep slopes that generally lack extensive, near-shore riparian and wetland habitat. Emergent vegetation within the wetland and riparian communities of the reservoirs includes sedge, rush, bentgrass, bulrush, and cattail. Coyote willow is the dominant shrub layer of the wetlands at reservoirs in the project area (PacifiCorp 2004a).

Wetland and riparian habitats currently existing along the shorelines of the project reservoirs are anthropogenic, formed when the natural hydrology of the Klamath River was altered and the reservoirs were created. Riparian corridors typically exist as narrow, fragmented bands with habitat extending from water channels only as far as can be supported by a river's hydrology and elevated water table. However, project reservoirs have shoreline elevations that include expanses of flat, formerly upland areas, which now support wider fragmented patches of wetland and riparian habitat. Although altered from the natural state of the historic Klamath River, the existing wetland and riparian habitats provide important functions, including nursery areas for fish and other aquatic wildlife and food, cover, foraging, and nesting habitat for birds and other terrestrial wildlife.

Figures 3.5-3, 3.5-4, and 3.5-5 show the historic vegetation types for areas currently inundated by J.C. Boyle, Copco, and Iron Gate reservoirs, respectively (PacifiCorp

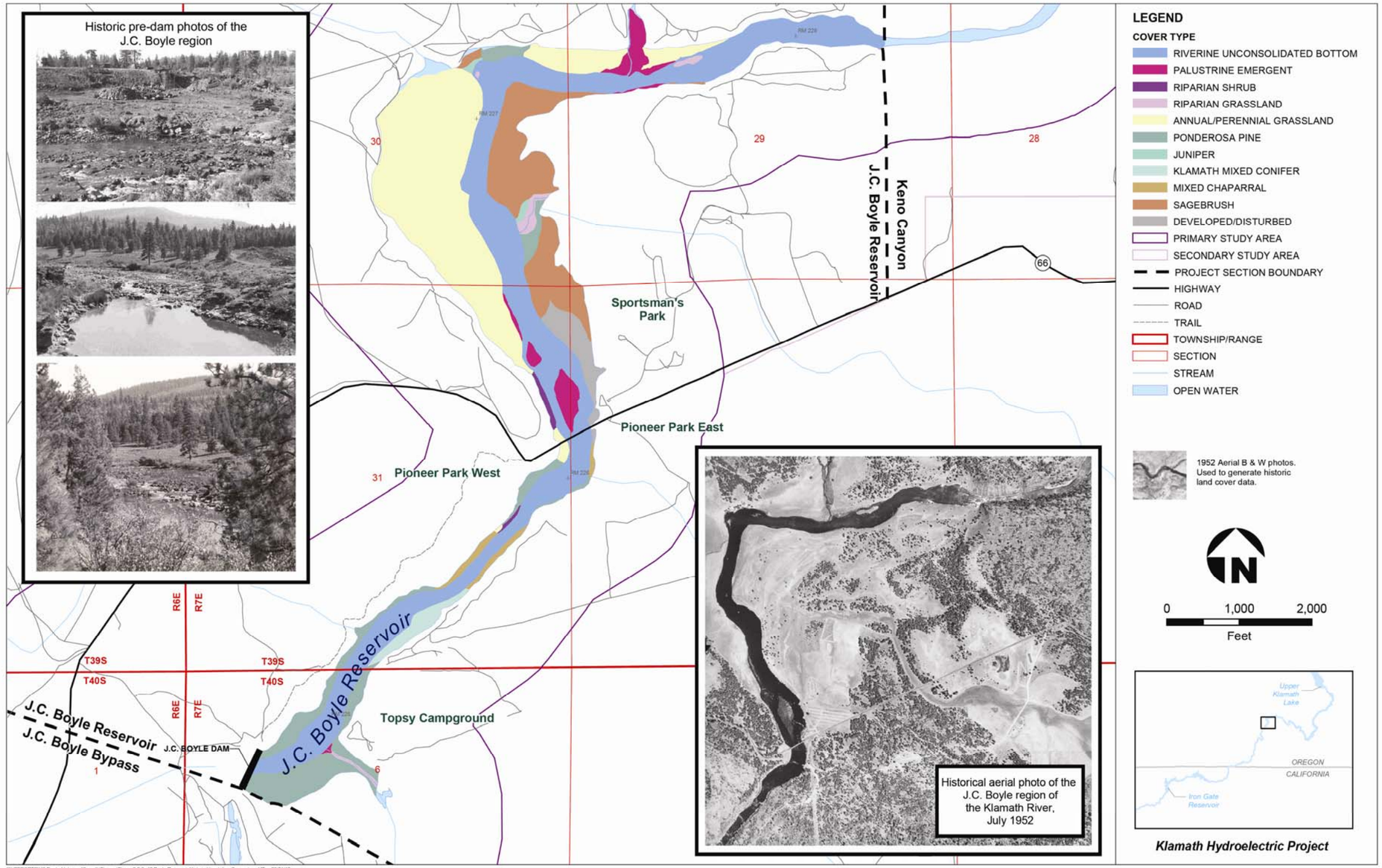


Figure 3.5-3. J.C. Boyle Reservoir Historic Vegetation Types.

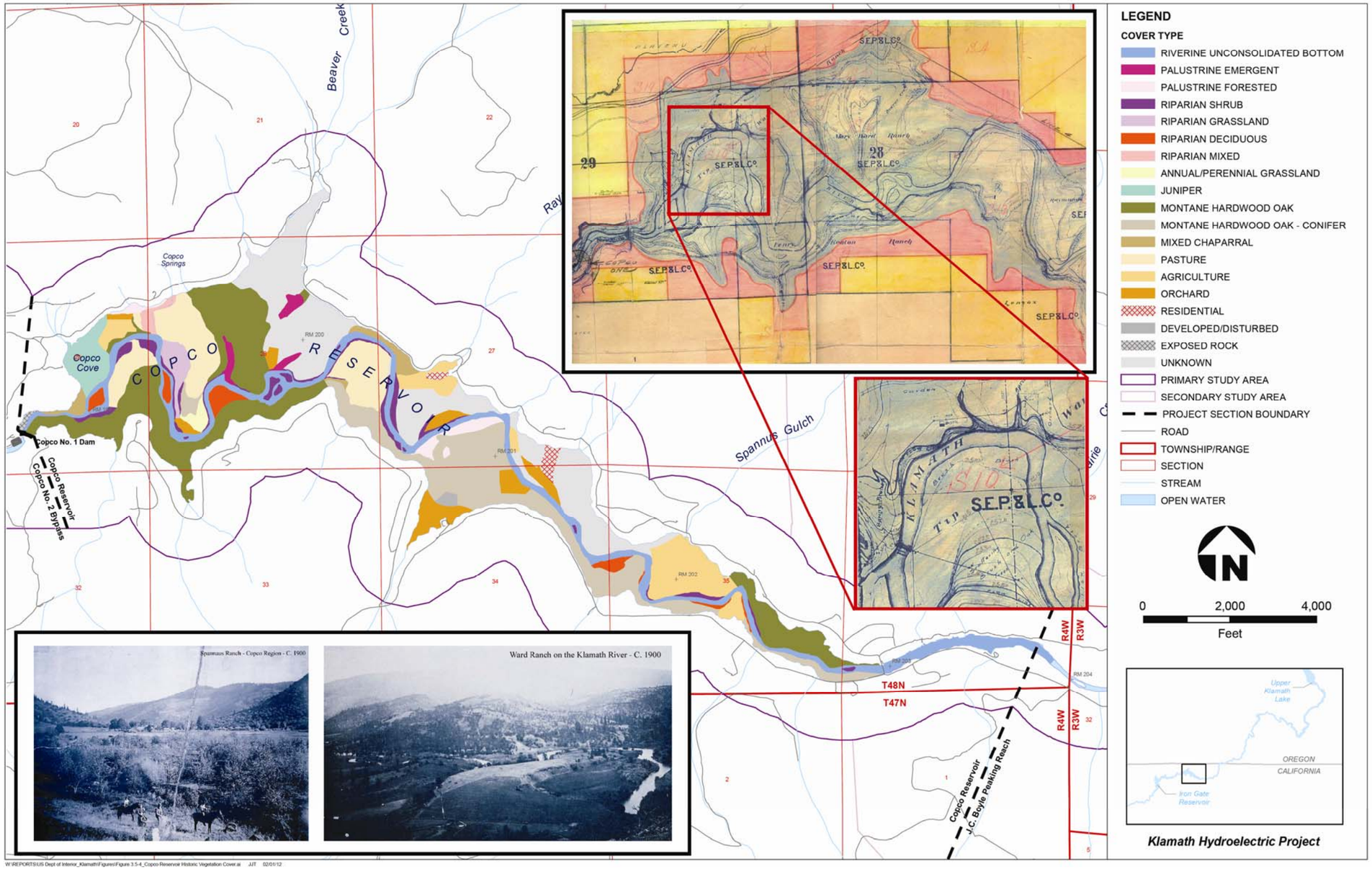


Figure 3.5-4. Copco Reservoir Historic Vegetation Types.

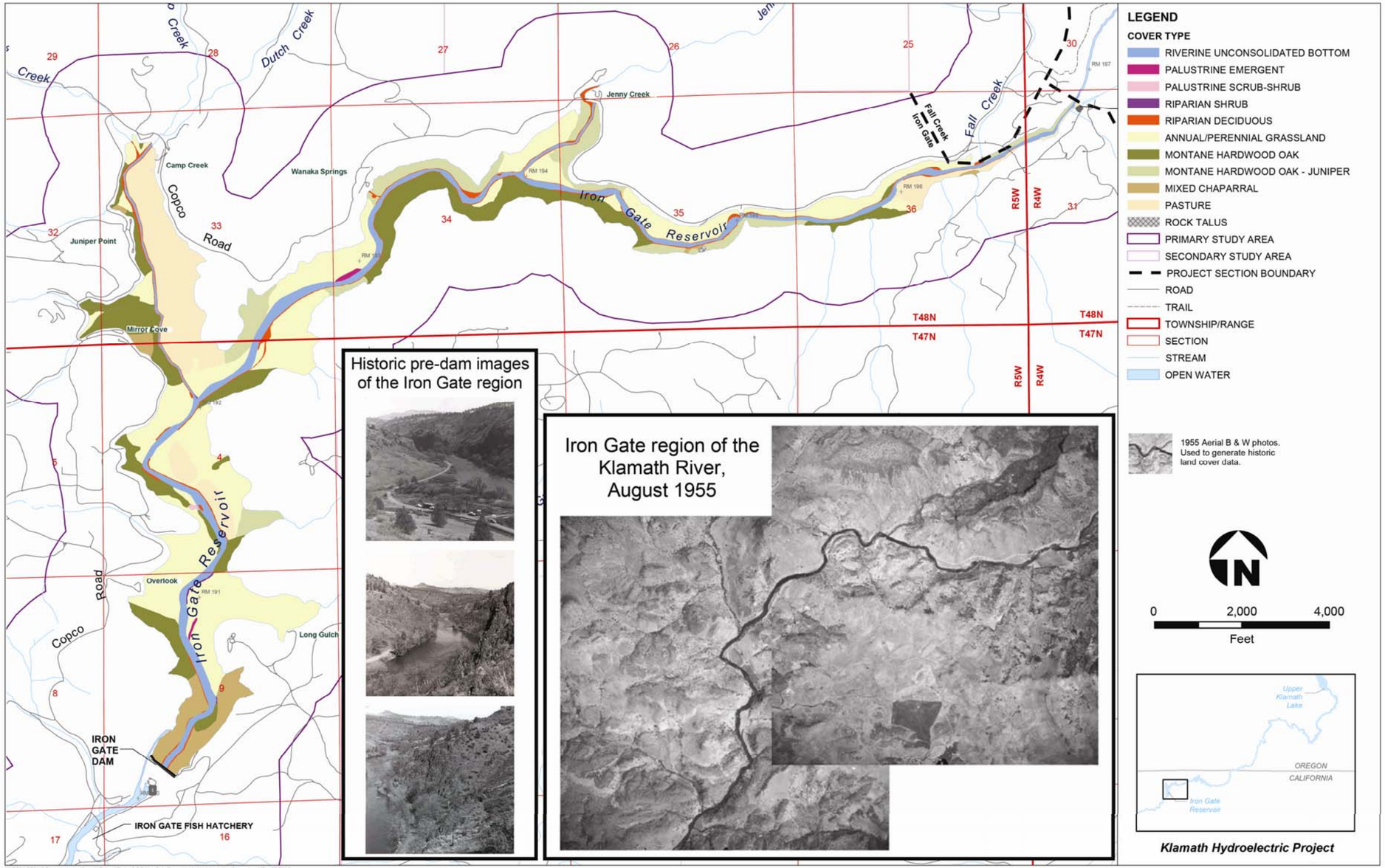


Figure 3.5-5. Iron Gate Reservoir Historic Vegetation Types.

2004a). Assessment of the aerial and oblique photography before dam construction indicated that in general, the distribution of wetland (shown as Palustrine Emergent) and riparian habitat in these areas consisted of long, thin bands running along the historic Klamath River channel. In comparison, somewhat wider, but more widely scattered patches of these vegetation types currently exist along the project reservoir shorelines (PacifiCorp 2004a).

A comparison of historic vegetation communities at J.C. Boyle Reservoir indicates that there is more wetland and riparian habitat surrounding the reservoir than historically occurred. Historically, low-lying uplands located southeast of the Klamath River were composed of sagebrush and grassland (see Figure 3.5-3). These areas are now dominated by a large contiguous patch of palustrine emergent wetland near the Sportsmen's Park that has formed from the raised water level (PacifiCorp 2004a).

At Copco 1 Reservoir, topography limited the establishment of wetland and riparian areas following reservoir inundation. The area where Copco 1 Reservoir is currently located historically consisted of a wide floodplain confined by steep slopes, with a wide, dense riparian forest located along several river bends (see Figure 3.5-4). Currently, the reservoir shoreline extends up these steep slopes, and few areas are available for wetland and riparian habitat establishment due to the steep topography (PacifiCorp 2004a).

At Iron Gate Reservoir, the large wetland and riparian habitat areas that currently exist near the mouths of Jenny, Scotch, and Camp creeks were historically at elevations above the Klamath River and supported primarily upland vegetation including grasslands (see Figure 3.5-5). Creation of the Iron Gate Reservoir raised the water level and created a flat bench for wetland and riparian vegetation (PacifiCorp 2004a).

Based on mapping shown in Figure 3.5-3, Figure 3.5-4, and Figure 3.5-5, an estimated 34.9 total acres of wetland habitats and 101.3 acres of riparian habitats historically occurred along the Klamath River at the current location of the reservoirs prior to construction of the dams. As shown in Table 3.5-2, there are currently a total of 244.4 acres of wetland habitats and 68.2 acres of riparian habitat at the reservoirs based on PacifiCorp mapping (2004a).

3.5.3.1.1 Noxious Weeds and Invasive Plant Species

During biological surveys conducted in 2002, 2003, and 2004, 17 species of noxious weeds were identified within the study area. The noxious weed inventory fieldwork emphasized areas around PacifiCorp facilities, roads, transmission lines, and at reservoirs, riverine shorelines, and riparian areas from the Link River to the mouth of the Shasta River. In addition, data from resource agencies on noxious weeds was obtained to supplement surveys for a 0.25-mile wide (0.4-km-wide) buffer around PacifiCorp structures, reservoirs, and river reaches (PacifiCorp 2004a).

During the surveys, the following 17 noxious weed species were found in the study area:

- Bull thistle (*Cirsium vulgare*)
- Canada thistle (*Cirsium arvense*)
- Cheatgrass (Bromus tectorum)
- Diffuse knapweed (*Centaurea diffusa*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Dyer's woad (Isatis tinctoria)
- Hoary Cress (*Cardaria draba*)
- Mediterranean sage (*Salvia aethiopsis*)
- Medusahead (Taeniatherum caput-medusae)
- Perennial pepperweed (*Lepidium latifolium*)
- Puncture vine (Tribulus terrestris)
- Russian knapweed (*Acroptilon repens*)
- Scotch thistle (Onopordum acanthium)
- Scotch broom (Cytisus scoparius)
- Spiny cocklebur (*Xanthium spinosum*)
- St. John's wort (Hypericum perforatum)
- Yellow starthistle (*Centaurea solstitialis*)

In addition to the species listed above, reed canarygrass is an invasive plant species found throughout the project area.

In addition to these species, other invasive species occur throughout the project area, including the middle and ~~lower~~Lower Klamath River reaches. These species include reed canarygrass, Japanese and Himalayan knotweed, and Himalayan blackberry (~~personal communication with J.~~ Hamilton~~, USFWS, January 7,~~ 2011). In addition, poison hemlock (*Conium maculatum*) is a common noxious weed present along the shores of Keno Impoundment (~~personal communication with R.~~ Larson~~, USFWS, March 13,~~ 2011).

During the PacifiCorp vegetation surveys, cheatgrass, yellow starthistle, and medusahead were the most widespread noxious weed species across all 11 of the study area sections. Bull thistle and Canada thistle were also pervasive in the study area (PacifiCorp 2004a). Noxious weeds occurred in 62 percent of the sampled riparian/wetland sites. Many of the weed species occur in uplands or near the riparian/upland interface. In general, noxious weeds were found to be abundant where ground disturbance had occurred. The spread of these weeds likely occurs as a result of vehicles or machinery spreading weed seeds and propagules in areas where bare soil is exposed. Ground disturbance has resulted from various land uses and maintenance activities in the study area, including maintenance of power plants, transmission lines, flowlines, recreation sites, and roads. The abundance of weeds at Keno Impoundment may be the result of agricultural development and livestock grazing. In addition, residential and commercial developments contribute to the spread of these invasive plants (PacifiCorp 2004a).

In addition to the surveys conducted by PacifiCorp (2004a), vegetation surveys were conducted around the perimeter of J.C. Boyle, Copco, and Iron Gate Reservoirs in November 2009 and July 2010 (U~~nited States~~.S. Department of the Interior [DOI] 2011a). These surveys confirmed the presence of yellow starthistle and medusahead at Copco and Iron Gate Reservoirs, but did not find these species at J.C. Boyle Reservoir. However, large stands of reed canarygrass were documented along the eastern shoreline of the northern section of the J.C. Boyle Reservoir.

Upper Klamath River

The Upper Klamath River includes the areas upstream of J.C. Boyle Reservoir. Findings of vegetation and wildlife surveys conducted for the PacifiCorp study (2004a) in the Link River Reach, Keno Impoundment, and Keno Canyon Reach are summarized below. As described in Section 3.5.1, the area of analysis for this Environmental Impact Statement/Environmental Impact Report (EIS/EIR) also includes areas of the Upper Klamath Basin where KBRA actions would occur, particularly those areas associated with the ~~National Wildlife Refuges (~~NWRs~~)~~. Lower Klamath, Tule Lake, and Upper Klamath NWRs would be most directly affected by the KBRA (USFWS 2010). These NWRs are managed to provide habitat and food for waterfowl. As such, they consist largely of seasonal and permanently flooded marshes with emergent and submergent wetland vegetation. In addition, a large amount of croplands surrounding these wetlands provide food for wintering waterfowl.

Link River Reach

The Link River is the headwaters reach of the Klamath River just above Lake Ewauna near the city of Klamath Falls. The Link River Dam and its reservoir (Upper Klamath Lake) are not part of the project area for the Klamath Hydroelectric Settlement Agreement, but are part of the area that would be affected by the KBRA.

In addition to being affected by river hydrology and seepage from canals and penstocks, user-created trails and encampments and maintenance activities have adversely affected riparian vegetation along the Link River reach through ground disturbance that precludes vegetation growth. The riparian vegetation along the right bank is structurally diverse and relatively continuous, while the vegetation on the left bank is more disturbed and patchy. Vegetation in the reach has an abundance of introduced woody species, including apple, plum, and elm (PacifiCorp 2004a).

Keno Impoundment

Keno Impoundment is not part of the project area for the Klamath Hydroelectric Settlement Agreement, but is part of the area that would be affected by the KBRA. Keno Impoundment has a surface area of 2,475 acres. As with the other project reservoirs, wetlands at the Keno Impoundment are influenced by the hydrology of the reservoir. However, the water level at the Keno Impoundment fluctuates less than at the other reservoirs, and the wetlands occur in naturally low-lying areas that probably supported significant wetlands before formation of the Keno Impoundment (PacifiCorp 2004a).

The wetland vegetation at Keno Impoundment is more diverse than at any other project reservoir, with the most abundant wetland vegetation types dominated by hardstem bulrush and broadfruited bur-reed. Applegate's milk-vetch (*Astragalus applegatei*), a federally endangered and Oregon endangered species, was documented during surveys at Keno Impoundment (PacifiCorp 2004a). See Table 3.5-4 in Section 3.5.3.4 for a discussion of special-status species that occur in the project area. The coyote willow vegetation type, which is dominated by coyote willow in the shrub layer, is not common at the Keno Impoundment, but occurs in dense, small stands in low-lying pastures protected by levees. The tops of the levees are dominated by noxious weed species, such as poison hemlock and Canada thistle (PacifiCorp 2004a). The noxious weed, perennial pepperweed (*Lepidium latifolium*), also occurs in wetlands along the Keno Impoundment and is likely to be present on private lands (~~personal communication with R.~~ Larson~~, [USFWS], March 13,~~ 2011).

Keno Canyon Reach

The Keno Canyon reach has steep slopes with a narrow shoreline. The reach experiences low flows in the growing season, resulting in the growth of intact, undisturbed riparian grass vegetation dominated by reed canarygrass. Willow reproduction in the Keno Canyon reach is lacking, and existing willow trees are in a state of decay with large horizontal branches broken because of rot or chewing by beavers (PacifiCorp 2004a). There is a mostly intact transition from the riparian zone to the upland zone that consists

primarily of shrub vegetation on the canyon slopes. Some riparian areas are disturbed from recreational use by fishermen.

J.C. Boyle Reservoir

The water level in J.C. Boyle Reservoir is controlled at the J.C. Boyle powerhouse and by inflows from upstream irrigation. As a result, there are wide mudflats exposed on a daily basis in some portions of the reservoir, and there is no woody riparian/wetland vegetation immediately along the shoreline. In spite of water fluctuations, the wetland vegetation at the reservoir is diverse and largely undisturbed, with patches of dense emergent marsh in low-gradient areas. Areas that are fenced and protected, such as at the mouth of Spencer Creek, support high quality woody and herbaceous riparian and wetland vegetation. In contrast, wetlands along the northwest shoreline are highly disturbed by cattle grazing (PacifiCorp 2004a).

J.C. Boyle Bypass and Peaking Reaches

The J.C. Boyle bypass reach generally has a stable water level with low flows, supporting reed canarygrass as well as sedges and willows. A canal with long steep slopes covered by boulders runs along the bypass reach. At the end of the canal is a spillway below which vegetation is lacking due to scour from periodic high flows (PacifiCorp 2004a). In both the J.C. Boyle bypass and peaking reaches, Oregon oak and Oregon ash are dominant tree species, with arroyo willow and coyote willow also common (PacifiCorp 2004a).

Approximately two-thirds of the riparian habitat in the J.C. Boyle bypass reach is riparian grassland, which is predominately reed canarygrass (Administrative Law Judge 2006). The current low-flow situation and the lack of natural flow variability and scouring from intermittent high flows likely contribute to the prevalence of reed canarygrass in this area ~~is a result of current low flows~~. Project operations have adversely affected riparian resources in both the J.C. Boyle

bypass and peaking reaches by supporting the perpetuation of reed canarygrass and by affecting the structure, size, and nature of depositional features (Administrative Law Judge 2006).

The J.C. Boyle peaking reach has a generally lower gradient and supports large stands of shrub and tree-dominated riparian vegetation. Wetland habitat occurs on wide benches above the banks that are used for hay production and pasture. Some parts of this reach are accessible to cattle grazing. Many of these wide terraces along this reach are used as large irrigated pastures. Irrigation has created vertical and horizontal discontinuity in the riparian vegetation along the river and reduced cover of native herbaceous and woody riparian vegetation. As a result, exotic and non-native invasive species such as Himalayan blackberry, whitetop, and non-native pasture grasses, have become established (PacifiCorp 2004a).

Copco 1 and Copco 2 Reservoirs

PacifiCorp considered Copco 1 and Copco 2 as one reservoir during their study, and collectively referred to them as Copco Reservoir (PacifiCorp 2004a). Along the shorelines of Copco Reservoir, wetlands are highly disturbed in many areas by a variety of land uses, including livestock grazing and recreational fishing. At the shoreline, the low herbaceous vegetation is heavily grazed and has an abundant "weedy" component of yellow starthistle and medusahead in many locations. Willow habitat is limited to areas where the steep banks of the reservoir shorelines are eroding to form benches upon which coyote willow has become established (FERC 2007).

During invasive plants surveys conducted in November 2009 and July 2010, yellow starthistle was only observed growing on the northern side of the reservoir, where it occurs in dense stands in some areas (~~DOI 2011a~~Reclamation 2011).

Copco 2 Bypass Reach

In the Copco 2 Bypass Reach, a dense riparian community of white alder dominates, likely prohibiting shade-intolerant coyote willow and reed canarygrass in this reach. Low river flows and water levels in this reach have provided substrate for the establishment of riparian and wetland vegetation consisting of native and non-native hydrophilic herbaceous species that form a relatively sparse herb layer under the dense white alder canopy (PacifiCorp 2004a).

Iron Gate Reservoir

Wetland and riparian areas along the shorelines of Iron Gate Reservoir are highly disturbed by livestock grazing. The reservoir has moderately steep slopes. Along the larger tributaries of Jenny, Scotch, Dutch, and Beaver Creeks, some tree-dominated riparian habitat occurs, and consists of Oregon ash, Oregon oak, and white alder. Shining willow also occurs at Iron Gate Reservoir.

During invasive plant surveys conducted in November 2009 and July 2010, yellow starthistle was documented as prolific in the dry upland slopes and near roadsides around Iron Gate Reservoir (~~DOI 2011a~~Reclamation 2011).

Fall Creek Reach

Fall Creek is a tributary to the Klamath River just upstream ~~from~~ ofIron Gate Reservoir. In the Fall Creek Reach, there is a unique abundance of conifers in the riparian zone, and coyote willow is absent. Four riparian/wetland vegetation types occurring along Fall Creek include Oregon ash/western birch, Oregon ash/Douglas' spiraea, white alder, and ponderosa pine/Douglas fir/western serviceberry, which typically occurs in drier and more upland areas (PacifiCorp 2004a).

Middle Klamath River

The Mid-Klamath subbasin includes the lower Mid-Klamath and the upper Mid-Klamath. The upper Mid-Klamath includes all watersheds from Iron Gate Reservoir downstream to Seiad Creek, excluding the Scott and Shasta Rivers, while the lower Mid-Klamath includes the mainstem of the Klamath River and all watersheds from Grinder Creek downstream to Weitchpec, excluding the Salmon River (Karuk Tribe of California 2003).

The upper Mid-Klamath subbasin has an interior montane climate. Vegetation within the Klamath Range is primarily mixed conifer/hardwood forests while vegetation in the Great Basin consists of chaparral, sagebrush, and juniper woodland. Riparian habitat in the upper Mid-Klamath is affected by a variety of land management practices, including grazing and irrigated agricultural lands, dams and diversions, gravel mining, and roads (Karuk Tribe of California 2003).

The Klamath River from Iron Gate Dam to Shasta River contains the highest percentage (10.9 percent; Table 3.5-2) of riparian habitat in the PacifiCorp (2004a) study area. In most of the reach, the floodplain is mostly restricted to narrow terraces between the in-channel alluvium and steeper slopes or higher elevation surfaces. The narrow terraces typically support coyote willow, shining willow, Oregon ash, and Oregon oak. Cattle grazing in many areas have degraded these stands, as well as some of the coyote willow stands growing on in-channel bars. Even so, woody riparian vegetation is more abundant in this reach than in any other reach of the study area, although tree-dominated stands are typically much smaller in area than in other reaches, due to recreation development on the larger floodplain surfaces between Iron Gate Dam and Cottonwood Creek. Reed canarygrass is not common along the river downstream ~~of~~ from Iron Gate Dam for unknown reasons (PacifiCorp 2004a).

Langley Falls is along the middle Klamath River at Gottsville, where several tributaries enter from the north and form a large alluvial fan complex that constricts the river. At the lower end of the Middle Klamath River, Seiad Valley lies where large alluvial fans from Seiad Creek, Little Grider Creek and Grider Creek form a wider alluvial valley with large unvegetated gravel bars (~~Griemann et al 2010~~Reclamation 2012).

The lower Mid-Klamath subbasin has a coastal–influenced, Pacific-maritime climate, grading to interior climates of the Klamath Range. The Klamath River and tributaries in this portion of the project area generally have steep slopes and are vegetated with mixed hardwood/conifer forests with mixed conifer evergreen and true fir forests upslope. Riparian habitat in the lower Mid-Klamath has been altered primarily by timber harvest, gravel mining, roads, and fire suppression (Karuk Tribe of California 2003). Several reaches of the middle Klamath River in this area have been extensively mined. Unvegetated gravel bars are common. Major tributaries include the Salmon River, Trinity River, Bluff Creek, Camp Creek and Ukonom Creek (~~Griemann et al 2010~~Reclamation 2012). The middle Klamath River runs through both the Klamath National Forest and the Six Rivers National Forest.

Lower Klamath River and Klamath River Estuary

The Lower Klamath subbasin extends from the confluence of the Klamath and Trinity Rivers to the Pacific Ocean. The coast redwood groves are unique to this part of the project area. Vegetation types are similar to that of the lower Mid-Klamath subbasin, with mixed hardwood/conifer forests dominant. However, based on habitat surveys conducted in 1996 and 1997, conifers comprise less than one third of the riparian canopy in ~~lower~~Lower Klamath tributaries. Riparian areas are dominated by deciduous trees including red alder, which are less able to stabilize streambanks than coniferous trees. Red alder is the most common hardwood in riparian zones, and tanoak is the most common mid to upper slope hardwood, with Pacific madrone occurring as a minor stand component on drier sites (Green Diamond Resource Company 2006). Grazing, timber harvest, and roads have degraded riparian habitat in the Lower Klamath (Yurok Tribal Watershed Restoration Program 2000).

The Klamath River estuary lies where the Klamath River enters the Pacific Ocean. A mile-long spit extends from the south shore of the estuary. The estuary is shallow and is about 2,500 feet long and up to 1,000 feet wide. The river channel in the estuary changes positions often as a result of large flood events, during which most ~~of~~ fine-grained sediments are flushed to the ocean (DOI 2010).

The estuary consists of several wetland complexes, which have been altered to varying degrees from their historical condition. Large wetlands have been converted into grass pastures for cattle or sown for hay, and hydrology has been altered for the construction of roads including U.S. Highway 101. In addition, many tributaries to the estuary have been straightened and lack connection to the floodplain (Yurok Tribe Environmental Program 2009). The lower channel of the estuary was extensively cleared of snags and large woody debris at the turn of the 20th century for commercial gillnetting and navigational purposes (Green Diamond Resource Company 2006).

Freshwater emergent wetland vegetation dominates the estuary. The estuary also supports a number of salt-tolerant species. Invasive species, including reed canarygrass *(Philaris urundinacea)*, Himalayan blackberry *(Rubus procerns)*, and common reed *(Phragmites australis*) also occur, particularly in areas of disturbed soil. Beaver activity

in the estuary helps to create and maintain wetland conditions through the building and maintenance of beaver dams (Yurok Tribe Environmental Program 2009).

3.5.3.2 Culturally Significant Species

Many plants, especially wetland plants, in the project area are culturally important to Indian Tribes in the Klamath River region for food and basketry (Larson and Brush 2010). Among these plants are ipos (roots of *Carum oregonum*), desert parsley (*Lomatium canbyi*), camas bulbs, cattail roots, and wocas (yellow pond lily seeds). Wild celery, wild parsley, and wild rhubarb were gathered along with hazelnuts, acorns, and pine nuts and the fruits of chokecherries, serviceberries, Klamath plums, elderberries, blackberries, gooseberries, wild grapes, and huckleberries (FERC 2007).

All of the tribes in the Klamath basin collect materials from along the Klamath River for making baskets that are used in various ceremonies. Willows *(Salix spp.)* and ferns *(Pteridophyta)* are both common species used in making basketry and regalia, and are important medicinal plants used in healing and ceremony (Yurok Tribe Environmental Program 2009). Tribes commonly collect young willow shoots from gravel bars within riparian areas. Other plant materials used in basket-making include pine, redwood and spruce roots, and grapevine (FERC 2007).

3.5.3.3 Wildlife

The project area supports a large number and diversity of wildlife species. During PacifiCorp surveys conducted in 2002 and 2003, 225 vertebrate wildlife species were detected or confirmed from other sources as occurring in the study area, including five amphibians, 16 reptiles, 174 birds, and 30 mammal species (PacifiCorp 2004a).

3.5.3.3.1 Amphibians

Amphibians and some reptiles are reliant on aquatic, wetland, and riparian habitat. PacifiCorp conducted an inventory of amphibians and reptiles in 2002 and 2003 to document species occurrence and identify important habitats and sites for amphibians and reptiles within the same study area that was used for the community mapping (PacifiCorp 2004a). The focus of the study included aquatic, wetland, and riparian habitats at the reservoirs and within a 0.25 mile buffer around river reaches from Link River to Shasta River. During the surveys, biologists searched suitable aquatic and riparian habitat for adults, larvae, and egg masses, turning rocks, litter, and other cover objects and using nets to catch individuals (PacifiCorp 2004a). Amphibian and reptile surveys were also conducted in suitable upland areas and complemented surveys conducted during previous investigations. Riverine surveys for amphibians found only two amphibian species, Pacific giant salamander and Pacific chorus frog. No amphibians were found during upland surveys. Based on the 2002 and 2003 surveys as well as previous investigations, five amphibian species are known to occur in the Klamath River study area: long-toed salamander, bullfrog, Pacific chorus frog, western toad, and Pacific giant salamander. ~~All of these~~These species are generally restricted to ponds or other still-water habitat, except for the Pacific giant salamander, which is a stream-dwelling species, and the western toad, which can breed in streams and standing water. Results of the PacifiCorp study indicate that reservoirs in the study area appear to provide only marginal breeding habitat for native pond-breeding amphibians. Fluctuating water levels and predation by yellow perch and bullfrog may limit the suitability of these habitats for amphibian breeding. Existing land uses, including roads, cattle grazing, and recreational activities also affect habitat quality in the study area (PacifiCorp 2004a).

In addition to the species listed in PacifiCorp (2004a), other amphibian species are also known to occur in the Klamath Basin. Western toad and foothill yellow-legged frog were reported in some of the tributaries of the Lower Klamath subbasin during trapping studies conducted in 1991 (USFWS 1992). In addition to the species listed in these previous reports, other amphibians are also known to occur in the Klamath Basin. Foothill yellow-legged frog is known by CDFG to breed in the mainstem of the Lower Klamath River (CDFG unpublished data). The northern red-legged frog is known by CDFG to breed in still water and low-velocity habitats, such as wetlands, ponds, and disconnected side channel habitats in coastal areas of the Lower Klamath River (CDFG unpublished data). The foothill yellow-legged frog and northern red-legged frog are both California Species of Special Concern. In addition, Green Diamond Resource Company conducted presence/absence surveys for tailed frogs and southern torrent salamanders (both California species of concern) in ~~the lower Klamath River and~~ tributary streams of the Lower Klamath River and found these two amphibian species to be widespread in the tributaries (Green Diamond Resource Company 2006). ~~In addition, western toad and yellow-legged frog were reported in some of the tributaries of the lower Klamath subbasin during trapping studies conducted in 1991 (USFWS 1992).~~However, due to lack of suitable habitat for these species, neither tailed frog nor southern torrent salamander would be expected to occur in the mainstem of the Lower Klamath River.

3.5.3.3.2 Reptiles

Based on surveys conducted in 2002 and 2003 as well as previous surveys in the study area, reptile species diversity and relative abundance is considered high in the study area, particularly in the Klamath River Canyon, along the J.C. Boyle canal, and near Keno Impoundment. In total, 16 reptile species were documented in the study area. Of these, the western fence lizard was the most abundant reptile species and was found in a variety of habitats. Other reptile species found during the surveys included gopher snake, northern sagebrush lizard, western rattlesnake, southern alligator lizard, yellow-bellied racer, common garter snake, western terrestrial garter snake, and western pond turtle. The remaining seven (7) species documented in the study area were recorded as incidental observations or from other investigators and include common kingsnake, striped whipsnake, sharptail snake, ringneck snake, western skink, rubber boa, and California mountain kingsnake (PacifiCorp 2004a).

Surveys for snake hibernacula, or over-wintering locations, were conducted at six specific areas. Although no snake hibernacula locations were confirmed through 2003 surveys, several locations with suitable habitat were identified (PacifiCorp 2004a).

3.5.3.3.3 Birds

A portion of the project area is in the Upper Klamath Basin along the Pacific Flyway, a major north-south route of travel for migratory birds in the Americas. The Upper Klamath Basin supports the largest concentration of migratory waterfowl in North America, with up to 2 million migratory birds during peak fall migration and about half that number in peak spring migration (Jarvis 2002). Migratory birds travel along the Pacific Flyway in spring and in fall, following food sources, heading to breeding grounds, or travelling to overwintering sites. Fall migration peaks in September and October and spring migration peaks in March and April in the Upper Klamath Basin (Jarvis 2002).

During these months, the wetlands of the Basin support nearly 80 percent of the Pacific Flyway's migratory waterfowl along with thousands of shorebirds and other waterbirds (Point Reyes Bird Observatory 2010).

Large numbers of water-related birds also use the Upper Klamath Basin for breeding. Several bird species have basin-wide populations of greater than 5,000 individuals during the summer months, and 11 other species exceed 1,000 individuals (Shuford et al. 2004). The wetlands support large breeding colonies of American white pelicans, double-crested cormorants, eared, Western, and Clark's grebes, great egret, white-faced ibis, ring-billed gull, California gull, and Caspian, Forster's, and black terns. A large number of these species also use the Upper Klamath Basin for staging prior to breeding in California's Central Valley. The Upper Klamath Basin also supports a high number of nesting bald eagles.

Overwintering birds that occur in the Upper Klamath Basin include tundra swans, snow geese, sandhill cranes, and a large number of waterfowl, other water birds, and raptors. In addition, the Upper Klamath Basin supports the largest wintering population of bald eagles in the coterminous United States (Shuford et al. 2004). Waterfowl are important prey for bald eagles in the Upper Klamath Basin (Manning and Edge 2002).

PacifiCorp conducted avian surveys in 2002 and 2003, consisting of avian point counts and area searches, protocol surveys for northern spotted owl and northern goshawk, and reservoir surveys. In addition, five Rapid Ornithological Inventories were conducted in 2002 by ornithologists from the Klamath Bird Observatory to document avian use and occurrence in riparian habitat during the fall migration. The Rapid Ornithological Inventories included mist-netting and banding along with area searches and nocturnal call-and-response owl surveys conducted during an intensive 3-day survey period in several river reaches. During these surveys, 174 bird species were detected with a total of more than 20,000 individual detections. Over 11,000 of these detections were recorded as occurring on reservoirs, with the highest number of birds found at Keno and Iron Gate Reservoirs. The importance of reservoir habitat was evidenced by the fact that approximately 67 percent of all birds documented by PacifiCorp during its field surveys were waterfowl and other water-related birds. The field surveys documented 47 species of water birds, including 20 species of waterfowl and 19 species of open-water, marsh, and wading birds other than waterfowl (PacifiCorp 2004a).

Seven common bird species were found in all 11 PacifiCorp study area sections. These include the western wood pewee, song sparrow, Brewer's blackbird, yellow warbler (a California species of special concern), brown-headed cowbird, black-headed grosbeak, and mourning dove. Each of these species is associated with riparian and/or wetland habitat (PacifiCorp 2004a). In addition, PacifiCorp documented 19 species of birds ~~of~~ of prey, including six species of hawk, two eagle species, three falcon species, seven ~~owl~~ owl species, and one species of vulture; eight species of woodpeckers, including ~~acorn~~

acorn woodpecker, white-headed woodpecker, Lewis' woodpecker, red-shafted flicker~~,~~ , red-breasted sapsucker, downy woodpecker, hairy woodpecker, and ~~pileated~~ pileated woodpecker~~,~~; and five game bird species, including wild turkey, blue grouse, California quail, mountain quail, and mourning dove (PacifiCorp 2004a).

3.5.3.3.4 National Wildlife Refuges (NWRs)

Key wetland sites that support large numbers of birds in the Upper Klamath Basin include Clear Lake NWR, Klamath Marsh NWR, Lower Klamath NWR, Sycan Marsh, Tule Lake NWR, and Upper Klamath Lake (Shuford et al. 2004). These large wetland complexes support the vast majority of birds in the Basin (Jarvis 2002). Of the six refuges within the Upper Klamath Basin NWR System, Lower Klamath, Tule Lake, and Upper Klamath NWRs would be most directly affected by the KBRA (USFWS 2010). For this reason, the affected environment/existing conditions of three NWRs are described in the following paragraphs. Lower Klamath NWR and Tule Lake NWR are shown in Figure 2-13; Upper Klamath NWR is shown in Figure 2-15.

Lower Klamath NWR

Lower Klamath NWR represents the remnants of historic 80,000 acre Lower Klamath Lake and is divided into a number of management units ranging from 63 acres to over 4,000 acres. Basic wetland habitat types consist of seasonal and permanently flooded marshes and winter irrigated grain fields. Seasonally flooded wetlands are critical to meeting the migratory waterfowl goals of the refuge and for providing brood areas for early nesting waterfowl species. Permanent wetlands are flooded year-round and are crucial to meeting the refuge goals of waterfowl production and habitat for fall and spring migrant waterfowl. In addition, permanently flooded wetlands provide key breeding habitat for colonial nesting waterbirds such as several heron and egret species. The emergent vegetation provides nesting substrate for many species of waterfowl, wading birds, and passerine birds and acts as cover for resting waterfowl during periods of inclement weather. The submergent plant community supports a diverse and productive invertebrate community. An additional use of permanently flooded wetlands is by molting waterfowl in July-September (USFWS 2010, Yarris et al. 1994).

In addition to wetland habitats, Lower Klamath NWR also contains approximately 9,000 acres of agricultural lands including grain fields that are extremely attractive to fall migrant and wintering waterfowl and large numbers of wintering raptors, with bald eagles being the most conspicuous. Hayfields attract large populations of spring migrant geese which helps alleviate potential damage to private farmlands off the refuge.

Lower Klamath NWR receives most of its water from two sources: 1) D Plant, which pumps water from Tule Lake through the Sheepy Ridge tunnel and 2) the Ady Canal, which supplies water directly diverted from the Klamath River. Deliveries to the refuge in recent years (since about 2004) have been limited (USFWS 2010).

Tule Lake NWR

Tule Lake NWR is comprised of approximately 17,000 acres of croplands and 13,000 acres of wetlands contained within Sumps 1(A) and 1(B). Most of the area is comprised

of open water dominated by submergent plant communities with extensive periodic blooms of filamentous green algae. High fish densities in Sumps 1(A) and 1(B) make them extremely important foraging areas for fish-eating birds such as white pelicans, western and Clark's grebes, and double crested cormorants. Large areas of submerged aquatic vegetation are very important to migrating diving ducks, especially canvasback, ruddy ducks and lesser scaup (USFWS 2010).

In addition, Tule Lake NWR agricultural programs require growers to leave a proportion of small grain crops (typically 25-33 percent) standing for wildlife consumption. The high energy content of agricultural crops provides an important energy source for migrating waterfowl as they travel northward and southward in the Pacific Flyway (USFWS 2010).

Tule Lake NWR Sumps 1(A) and 1(B) primarily receive agricultural return flows during the spring/summer irrigation season and runoff during winter and spring precipitation events. Excess water in Sumps 1(A) and 1(B) is removed via a tunnel (D-Plant) through Sheepy Ridge to Lower Klamath NWR.

Upper Klamath NWR

Upper Klamath NWR is in Klamath County, Oregon, approximately 35 miles north of the California border and consists of 14,966 acres divided into two units; Hank's Marsh (approximately 1,191 acres) at the south end of Upper Klamath Lake, and Upper Klamath Marsh at the north end. Both Upper Klamath Marsh and Hank's Marsh represent relatively undisturbed remnant wetlands. Additional acreage of water storage within the Upper Klamath NWR include Agency Lake (approximately 9,000 acres) connected to the northern part of Upper Klamath Lake, and Barnes Ranch (approximately 2,000 acres) located northwest of Agency Lake. Because emergent wetlands of Upper Klamath NWR are not separated from the open waters of the lake by perimeter levees, water elevations in the lake have a direct effect on wetland water levels (USFWS 2010).

3.5.3.3.5 Mammals

During the PacifiCorp study, surveys for mammals included small mammal trapping, canal wildlife surveys, winter bait station and track surveys, and bat roost surveys. Common mammals that were found throughout the study area include black-tailed jackrabbit, mule deer, and California ground squirrel. Small mammals commonly found during trapping included deer mouse, bushy-tailed woodrat, least chipmunk, and montane vole. Medium-sized mammals detected in the study area included bobcat, striped skunk, gray fox, yellow-bellied marmot, and coyote. Large mammals included deer, elk, mountain lion, and black bear. Five aquatic and/or riparian-associated fur-bearing mammals were detected: raccoon, beaver, muskrat, mink, and river otter (PacifiCorp 2004a).

3.5.3.4 Special-Status Species

During the PacifiCorp (2004a) study, focused surveys for special-status species were conducted. Appendix G includes a series of 5 maps that show the occurrences of special-status plant species and three maps that show the occurrence of special-status

wildlife species observed during the PacifiCorp study (PacifiCorp 2004a). These maps

are assumed to reflect current conditions, as recent comprehensive wildlife surveys have not been conducted. The methods used during these surveys are also summarized in Appendix H.

Fourteen special-status plants and 47 special-status wildlife species were detected in the PacifiCorp study area. Plant species include one federally endangered and Oregon endangered plant, Applegate's milk-vetch, and five ~~federal~~Federal plant species of concern. Wildlife species include one ~~federal~~Federal threatened species, the northern spotted owl, 15 ~~federal~~Federal species of concern, two Oregon threatened species and one California threatened species, three California endangered wildlife species, and four fully protected bird species, golden eagle, bald eagle, peregrine falcon, and greater sandhill crane; ~~Table~~ Table 3.5-4 lists these species.

In addition to those species identified by PacifiCorp as having the potential to occur, new species lists were obtained for this Klamath Facilities Removal EIS/EIR from USFWS, Oregon Department of Fish and Wildlife (ODFW), Oregon Biodiversity Information Center (ORBIC), and CDFG's California Natural Diversity Database (CNDDB). The USFWS list included species listed by the National Marine Fisheries Service. The ORBIC database search included a 0.25 mile buffer around the Klamath River and the Keno Impoundment and J.C. Boyle Reservoir within Oregon. The CNDDB search included a total of 27 U~~nited States~~.S. Geological Survey (USGS) 7.5-minute topographic quadrangles within which the project area is within California. A list of these quadrangles is provided in Appendix I.

Any new species that appeared on lists provided by the resource agencies (in addition to those found during the PacifiCorp study) were compiled into a comprehensive list of special-status species with some potential to occur in the project area (Appendix I). This list includes 242 special-status species: 2 invertebrates, 14 amphibians, 5 reptiles, 70 birds, 24 mammals, 115 plants, 3 bryophytes, and 9 lichens. Non-terrestrial species (fish, sea turtles, sea birds [albatross], marine invertebrates [abalone], and marine mammals) were not included here but are addressed in the Biological Assessment prepared for the project under Section 7 of the ~~federal Endangered Species Act~~Federal ESA.

No additional plant or wildlife surveys beyond those conducted by PacifiCorp (2004b) were conducted for this EIS/EIR.

Table 3.5-4 identifies all the special-status plant species with documented occurrences in the project area based on the results of the PacifiCorp study and the ORBIC, and CNDDB searches. A total of ~~77~~78 special-status species have been documented as occurring in the project area, including: 1 invertebrate, 3 amphibians, 5 reptiles, 47 birds, 5 mammals, and 17 plants, based on information from PacifiCorp surveys plus occurrences documented on ORBIC and CNDDB and information provided by the USFWS.

Special-status wildlife species were found to occur in each of the 11 PacifiCorp study area sections and in every delineated habitat type except rock talus. The largest number of special-status plants and wildlife species was found in the J.C. Boyle peaking reach. Keno Impoundment, which has the highest amount of wetland and riparian habitat of the study area sections as well as limited water level fluctuations, was found to support a relatively high abundance of special-status wildlife across species groups, including the largest number of western pond turtles. Keno Impoundment also supports special-status plants including Applegate's milk-vetch (PacifiCorp 2004a; USFWS 2009).

3.5.3.4.1 Amphibians

Western toad was the only special-status amphibian species detected in the study area during PacifiCorp surveys; tailed frog and southern torrent salamander have also been documented in the study area during other investigations (Table 3.5-4). During PacifiCorp surveys, western toad breeding sites were confirmed in 2002 along the north shore of Iron Gate Reservoir and in the J.C. Boyle peaking reach along Way Creek. Adult toads were also reported from near the Copco 1 village. There are likely other breeding sites either along the reservoir shorelines or in small, isolated ponds throughout the study area (PacifiCorp 2004a). Tailed frog and southern torrent salamander were found to be widespread in the ~~lower~~tributaries of the Lower Klamath River ~~and tributaries~~ (Green Diamond Resources Company 2006~~)~~), but due to lack of suitable habitat for these species, neither tailed frog nor southern torrent salamander would be expected to occur in the mainstem of the Lower Klamath River.

No Oregon spotted frogs were detected during 2003 surveys, or during surveys conducted in 1994 at locations of historic occurrence based on the Oregon Natural Heritage Program database. The presence of non-native bullfrog throughout the study area may indicate that predation has ~~lead~~led to the extirpation of Oregon spotted frogs from the study area. Habitat degradation and poor water quality are other likely reasons why the Oregon spotted frog does not occur in the study area (PacifiCorp 2004a).

There is one historical record of foothill yellow-legged frog near the site of the J.C. Boyle Dam. There were no foothill yellow-legged frog detections during focused surveys in 2003, and it is likely that this species has been extirpated from the study area. This species is affected by loss of river habitat, predation by bullfrog and other aquatic predators, and desiccation or scour of egg masses resulting from flow alterations (PacifiCorp 2004a).

3.5.3.4.2 Reptiles

Four special-status reptile species were documented during PacifiCorp surveys: western pond turtle, northern sagebrush lizard, California mountain kingsnake, and common kingsnake. One additional species, sharptail snake, is known to occur based on previous studies (Table 3.5-4). Focused surveys for western pond turtle in 2002 resulted in 501 western pond turtle detections recorded during turtle surveys and 47 incidental observations in the study area, including 18 turtles in the beaver dam pond/wetland between Fall Creek and Iron Gate Reservoir, and 24 turtle observations along the Keno Impoundment shoreline during other wildlife surveys. A total of 276 turtles were documented in Keno Impoundment, 23 in J.C. Boyle Reservoir, 12 in Copco Reservoir, and 17 in Iron Gate Reservoir.

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Invertebrates				
Siskiyou (= Chace) sideband	*Monadenia chaceana*	S/M-B, ONHP List 1	Lower reaches of major drainages, in talus and rock slides, under rocks and woody debris in moist conifer forests, in caves, and in shrubby areas in riparian corridors. Rocks and large woody debris serve as refugia during the summer and late winter seasons.	Not documented during PacifiCorp surveys. Historic occurrence 0.25 miles below Copco Dam in lava rockslide (CNDDB 2010).
Amphibians				
Tailed frog	*Ascaphus truei*	CSSC	Perennial, cold, fast-flowing mountain streams with dense vegetation cover, or streams in steep-walled valleys in non-forested areas.	Widespread in tributary streams in the ~~lower~~Lower Klamath River (Green Diamond Resource Company 2006).
Western toad	*Bufo boreas*	BLM, SV, ONHP List 4	Breeds from February to early May in ponds, the edges of shallow lakes, and in slow-moving streams. Adults are common near marshes and small lakes but may also be found in dry forests, shrubby areas, and meadows.	Documented during PacifiCorp surveys along J.C. Boyle peaking reach, along the north shore of Iron Gate Reservoir, and along Klamath River near river mile 185 (between the confluence of Bogus and Cottonwood Creeks). One occurrence near Frain Ranch, Klamath River Canyon (ORBIC 2010).
~~Southern torrent salamander~~Northern red-legged frog	~~*Rhyacotriton variegatus*~~ *Rana aurora*	~~FSC,~~ CSSC USFS:S	~~Uppermost portions of cold, well shaded permanent streams with a loose gravel substrate, springs, headwater seeps, waterfalls, and moss covered rock rubble with flowing water.~~ Breeds in quiet low-velocity habitats, such as wetlands, ponds, and disconnected side channel habitats in coastal areas of the Lower Klamath River. Usually breeds January through March (Lannoo 2005).	~~Widespread in tributary streams in the lower Klamath River (Green Diamond Resource Company 2006).~~ Documented by CDFG as breeding in coastal areas of the Lower Klamath River.
Foothill yellow-legged frog	*Rana boylii*	BLM, CSSC	Streams and rivers with cobble-size or larger substrate. Breeds generally between late April and June (Lannoo 2005).	Known to CDFG to breed in the Lower Klamath River Mainstem and major tributaries.
Southern torrent salamander	*Rhyacotriton variegatus*	FSC, CSSC	Uppermost portions of cold, well shaded permanent streams with a loose gravel	Widespread in tributary streams in the Lower Klamath River (Green Diamond Resource Company

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
			substrate, springs, headwater seeps, waterfalls, and moss covered rock rubble with flowing water.	2006).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Reptiles				
Western pond turtle	*Actinemys marmorata*	FSC, BLM, SC, ONHP List 2, CSSC	Prefers quiet water in small lakes, marshes, and sluggish streams and rivers; requires basking sites.	Documented during PacifiCorp surveys at Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, along J.C. Boyle bypass reach, along J.C. Boyle peaking reach in California, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir and along Klamath River (ORBIC, CNDDB 2010).
Northern sagebrush lizard	*Sceloporus graciosus graciosus*	FSC, BLM, SV, ONHP List 4	Inhabits sagebrush, chaparral, juniper woodlands, and dry conifer forests.	Documented during PacifiCorp surveys in the rocky riparian shrub habitat of Keno reach, along J.C. Boyle peaking reach, near J.C. Boyle powerhouse intake canal, and near the edge of a forested wetland along Iron Gate Reservoir.
Sharptail snake	*Contia tenuis*	BLM	Inhabits moist sites in chaparral, conifer forests, and deciduous forests, but primarily occurs in oaks and other deciduous tree woodlands, particularly in the forest edges.	Known to occur along upper J.C. Boyle peaking reach west of Frain Ranch in Douglas-fir habitat but not detected by PacifiCorp during its surveys.
California mountain kingsnake	*Lampropeltis zonata*	FSC, BLM, SV, ONHP List 4	Inhabits thick vegetation along watercourses, farmland, chaparral, deciduous, and mixed-coniferous forests; specifically associated with moist river valleys and dense riparian vegetation.	Documented during PacifiCorp surveys along Copco Road and in close proximity to J.C. Boyle powerhouse intake canal. Also known to occur along J.C. Boyle peaking reach. Documented in Klamath River Canyon and at J.C. Boyle Dam (ORBIC 2010).
Common kingsnake	*Lampropeltis getula*	FSC, BLM, SV, ONHP List 4	Occurs in pine forests, oak woodlands, and chaparral in, under, or near rotting logs and usually near streams; associated with well-illuminated rocky riparian habitat with mixed deciduous and coniferous trees.	Documented during PacifiCorp surveys along J.C. Boyle peaking reach in oak/woodland and mixed conifer woodland and along Copco Road.
Birds				
Common loon	*Gavia immer*	FSC, CSSC	May over-winter on project reservoirs or occur in aquatic habitat associated with large bodies of water like the project reservoirs while migrating from sub-arctic freshwater breeding grounds to coastal and near-shore pelagic marine	Documented during PacifiCorp surveys at Iron Gate Reservoir.

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
			habitat along the Pacific coast.	
American white pelican	*Pelecanus erythrorhynchos*	BLM, SV, ONHP List 2, CSSC	Nests at lakes and marshes and uses almost any lake outside of the breeding season; have a restricted range in southern Oregon and along the California border, where they are found to be associated with only a few large bodies of inland water.	Documented during PacifiCorp surveys on all project reservoirs, with the highest number occurring on Keno Impoundment, and along Link River, Keno reach, J.C. Boyle bypass reach, and on Klamath River between Iron Gate Dam and Shasta River.
Double-crested cormorant	*Phalacrocorax auritus*	Nesting colonies are afforded special protection by CDFG.	Colonial nester on coastal cliffs, rocks, offshore islands, and along lake margins.	Documented during PacifiCorp surveys at Keno and J.C. Boyle Dams. Documented nesting colonies near mouth of Klamath River (CNDDB -2010).
Black-crowned night heron	*Nycticorax nycticorax*	FSC	Found in riparian habitats and in wetland sites.	Documented during PacifiCorp surveys primarily along Keno reach, but also along Link River, at Keno Impoundment, and along Klamath River from Iron Gate Dam to Shasta River. Communal roost used by night herons and other heron species in a group of willow trees near the East Side powerhouse adjacent to Link River.
Snowy egret	*Egretta thula*	BLM, SV, ONHP List 2	Inhabits emergent wetlands associated with freshwater marshes and along the periphery of large water bodies. The northern limit of the species range includes southern Oregon.	Documented during PacifiCorp surveys near Link River Dam, at Keno Dam, and along Keno reach.
Great egret	*Casmerodius albius*	BLM	Nests in willows and other trees; forages in shallow water, wetlands, and fields. Range includes Klamath basin and eastern Siskiyou County. Known to occur in the study area.	Documented during PacifiCorps surveys at J.C. Boyle and Keno Impoundments, Keno Canyon reach, J.C. Boyle bypass and peaking reaches, and Link River.
Great blue heron	*Ardea herodias*	Breeding colonies are afforded special-	Forages mostly in slow-moving or calm salt, fresh, or brackish water in a variety of habitats, including rocky shores, coastal lagoons, saltwater and freshwater marshes, mudflats, bays,	Documented during PacifiCorps surveys at all reservoirs and most study area reaches; colony documented at Copco Reservoir. Several rookeries documented along the Klamath River (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
		status protection by CDFG	estuaries, along the margins of rivers, lakes, and irrigation canals, and in flooded fields. Nesting colonies are typically found in groves of large trees, often in mixed colonies with other herons, egrets, and cormorants.	
White-faced ibis	*Plegadis chihi*	FSC, BLM, ONHP List 4, CSSC	Breeds in freshwater marshes and lakes, and estuaries, and nests near the water on mats of vegetation and twigs; usually occurs in isolated con-specific flocks. Does not typically overwinter in Oregon but is a fairly common visitor in the Klamath Wildlife Area during the spring and summer.	Documented during PacifiCorp surveys along Link River and at Keno Impoundment and J.C. Boyle Reservoir.
Bufflehead	*Bucephala albeola*	BLM, SU, ONHP List 4	Typically breeds around isolated mountain lakes; nesting habitat includes mixed conifer forest and ponderosa pine forests with sparse to moderate tree canopy closure close to lakes and ponds. Nests in cavities, including artificial nest boxes. May be found in open water and riverine habitat throughout southern Oregon after the breeding season.	Documented during PacifiCorp surveys primarily from January until April along the Link River, at Keno Impoundment and Copco and Iron Gate Reservoirs.
Barrow's goldeneye	*Bucephala islandica*	SU, ONHP List 4, CSSC	Tends to breed along high-elevation mountain lakes and winter in coastal areas. Potential nesting habitat includes forests with sparse to moderate tree canopy closure next to rivers and reservoirs.	Documented during PacifiCorp surveys along Keno Impoundment, in an inundated drainage ditch off of Copco Reservoir, and on Iron Gate Reservoir. Common winter migrant on the Link River and Keno Impoundment (R. Larson, USFWS).
Osprey	*Pandion haliaetus*	CSSC	Nests in all forested vegetation types with large trees near water, as well as on platforms erected in less optimal habitat.	A minimum of 16 active osprey nests, both artificial nesting platforms and natural sites, are found along the shores of the project reservoirs and river reaches. Documented during PacifiCorp surveys along the Keno reach, along the J.C. Boyle bypass reach, along the J.C. Boyle peaking reach, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along Fall Creek, and along Klamath River from Iron Gate Dam

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
				to Shasta River. Several occurrences along ~~lower~~Lower Klamath River (CNDDB 2010).
Northern harrier	*Circus cyaneus*	CSSC	Nests and forages in grasslands and emergent wetlands. Permanent residents in the project vicinity and common at the Klamath Wildlife Area.	Documented during PacifiCorp surveys in the low-lying marshland and agricultural fields east of Keno Impoundment and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Golden eagle	*Aquila chrysaetos*	CSSC, BCC, FP	Breeds in open mountain and hill habitats, nests in coniferous and deciduous trees and on cliff ledges, forages in grasslands and open conifer forests and woodlands with sparse to open tree canopy closure. Eagles typically use two to three nests during a lifetime.	Historical records exist of several golden eagle nests on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. Documented during PacifiCorp surveys at J.C. Boyle powerhouse, along the lower section of J.C. Boyle peaking reach, along Copco and Iron Gate Reservoirs, and Copco bypass reach.
Bald eagle	*Haliaeetus leucocephalus*	FD, BCC, OT, ONHP List 4, CE, FP	Nests in large conifers within several miles of water; forages in rivers and lakes for fish and waterfowl; requires large snags for perching and conifers for night roosts.	Documented during PacifiCorp surveys at all project reservoirs and in all project reaches throughout the project vicinity. Also documented on Upper Klamath River, on the Klamath River near OR-CA border (ORBIC 2010), and along ~~lower~~Lower Klamath River (CNDDB 2010).
Cooper's hawk	*Accipiter cooperii*	CSSC	Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak-juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure.	Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches, and along Klamath River from the Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Northern goshawk	*Accipiter gentilis*	FSC, BLM, BCC, SC, ONHP List 4, CSSC	Inhabits forested communities with at least 60 percent canopy cover and trees greater than 6 inches in diameter, except oak woodland, oak-conifer woodland, and oak-juniper woodland; forages over large home ranges.	Documented during PacifiCorp surveys flying over J.C. Boyle peaking reach. Documented near tributaries of ~~lower~~Lower Klamath River (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Sharp-shinned hawk	*Accipiter striatus*	CSSC	Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure and tree diameters ranging from 6 to 24 inches.	Documented during PacifiCorp surveys in oak habitat along J.C. Boyle bypass and peaking reaches, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Swainson's hawk	*Buteo swainsoni*	FSC, BLM, SV, ONHP List 4, , CT	Dwells in open country and typically inhabits sagebrush, annual grassland, juniper woodland, montane hardwood oak-juniper, and riparian deciduous forest with sparse to open tree canopy closure. The species' range generally lies east of the project vicinity and includes the plains of the Great Basin in southeast Oregon and eastern northern California.	Documented during PacifiCorp surveys flying over agricultural fields southeast of Keno Impoundment. Not listed on CNDDB for project area (CNDDB 2010).
Merlin	*Falco columbarius*	BLM, ONHP List 2, CSSC	Uses a variety of forested and open habitats. Ranges throughout North America and travels great distances during migration from breeding grounds in northern Canada and Alaska to wintering habitat through the contiguous United States south to Central America.	Documented during PacifiCorp surveys at J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2010).
Prairie falcon	*Falco mexicanus*	CSSC	Uses cliffs for nesting and plateau grasslands for foraging.	Documented during PacifiCorp surveys near Keno campground and boat ramp, above J.C. Boyle bypass reach, near Copco Reservoir, and flying over Klamath Wildlife Refuge. Several occurrences listed as sensitive (CNDDB 2010).
American peregrine falcon	*Falco peregrinus anatum*	FD, BLM, BCC, OE, ONHP List 2, FP	Breeds at suitable nest sites on cliffs and rocky outcroppings. Uses a variety of habitats, including open grassland areas, forest stands, and reservoirs throughout the project vicinity.	The project vicinity is in a management area designated for peregrine falcon recovery. Known to occur along Keno Impoundment and the J.C. Boyle bypass reach but not documented during PacifiCorp surveys. Several occurrences listed as sensitive (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Mountain quail	*Oreortyx pictus*	FSC, BLM, SU, ONHP List 4	Inhabits open forests, chaparral, and juniper woodlands with dense undergrowth offering suitable refuge; breeds in higher elevation areas; migrates on foot up to 40 miles to lower elevation winter grounds.	Documented during PacifiCorp surveys at J.C. Boyle reservoir, along the J.C. Boyle bypass reach and peaking reaches, along Fall Creek, and along Klamath River from the Iron Gate Dam to Shasta River.
Greater sandhill crane	*Grus canadensis tabida*	FSC, BLM, SV, ONHP List 4, CT, FP	Nests in marshes and wet meadows, and occasionally in pastures and irrigated hayfields. A primary requirement for suitable nesting habitat is the presence of surrounding water or undisturbed habitat.	Documented during PacifiCorp surveys east of Keno Impoundment and along J.C. Boyle reservoir. PacifiCorp located an active nest with two eggs in it in the emergent wetland bordering J.C. Boyle Reservoir. Several occurrences in the Lower Klamath Lake NWR (CNDDB 2010).
Caspian tern	*Sterna caspia*	BCC	Nests in tightly packed colonies on undisturbed islands, levees, and shores along inland water bodies during the summer breeding season. Forages over water.	Documented during PacifiCorp surveys on all project reservoirs as well as along Link River, Keno and J.C. Boyle bypass reaches, and along the Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Forster's tern	*Sterna forsteri*	BLM, ONHP List 4	Breeds at lakes and marshes and on mud or sand flats near water; forages over water.	Documented during PacifiCorp surveys along Link River, along Keno and J.C. Boyle bypass and peaking reaches, and at all project reservoirs. Not listed on CNDDB for project area (CNDDB 2010).
Black tern	*Chlidonias niger*	FSC, BLM, ONHP List 4, CSSC	Nests in emergent vegetation along the shoreline periphery of freshwater lakes, wetlands, and marshes along rivers and ponds; forages in wet meadows, pastures, agricultural fields, and water.	Documented during PacifiCorp surveys at Keno and J.C. Boyle Reservoirs. Not listed on CNDDB for project area (CNDDB 2010).
Marbled murrelet	*Brachyramphus marmoratus*	FT, OT, ONHP List 2, CE	Spends most of the time in the marine environment foraging in nearshore areas. Uses old-growth forests (coast Redwood forests in California) for nesting.	Known to occur within National Forest lands and Green Diamond Resource Company managed lands near the coast. Critical habitat has been designated near the mouth of the Klamath River.
Flammulated owl	*Otus flammeolus*	BLM, BCC, SC, ONHP List 4	Nests in abandoned woodpecker nest cavities in open forests with a ponderosa pine component.	Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches.

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Great gray owl	*Strix nebulosa*	BLM, S/M-C, SV, ONHP List 4, CE	Inhabits mixed conifer, ponderosa pine, and riparian mixed forest stands with trees greater than 11 inches in diameter providing at least 60 percent canopy cover within at least 984 feet of a natural or manmade opening greater than 10 acres. Breeds in tree cavities, typically near suitable open grassland foraging habitat.	Documented during PacifiCorp surveys east of Fall Creek near Jenny Creek. Not listed on CNDDB for project area (CNDDB 2010).
Northern Spotted Owl	*Strix occidentalis caurina*	FT, OT, ONHP List 1	Inhabits ponderosa pine forest, mixed conifer forest, and conifer forest with trees greater than 11 inches in diameter. Prefers old-growth forests with multi-layered tree canopies. Critical habitat occurs within the project area upstream of Copco Reservoir and south of the Klamath River and along portions of the ~~lower~~Lower Klamath River.	Documented during PacifiCorp surveys near J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Several occurrences within the project area (CNDDB 2010). Known to occur within National Forest lands and Green Diamond Resource Company managed lands near the coast. Critical habitat has been designated near the mouth of the Klamath River.
Vaux's swift	*Chaetura vauxi*	CSSC	Found in mixed conifer, ponderosa pine, lodgepole pine, riparian deciduous, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper forests with trees greater than 11 inches in diameter.	Documented during PacifiCorp surveys at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle bypass and peaking reaches, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Black swift	*Cypseloides niger*	SP, ONHP List 2, CSSC	Suitable nesting habitat is limited to cliffs near water courses. Breeding sites are widely distributed in Oregon and California; none known in Klamath or northern Siskiyou Counties.	Not documented during PacifiCorp surveys. Documented along Klamath River near Orleans (CNDDB 2010).
Pilelated woodpecker	*Drycopus pileatus*	BLM, SV ONHP List 4	Occurs in all forest and woodland cover types with moderate to dense tree canopy closure. Requires large snags 25 inches or more in diameter for excavating suitable nest cavities.	Documented during PacifiCorp surveys along Keno reach, at J.C. Boyle Reservoir, along J.C. Boyle bypass and peaking reaches, and along Fall Creek.

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Acorn woodpecker	*Melanerpes formicivorus*	FSC, BLM, ONHP List 4	Nests in cavities in snags of deciduous tree species, particularly oak snags at least 17 inches in diameter.	Several nesting colonies documented during PacifiCorp surveys in oak, oak-juniper, and oak/conifer habitats, primarily at Copco Reservoir. Also documented during PacifiCorp surveys at J.C. Boyle and Iron Gate Reservoirs, along J.C. Boyle peaking reach, along Copco bypass reach, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River.
Lewis' woodpecker	*Melanerpes lewis*	FSC, BLM, BCC, SC, ONHP List 2	Associated with oak woodlands and mixed oak conifer habitat, but also can be found in a variety of open forest stands including ponderosa pine and cottonwood-dominated riparian areas.	Documented during PacifiCorp surveys in upland habitats along J.C. Boyle peaking reach, in riparian habitats at Iron Gate Reservoir, and along Klamath River from Iron Gate Dam to Shasta River. Documented in Klamath River Canyon (ORBIC 2010).
White-headed woodpecker	*Picoides albolarvatus*	FSC, BLM, BCC, SC, ONHP List 2	Nests in cavities typically in ponderosa pine at least 18 inches in diameter. Occurs in lodgepole pine, ponderosa pine, and Klamath mixed conifer forests with trees greater than 11 inches in diameter.	Documented during PacifiCorp surveys along J.C. Boyle bypass reach. Not listed on CNDDB for project area (CNDDB 2010).
Williamson's sapsucker	*Sphyrapiicus thyroideus*	BLM, SU	Associated with higher-elevation coniferous forest types including ponderosa pine, lodgepole pine, and Douglas-fir.	Known to occur in the general project vicinity but not documented during PacifiCorp surveys.
Olive-sided flycatcher	*Contopus cooperi*	FSC, BLM, BCC, SV, ONHP List 4	Typically found in coniferous forests with tall trees providing suitable perch sites.	Documented during PacifiCorp surveys along Link River, at Keno, J.C. Boyle and Iron Gate Reservoirs, and along Keno and J.C. Boyle peaking reaches. Not listed on CNDDB for project area (CNDDB 2010).
Willow flycatcher	*Empidonax traillii*	FSC, BLM, BCC, SV, ONHP List 4, CE	Associated with dense riparian willow thickets.	Documented during PacifiCorp surveys in some of the more dense willow patches along Link River, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle peaking reach, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir at Jenny Creek (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Black phoebe	*Sayornis nigricans*	BLM	Nests on cliffs or rock outcrops near water. Forage in riparian areas with thick vegetation and some nearby vertical surface. The Klamath study area exists along the northern limit of the species range.	Documented during PacifiCorp surveys along the Iron Gate-Shasta reach. Also regularly seen along the Miller Island section of the Keno Impoundment (R. Larson, USFWS).
Purple martin	*Progne subis*	FSC, BLM, SC, ONHP List 2, CSSC	Riparian and wetland forests, as well as Klamath mixed conifer forest, ponderosa pine forest, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper with sparse to moderate tree canopy closure (<60 percent). Range is patchy and may include portions of the study area.	Documented during PacifiCorp surveys above the upper falls at Fall Creek.
Black-capped chickadee	*Parus atricapillus*	CSSC	Nests in a variety of woodland habitats wherever suitable, small nest cavities can be found.	Documented during PacifiCorp surveys along Link River and at Copco and Iron Gate Reservoirs.
Pygmy nuthatch	*Sitta pygmea*	BLM, SV	Typically found in ponderosa pine forests with less than 70 percent canopy closure.	Documented during PacifiCorp surveys at Keno Impoundment and J.C. Boyle Reservoir.
Blue-gray gnatcatcher	*Polioptila caerulea*	BLM	Mixed chaparral, montane hardwood oak woodland, montane hardwood oak-juniper. Range overlaps the study area. The species is specifically known to breed in the chaparral of the Klamath basin.	Documented during PacifiCorp surveys at Iron Gate reservoir.
Western bluebird	*Sialia mexicana*	BLM, SV, ONHP List 4	Found in a variety of open habitats; may be limited by the availability of suitable nesting cavities. Nests in open clearings adjacent to woodlands or in human-made structures providing suitable nest sites.	Documented during PacifiCorp surveys along Copco bypass reach, along Fall Creek, and at Iron Gate Reservoir.

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Yellow warbler	*Dendroica petechia*	CSSC	Found in riparian deciduous forest, riparian shrub, scrub-shrub wetland, and forested wetland. Breeds in riparian habitat throughout North America and winters south from Mexico through South America.	Documented during PacifiCorp surveys throughout the project vicinity at all project reservoirs and in all project reaches. Not listed on CNDDB for project area (CNDDB 2010).
Yellow-breasted chat	*Icteria virens*	FSC, BLM, ONHP List 4, CSSC	Found in the brushy understory of deciduous and mixed woodlands; breeds in brushy vegetation, typically willow thickets, along rivers and streams.	Documented during PacifiCorp surveys primarily in wetland and riparian habitats along J.C. Boyle peaking reach, at Copco Reservoir, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Mammals				
Townsend's western big-eared bat	*Corynorhinus townsendii townsendii*	FSC, BLM, SC, ONHP List 2, CSSC	Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence.	Known from J.C. Boyle peaking reach but not documented during PacifiCorp surveys. One occurrence in project area listed as sensitive by ORBIC (2010). Not listed on CNDDB for project area (CNDDB 2010).
Yuma myotis bat	*Myotis yumanensis*	FSC, BLM, ONHP List 4	Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence.	Documented during PacifiCorp surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in rafters at Iron Gate south gatehouse. Also known from J.C. Boyle peaking reach. One occurrence outside project area (CNDDB 2010).
Western gray squirrel	*Sciurus griseus*	BLM, SU, ONHP List 4	Found in a variety of forested habitat types including mixed conifer forest, ponderosa pine forest, lodgepole pine, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak juniper with trees greater than 6 inches in diameter.	Documented during PacifiCorp surveys at J.C. Boyle and Copco Reservoirs, along J.C. Boyle peaking reach, and along Copco bypass reach.
Ringtail	*Bassariscus astutus*	BLM, SU, ONHP List 4	Uses a mixture of forest and shrublands or other habitats that provide vertical structure near rocky or riparian areas. Range overlaps the study area. The species is known to occur in the study area.	Not documented during PacifiCorp surveys. Documented in Klamath River Canyon (ORBIC 2010). Not listed on CNDDB for project area (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Fisher	*Martes pennanti*	FC, BLM, SC, ONHP List 2, CSSC	Mature, closed canopy forests with some deciduous trees; intermediate to large tree stages of conifer forests and riparian deciduous forests both with high tree canopy closure. Habitats in the study area include lodgepole pine, Klamath mixed conifer forest, ponderosa pine forest, riparian deciduous forest, montane hardwood oak-conifer with trees >11 inches dbh. Range overlaps the study area.	Not documented during PacifiCorp surveys. Documented along ~~lower~~Lower Klamath River (CNDDB 2010). Has been documented in the Upper Klamath Basin within the last two years (~~T.~~ Collom~~, ODFW, personal communication, April 29,~~ 2011).
Plants				
Applegate's milk-vetch	*Astragalus applegatei*	FE, OE, ONHP List 1	Occurs in flat-lying, seasonally moist, strongly alkaline soils.	Documented during PacifiCorp surveys at Keno Impoundment. 450 plants were found in 2009 on the west side of the Keno Impoundment near the PacifiCorp wareyard and 10,000 plants occur in a number of sites near the west side of Keno Impoundment on Collins Products property (R. Larson, USFWS).
Greene's mariposa-lily	*Calochortus greenei*	FSC, BLM, OC, ONHP List 1, CNPS List 1B	Occurs primarily in annual grassland, wedgeleaf ceanothus chaparral, and oak and oak-juniper woodlands.	Documented during PacifiCorp surveys at Iron Gate Reservoir. Yellow starthistle, medusahead, and annual bromes form the dominant herb layer cover at nearly all of the sites where Greene's mariposa lily was observed. Also known to occur at Copco Reservoir and along J.C. Boyle peaking reach. Several occurrences on CNDDB along Klamath River (2010).
Bristly sedge	*Carex comosa*	ONHP List 2	Marshes, lake shores, and wet meadows.	Not documented during PacifiCorp surveys. Documented along east shore of J.C. Boyle Reservoir (ORBIC 2010).
Brown fox sedge	*Carex vulpinoidea*	CNPS List 2	Near water on moist open ground in swamps, prairie swales, lowland forests, wet ditches, ravines, and along the edges of marshes, springs, lakes, and ponds.	Not documented during PacifiCorp surveys. Documented on north shore of Iron Gate Reservoir, 0.1 mile downstream from mouth of Fall Creek (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Mountain lady's slipper	*Cypripedium montanum*	BLM, S/M-D, ONHP List 4, CNPS List 4	Occurs in dry, open conifer forests, but more often in moist riparian habitats.	Documented during PacifiCorp surveys on a shaded and mesic, forested slope above Frain Creek, a small tributary to the Klamath River at Frain Ranch along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2010).
Del Norte buckwheat	*Eriogonum nudum* var. *paralinum*	CNPS List 2	Coastal bluff scrub, coastal prairie.	Not documented during PacifiCorp surveys. Documented on sand bar at mouth of Klamath River (CNDDB 2010).
Bolander's sunflower	*Helianthus bolanderi*	BLM, ONHP List 3	Occurs in yellow pine forest, foothill oak woodland, chaparral, and occasionally in serpentine substrates or wet habitats.	Documented during PacifiCorp surveys in highly disturbed and degraded sites filled with annual bromes and starthistle along the lower reach of Hayden Creek, a tributary to the Klamath River along J.C. Boyle peaking reach, and south of Iron Gate Reservoir.
Salt heliotrope	*Heliotropium curvasassavicum*	BLM, ONHP List 2	Occurs in seasonally flooded, low-lying, non-porous areas on the east side of the Cascades.	Documented during PacifiCorp surveys at the upper end of Keno Impoundment.
Bellinger's meadow-foam	*Limnanthes floccosa ssp. ~~bellingerana~~Bellingerana*	FSC, BLM, OC, ONHP List 1, CNPS List 1B	Occurs in rocky, seasonally wet meadows, or along the margins of damp rocky meadows often partially shaded by adjacent trees and shrubs.	Not documented during PacifiCorp surveys. Known to occur along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2010).
Detling's silverpuffs	*Microseris laciniata* ssp. ~~*detlingii*~~*Detlingii*	CNPS List 2	Chaparral and grassy openings among Oregon white oak trees.	Not documented during PacifiCorp surveys. Documented west of Iron Gate Reservoir, 1.2 miles north of Klamath River bridge at Iron Gate Dam (CNDDB 2010).
Egg Lake monkeyflower	*Mimulus pygmaeus*	FSC, CNPS List 4	Occurs in damp areas or vernally moist conditions in meadows and open woods.	Documented during PacifiCorp surveys on the southwest end of J.C. Boyle Reservoir in damp mudflats adjacent to shallow and narrow tributaries to the Reservoir and under the transmission line just southwest of J.C. Boyle Dam. Not listed on CNDDB for project area (CNDDB 2010).
Wolf's evening-primrose	*Oenothera wolfii*	CNPS List 1B	Coastal bluff scrub, coastal dunes, coastal prairie, lower montane coniferous forest.	Not documented during PacifiCorp surveys. Documented along ~~lower~~Lower Klamath River (CNDDB 2010).

Table 3.5-4. Special-Status Species Known to Occur in the Project Area

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*
Red-root yampah	*Perideridia erythrorhiza*	FSC, BLM, OC, ONHP List 1	Occurs in moist prairies, pastureland, seasonally wet meadows, and oak or pine woodlands, often in dark wetland soils and clay depressions.	Not documented during PacifiCorp surveys. Known to occur along Keno reach, at J.C. Boyle Reservoir, and along J.C. Boyle peaking reach.
Columbia yellow cress	*Rorippa columbiae*	FSC, BLM, OC, ONHP List 1, CNPS List 1B	Occurs in cobbly, gravelly silt associated with seasonal creek drainages in ponderosa pine/juniper woodland, on the shores of alkaline lakes, along roadside ditches, in meadows, and seeps.	Documented during PacifiCorp surveys at Keno Impoundment. One occurrence at Klamath River near Orleans (CNDDB 2010).
Fleshy sage	*Salvia dorrii var. incana*	CNPS List 3	Occurs in silty to rocky soils in great basin scrub, pinyon, and juniper woodland.	Documented during PacifiCorp surveys on weathered bedrock outcrops overlain with thin, loose, and rocky substrate at Iron Gate Reservoir and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2010).
Pendulous bulrush	*Scirpus pendulus*	BLM, ONHP List 2, CNPS List 2	Occurs along streambanks and in wet meadows.	Documented during PacifiCorp surveys along Fall Creek and J.C. Boyle peaking reach. Documented outside project area (CNDDB 2010).
Short-podded thelypody	*Thelypodium brachycarpum*	FSC, BLM, ONHP List 2, CNPS List 4	Occurs in meadows and open flats.	Documented during PacifiCorp's field surveys in low-lying saltgrass grassland at Keno Impoundment. Large populations occur along both sides of the Keno Impoundment at Miller Island and on Collins Products property on the west side of Keno Impoundment (R. Larson, USFWS). Not listed on CNDDB for project area (CNDDB 2010).

Notes:
*Information on occurrence in the project area is based on PacifiCorp surveys (PacifiCorp 2004a) and information obtained from Oregon Biodiversity Information Center (ORBIC) and California Natural Diversity Database (CNDDB) databases (2010).
Key:
BCC: Birds of Conservation Concern (USFWS Division of Migratory Bird Management 2008a)
BLM: Bureau of Land Management sensitive species - species that could easily become endangered or extinct.

CDFG: California Department of Fish and Game
CE: California Endangered
CNPS List 1A: California Native Plant Society (CNPS)- Presumed extinct in California.
CNPS List 1B:rare, threatened, or endangered in California and elsewhere.
CNPS List 2: rare, threatened, or endangered in California, but more common elsewhere.
CNPS List 3: on the review list - more information needed
CNPS List 4: on the watch list - limited distribution
CSSC: California Department of Fish and Game Species of Special Concern - not listed under the ~~federal~~Federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occurring in low numbers and having current known threats to their persistence
CT: California Threatened
FC: Federal Candidate Species
FD: Federal Delisted
FE: Federal Endangered
FP: Fully protected under the California Fish and Game Code
FSC: Federal Species of Concern
FT: Federal Threatened
OC: Candidate listing by Oregon Department of Agriculture (ODA) or Oregon Department of Fish and Wildlife (ODFW)
OE: Listed as endangered by ODA or ODFW
ONHP List 1: Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range
ONHP List 2: threatened with extirpation or presumed to be extirpated from ~~the state~~ theStateof Oregon
ONHP List 3: more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range
OHNP List 4: of conservation concern but not currently threatened or endangered
OT: Listed as threatened by ODA or ODFW
SC: Sensitive Critical - listed by ODFW as threatened or endangered is pending, or listing as threatened or endangered may be appropriate if immediate conservation actions are not taken.
SP: Sensitive Peripheral or Naturally Rare - listed by ODFW with populations on the edge of the range or historically low because of naturally occurring limiting factors
SU: Sensitive Undetermined Status - listed by ODFW for which status is unclear
SV: Sensitive Vulnerable - listed by ODFW as threatened or endangered is not imminent and can be avoided through continued or expanded use of adequate protective measures and monitoring. In some cases the populations are sustainable and protective measures
S/M-~~C:~~B = Survey and Manage Species, as designated in the Northwest Forest Plan; category ~~C - Uncommon,~~B- pre-disturbance surveys not practical and not applicable (USFS and BLM 2011a). However, Attachment 4 of USFS and BLM 2011b indicates that for the Siskiyou (= Chace) sideband, “equivalent-effort, pre-disturbance surveys are required”.
S/M-~~D:~~C: Survey and Manage Species, as designated in the Northwest Forest Plan; category ~~D - Uncommon,~~C - pre-disturbance surveys ~~not~~ practical ~~or necessary~~
~~USFWS: United States Fish and Wildlife Service~~

~~Reptiles~~

~~Four special-status reptile species were documented during PacifiCorp surveys: western pond turtle, northern sagebrush lizard, California mountain kingsnake, and common kingsnake. One additional species, sharptail snake, is known to occur based on previous studies (Table 3.5-4). Focused surveys for western pond turtle in 2002 resulted in 501 western pond turtle detections recorded during turtle surveys and 47 incidental observations in the study area, including 18 turtles in the beaver dam pond/wetland between Fall Creek and Iron Gate Reservoir, and 24 turtle observations along the Keno Impoundment shoreline during other wildlife surveys. A~~

~~total of 276 turtles were documented in Keno Impoundment, 23 in J.C. Boyle Reservoir, 12 in Copco Reservoir, and 17 in Iron Gate Reservoir.~~

S/M-D: Survey and Manage Species, as designated in the Northwest Forest Plan; category D - pre-disturbance surveys not practical or not necessary
USFWS: United States Fish and Wildlife Service

Several river reaches were also found to support pond turtles, including Fall Creek, the J.C. Boyle Peaking reach, and the Iron Gate-Shasta River reach. The turtle nesting habitat suitability mapping conducted in 2002 indicates that out of the 198 miles (319 km) of river and reservoir shoreline in the study area, approximately 42 miles (68 km) (21 percent) were characterized as having suitable nesting and basking habitat. An additional 60 miles (97 km) (30 percent) have suitable basking habitat structure (logs, large rocks, or patches of persistent emergent vegetation), but do not have the high quality potential nesting habitat either because of steep slopes, developed shorelines, or shorelines with dense understory vegetation (PacifiCorp 2004a).

Habitat for western pond turtle is affected by fluctuating water levels at reservoirs and along river reaches, particularly Iron Gate Reservoir and the J.C. Boyle peaking reach. Lower water levels can reduce the amount of aquatic habitat and make bordering emergent wetlands less accessible due to increased distance from water for hatchling turtles (PacifiCorp 2004a).

In addition, dense emergent vegetation may reduce turtle access to upland habitat, although typically small breaks are present. Developed areas and recreation sites may restrict shoreline habitat for turtles and affect their movement into nesting and overwintering sites. Turtles are known to be sensitive to human activity at distances of 328 feet; thus, human disturbance along roads, vegetation management, recreational activities, and other human activities are likely to affect turtles in the study area (PacifiCorp 2004a).

Northern sagebrush lizard was found during PacifiCorp surveys in or near forest habitat at locations including Iron Gate Reservoir, Keno Canyon reach, and J.C. Boyle peaking reach. California mountain kingsnake was recorded along Copco Road and along the J.C. Boyle canal near riparian woodlands. Common kingsnake was found on Copco Road, at the Iron Gate Reservoir, on a road in the Iron Gate-Shasta River reach, and near the Fall Creek reach within oak/woodland or chaparral habitat. No sharptail snakes were detected in the study area during 2002 surveys; however, the species was detected in the upper J.C. Boyle peaking reach during Bureau of Land Management (BLM) surveys in the spring of 2001 (PacifiCorp 2004a).

3.5.3.4.3 Birds

Birds represent the largest group of special-status species detected in the study area with 46 of the 69 species with potential to occur detected during PacifiCorp surveys or listed by ORBIC or CNDDB as occurring in the project area (Table 3.5-4). Among these, there are 14 water birds, 1 quail, 11 raptors, 3 owls, 2 swifts, and 15 passerines.

Most detections of special-status birds during PacifiCorp surveys were recorded in wetland, riparian, or aquatic habitat. During reservoir surveys, large numbers of American white pelicans were found on all reservoirs: 191 birds on Keno Impoundment, 71 birds on J.C. Boyle Reservoir, 55 birds on Copco Reservoir, and 107 birds on Iron

Gate Reservoir. In addition, a great blue heron colony, which is afforded special protection by CDFG, was documented at Copco Reservoir during supplemental surveys in that area (PacifiCorp 2004b).

Bald eagles were also found at all reservoirs, with the highest number (12) found at Copco Reservoir (PacifiCorp 2004a). A known bald eagle nesting site is south of Copco Dam (USFWS 2007). Bald eagles also utilize the middle and ~~lower~~Lower Klamath River for foraging and nesting.

Golden eagles have historically nested on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. During PacifiCorp surveys, golden eagles were found in several locations, including Copco and Iron Gate Reservoirs and J.C. Boyle powerhouse (PacifiCorp 2004a).

The only federally~~-~~ listed bird species detected during PacifiCorp surveys was the northern spotted owl, a ~~federal~~Federal threatened species found near J.C. Boyle Reservoir and along J.C. Boyle peaking reach. A nest site is also known to occur near the Copco Reservoir. All known nest sites ~~and suitable nesting or roosting habitat is~~ are more than one mile away from the dams and associated facilities (~~personal communication with L.~~ Roberts 2011). The majority of habitat surrounding Project features between Iron Gate Dam and J.C. Boyle Reservoir are considered unsuitable, with only two areas containing suitable nesting and roosting habitat (1) southeast of Copco 1 Reservoir (more than one mile away from project facilities) and (2) patchy areas surrounding J.C. Boyle Dam (about 0.9 mile away from project facilities) (Oakley Consulting 2011 and E. Willy, Biologist, USFWS~~, June 27,~~ Fish and Wildlife, pers. comm.; both as cited in Reclamation 2012b). No additional suitable habitat is expected to grow by 2019 (Roberts 2011).

Critical habitat for northern spotted owl is located north of the Klamath Hydroelectric Project boundary in the Jenny Creek watershed, upstream of the Copco Reservoir, and along portions of the ~~lower~~Lower Klamath River. Northern spotted owls are also documented to occur on National Forest lands and along the Lower Klamath River on lands managed by Green Diamond Resources Company, and a Habitat Conservation Plan for the northern spotted owl is currently in development. Potentially suitable spotted owl habitat in the project area includes all forested communities and oak woodlands adjacent to mixed conifer stands with high canopy cover and large diameter trees (USFWS 2008b).

The marbled murrelet, a ~~federal~~Federal threatened bird species, is known to occur on National Forest lands along the coast as well as on lands managed by Green Diamond Resources Company. This species does not occur inland near the PacifiCorp dams and associated facilities.

Four fully protected bird species, bald eagle, golden eagle, American peregrine falcon, and greater sandhill crane, are known to occur in the project area. Bald and golden eagles are discussed above. American peregrine falcons are known to occur along the river

including the J.C. Boyle bypass reach. Greater sandhill cranes have been documented nesting at J.C. Boyle Reservoir.

3.5.3.4.4 Mammals

Two special-status mammals, western gray squirrel and Yuma myotis bat, were detected during PacifiCorp surveys (Table 3.5-4). Three other species, Townsend's western big-eared bat, ringtail, and Pacific fisher, have documented occurrences on ORBIC or CNDDB within the project area.

Yuma myotis was detected at the J.C. Boyle forebay spillway house, the Copco 1 powerhouse, and the Iron Gate south gatehouse (PacifiCorp 2004a). Although the presence of the seven other special-status bat species with potential to occur in the project area was not detected during bat roost surveys at PacifiCorp facilities, it is likely that one or more of these other special-status bat species occur in the roosting colonies (~~personal communication with G.~~ Leppig~~, CDFG, October 27,~~ 2010).

3.5.3.4.5 Terrestrial Invertebrates

PacifiCorp did not conduct surveys for terrestrial invertebrates; however, special-status invertebrate species may occur within the project area (~~personal communication with R.~~ Larson~~, USFWS, March 13,~~ 2011). One species that may occur based on known occurrences near the project area is the Siskiyou (Chace) sideband (*Monadenia chaceana*). ~~A petition for federal~~Although USFWS has determined that the Siskiyou sideband does not warrant Federal listing ~~of this species is currently under review~~ (USFWS 2011~~).~~), it is a special-status species under the Northwest Forest Plan (Regional Ecosystem Office [REO] 2011).

3.5.3.4.6 Plants

Ten special-status plant species were documented during PacifiCorp surveys. Of these, seven species are associated with wetland and/or riparian habitats. Seven additional species are known to occur in the project area based on previous investigations or occurrences listed on ORBIC or CNDDB (Table 3.5-4). Four of these additional species are associated with wetland and/or riparian habitats.

One federally~~-~~ listed species, Applegate's milk-vetch, was detected at the Keno Impoundment during PacifiCorp surveys. Applegate's milk-vetch, a ~~federal~~Federal and Oregon endangered species, was found growing in an area of dense, undisturbed salt grass within 45 to 100 feet (17 to 30 m) of Keno Impoundment. The plant was observed along the reservoir in an area of approximately 250 feet (76 m) in length at a height or elevation above the reservoir water surface of less than 2 feet (0.6 m) (PacifiCorp 2004a). Additional surveys have identified Applegate's milk-vetch at several sites along the Keno Impoundment totaling over 10,000 plants. Three sites occur in areas within 100 meters of the Keno Impoundment in areas dominated by rabbitbrush (USFWS 2009).

Two other ~~federal~~Federal endangered plants potentially occur in the project area. These are Yreka phlox (*Phlox hirsuta*) and Gentner's fritillary (*Fritillaria gentneri*). Ultramafic soils upon which the phlox is found occur within two miles of Copco Reservoir. The

habitat for the fritillary that consists of mixed hardwood-conifer vegetation dominated by Oregon oak is present in the reach along Copco and Iron Gate Reservoirs (~~personal communication with R.~~ Larson~~, USFWS, March 13,~~ 2011).

No rare or threatened natural communities were identified during the PacifiCorp study or documented on database searches by ORBIC or CNDDB.

3.5.3.5 Wildlife Corridors and Habitat Connectivity

Riparian corridors enable movement of both aquatic and terrestrial wildlife. Project reservoirs and waterways create substantial breaks in the connectivity of riparian habitat. Large mammals such as elk and deer are likely able to traverse these waterways, while they may create a barrier to movement by small mammals, reptiles, and amphibians. In addition, canals, roads, powerhouses, and other facilities often block movement of amphibians and reptiles (PacifiCorp 2004a).

Birds are highly mobile; however, the presence of transmission power lines has the potential to cause bird mortality from collisions, particularly when transmission lines cross flight paths that birds use during seasonal migration or daily movements between foraging and roosting areas. PacifiCorp determined that there are four segments of project transmission lines near areas of high waterfowl and wading bird use: one at Link River, one near the upstream end of Iron Gate Reservoir, and two segments of line that cross Iron Gate Reservoir. However, because these lines do not pass between the reservoirs/rivers and major wetlands or cropland that would attract foraging birds, the probability of collision is reduced, and there has been no evidence of avian collisions occurring on PacifiCorp lines (PacifiCorp 2004a).

3.5.4 Environmental Consequences

3.5.4.1 Environmental Effects Determination Methods

Evaluating potential impacts on terrestrial resources first entailed identification of the affected terrestrial resources within the analysis area. These include existing terrestrial vegetation communities and their value as habitat for wildlife; terrestrial special-status wildlife and plant species; use and dependence of terrestrial species on riparian, wetland, and aquatic reservoir habitat; and terrestrial wildlife corridors.

Habitats that are most likely to be most affected by the project alternatives are the riparian zones, wetlands, and aquatic habitats. Upland habitats would also be affected by KBRA actions. These habitats are important to many terrestrial wildlife species by providing food, water, cover, and breeding sites. Riparian and wetland communities have been greatly reduced in size within the Klamath Basin, with a wetland loses up to 90 percent by some estimations (Larson and Brush 2010). Thus, such habitats within the project area very important to the many species they support. Special-status species are vulnerable to any habitat loss or degradation. The ability to move to other habitat through wildlife corridors is vital to many terrestrial species. Modification of existing

terrestrial habitat in the project area, especially limited riparian and wetland habitat, would have the potential to cause adverse effects.

The evaluation of the project alternatives considered short-term construction effects as well as permanent effects on terrestrial resources. Outputs of sediment transport and hydrologic models were used to identify predicted modifications of terrestrial vegetation communities and how that would affect wildlife habitat, including riparian areas, wetlands, and at reservoirs.

3.5.4.2 Significance Criteria

For the purposes of this EIS/EIR, impacts would be significant if they would result in the following:

- A substantial adverse effect, either directly or through habitat modifications, on any special-status terrestrial species identified in local or regional plans, policies, or regulations, or by the CDFG, USFWS, BLM, or ~~USFWS~~USFS;
- A substantial adverse effect on any riparian habitat;
- A substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act through direct removal, filling, hydrological interruption, or other means;
- A substantial adverse effect on species considered significant to Indian Tribes;
- A substantial interference with the movement of any native resident or migratory wildlife species or with established native resident or migratory wildlife corridors; or
- A substantial adverse effect on natural communities through the introduction or spread of invasive plants.

3.5.4.3 Effects Determinations

3.5.4.3.1 Alternative 1: No Action/No Project

Under the No Action/No Project Alternative, the Four Facilities would remain in place. There would be no change to current sedimentation or scour rates in downstream river reaches.

As no construction would occur, there would be no impacts related to temporary loss of riparian habitat or direct mortality or disturbance of wildlife. No long-term habitat loss or gain would occur under the No Action/No Project Alternative. Existing habitat provided by the reservoirs would remain, which would benefit many species of birds, including waterfowl and bald eagles, bats, and other wildlife and plants that are supported by the aquatic habitat the reservoirs provide.

Populations of special-status plant and animal species, locally rare populations, and rare or threatened natural communities would continue to be influenced by various stressors in the Klamath Basin, including habitat degradation from surrounding land uses and invasive species. There would be no substantial changes to these stressors under the No Action/No Project Alternative. Under the No Action/No Project Alternative, existing

wildlife corridors would remain. The reservoirs and other facilities would continue to present a barrier to movement of some terrestrial wildlife species.

The KBRA would not be implemented under the No Action/No Project Alternative; however, some Ongoing Restoration Actions would occur, including the Agency Lake and Barnes Ranches project which would breach existing dikes to convert the current 63,770 acre feet of pumped storage to passive storage in Upper Klamath Lake. This would provide benefits to waterfowl and their habitat in Upper Klamath Lake NWR through the re-establishment of a natural system of passive water storage. However, since the KBRA would not be fully implemented under the No Action/No Project Alternative, there would continue to be uncertainty regarding water deliveries to the NWRs, and subsequent impacts on terrestrial resources within the Lower Klamath NWR, Tule Lake NWR, and Upper Klamath NWR. Specifically, there would be continued impacts on wetland habitat, waterfowl, and nongame waterbirds that utilize the NWRs based on predicted water deliveries without implementation of the KBRA.

Adverse impacts on terrestrial resources under the No Action/No Project Alternative would be associated with the continuance of various stressors within the area of analysis, including habitat degradation, invasive species, barriers to movement of some terrestrial wildlife species, and uncertainties in water deliveries to the NWRs. **There would be no change from existing conditions for these threats under the No Action/No Project Alternative.**

3.5.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

The Proposed Action would include the complete removal of power generation facilities, bypass canals, pipelines, unnecessary transmission lines, dams, and dam foundations associated with the Four Facilities. The Proposed Action also includes implementation of the KBRA.

This alternative would result in changes to the amount and distribution of habitat types and consequently to the species that depend on them, as described below. In addition, removal of the Four Facilities under the Proposed Action would enable salmon and other fish species to migrate upstream to reaches of the Klamath River which are currently inaccessible to them. These salmon would provide nutrient-rich food for terrestrial species, including bald eagles, osprey, and many other species of birds and mammals. These consumers would subsequently deposit these marine-derived nutrients into terrestrial habitats, increasing productivity of riparian vegetation and benefiting terrestrial ecosystems as a whole (Hilderbrand et al. 2004, Merz and Moyle 2006, Moore et al. 2011).

To facilitate dam removal, PacifiCorp reservoirs would be drawn down. Accumulated sediment behind the dams would be flushed downstream with river flows, particularly natural seasonal high flows, during dam removal. The drawdown of the reservoirs and dam demolition would begin in November 2019. It is assumed that blasting would be required to remove each of the dams. Blasting would occur between January and July 2020 and would be conducted twice a day (early morning and late afternoon) for up to six

days per week during the dam removal period. As described in Section 3.23, Noise and Vibration, blasting would introduce noise levels up to a maximum of 94 A-weighted decibels (dBA) at a distance of 50 feet, while maximum levels for typical construction equipment would range from 75 dBA (pickup truck) to 90 dBA (mounted impact hammer/hoe ram) at 50 feet.

Drawdown of all reservoirs would occur at a rate that would minimize riverbank erosion, while maintaining regulatory discharge rates from the reservoirs (Greimann et al. 2010). This rate would be adjusted depending on the water year, such that flow rates downstream ~~of~~from the dams would not increase significantly above regulatory rates.

Following drawdown of the reservoirs, existing upland vegetation is expected to remain unchanged and contribute to successional processes on newly exposed areas. Wetland-dependent vegetation currently along the margins of the reservoirs is expected to die out and transition to upland communities. Wetland species that occur near confluences may remain unchanged if the hydrology is unaltered, and could expand down to the river channel at reconnected tributaries. Passive restoration of wetland vegetation in areas along the restored river channel is considered feasible, since relatively high densities of viable wetland vegetation seed are present in reservoir sediments based on seedbank analysis (~~DOI 2011a~~Reclamation 2011).

In contrast, active restoration would be needed for upland and riparian areas. In accordance with the Reservoir Area Management Plan (~~DOI~~Reclamation 2011), the reservoir areas will be re-seeded with various herbaceous species (primarily grasses) following drawdown in the spring. Seeding is expected to occur via aerial application of hydromulch, as access to newly drawn down reservoir areas would be limited. Hydroseeding would occur prior to full drawdown, likely in stages as areas are exposed, and ultimately covering the entire area of exposed sediment following drawdown. It would be necessary to hydroseed before the reservoir sediment desiccates so that there is residual soil moisture for seed germination. Following hydroseeding, grasses would quickly germinate and grow on the exposed reservoir surfaces to stabilize the surface of the sediment, minimizing erosion. Invasive plant species would be controlled with the use of herbicides such as glyphosate that have low soil mobility and low toxicity to fish and aquatic organisms (DOI 2011a).

Riparian restoration activities would include planting of various woody species along the channel margins to stabilize the river banks and provide habitat for fish and other species. Pole plantings would be installed in the riparian/wetland zone once the reservoirs have been completely drawn down, the new river channel is established, and banks are stabilized so that labor crews can access riparian zones. Pole planting would occur in the spring the year after drawdown, ideal timing for establishment of woody species in riparian zones (~~DOI 2011a~~Reclamation 2011).

Following reservoir drawdown and prior to restoration activities, additional fencing may be necessary at the reservoir sites to keep livestock out and protect restoration areas, including Parcel B lands. If needed, any new fencing would be “wildlife-friendly” to

enable elk and deer to jump over without getting entangled in barbed wire. The amount and location of additional fencing would be determined once the Definite Plan is available.

In addition to restoration of reservoir areas, many of the developed recreation sites around the reservoirs would be removed and restored following dam removal. This would include regrading, seeding, and planting of parking lots (~~DOI 2011a~~Reclamation 2011).

Due to the likelihood for invasive or weedy species to colonize newly exposed areas, and the known presence and proximity of large stands of upland invasive species near the reservoir shorelines, active control measures would be required to ensure native species are established. A Habitat ~~Restoration~~Rehabilitation Plan (HRP) and construction specifications would be developed once the Definite Plan is available and would be submitted to the resource agencies for review and approval as part of required permit application packages prior to construction.

The ~~Habitat Restoration Plan~~HRP would include details for the installation of native plants and hydroseeding in appropriate areas to re-vegetate all areas disturbed during construction, including reservoir areas, demolition and disposal sites, staging, access and haul roads, and turn-arounds. Long-term maintenance and monitoring to control invasive species would be included. Performance standards to be met to ensure successful re-vegetation of disturbed areas will be developed as described in **Mitigation Measure *TER-1*** in ~~Section~~ Section 3.5.4.4.

In addition, to minimize the introduction of invasive plant species into construction areas, construction vehicles and equipment would be cleaned with compressed water or air within a designated containment area to remove pathogens, invasive plant seeds, or plant parts and dispose of them in an appropriate disposal facility.

Construction Impacts on Wetland and Riparian Vegetation Communities

Construction of the Proposed Action could result in the loss of wetland and riparian vegetation communities. Disturbances associated with construction areas and haul roads where clearing, grading, and staging of equipment would occur would have impacts on sensitive habitats, including wetlands and riparian habitats along reservoirs and river reaches. Culturally important species such as willows occur in these riparian areas. Heavy machinery traversing wetland and riparian areas could change local topography and destroy wetland and riparian vegetation, and could introduce hazardous materials that would adversely affect water quality in wetland and riparian areas.

Once the Definite Plan is prepared and construction areas are delineated, measures would be implemented prior to and during construction to avoid and mitigate impacts to sensitive vegetation communities such as wetlands. During construction for the Proposed Action, wetlands within 50 feet of any ground disturbance and construction-related activities (including staging and access roads) would be clearly marked and/or fenced to avoid impacts from construction equipment and vehicles. If new temporary access roads

are required, grading would be conducted such that existing hydrology would be maintained. In addition, best management practices (BMPs) would be implemented to address potential water quality impacts on wetlands. These construction BMPs are discussed further in Section 3.2, Water Quality. The following pollution and erosion control measures would be incorporated into the Proposed Action to prevent pollution caused by construction operations and to reduce contaminated stormwater runoff:

- Oil-absorbing floating booms would be kept onsite and the contractor would respond immediately to aquatic spills during construction.
- Vehicles and equipment would be kept in good repair, without leaks of hydraulic or lubricating fluids. If such leaks or drips do occur, they would be cleaned up

immediately. Equipment maintenance and/or repair would be confined to one location at each project construction site. Runoff in this area would be controlled to prevent contamination of soils and water.

- Dust control measures would be implemented, including wetting disturbed soils.
- A stormwater pollution prevention plan would be implemented to control the release of stormwater from construction areas. The plan would also prevent construction materials (fuels, oils, and lubricants) from spilling or otherwise entering waterways or water bodies.

Incorporation of these elements into the Proposed Action would avoid or reduce temporary impacts on wetland and riparian vegetation communities including culturally important species that occur there to less than significant.

Construction Impacts on Wildlife

Construction activities could result in direct mortality or harm to special-status invertebrate, amphibian, and reptile species during construction. Construction would require heavy machinery to move through construction areas, staging areas, and haul roads where special-status invertebrate, amphibian, and reptile species could occur. Contact with construction vehicles could result in direct mortality or injury to special-status invertebrate, amphibian, and reptile species including Siskiyou (Chace) sideband, western toad, western pond turtle, California mountain kingsnake, and common kingsnake.

To avoid or reduce the potential for mortality and disturbance of special-status species within construction areas for the Proposed Action, the following elements would be incorporated:

- Biological Resources Awareness Training. Before any ground-disturbing work (including vegetation clearing and grading) occurs in the construction area, a qualified biologist would conduct a mandatory biological resources awareness training for all construction personnel and the construction foreman. This training would inform the crews about special-status species that could occur on site. The training would consist of a brief discussion of the biology and life history of the special-status species; how to identify each species, including all life stages; the habitat requirements of these species; their status; measures being taken for the protection of these species and their habitats; and actions to be taken if a species is found within the project area during construction activities. ~~Identification~~Species identification cards would be issued to shift supervisors; these cards would have photos, descriptions, and actions to be taken upon sighting of special-status species during construction. Upon completion of the training, all employees would sign an acknowledgment form stating that they attended the training and understand all protection measures. An updated training would be given to new personnel and in the event that a change in special-status species occurs.
- Protocol-level Wildlife Surveys. Prior to construction, a biologist approved by the resource agencies (USFWS, ODFW, and/or CDFG) would conduct protocol

surveys to ensure no special-status animals are present within the area in which any construction activity would occur. For invertebrate species such as the Siskiyou (Chace) sideband, surveys for suitable habitat within construction areas would be conducted to determine the likelihood of presence, and if so, surveys for the species itself would be conducted consistent with the 2011 Survey & Manage settlement agreement memorandum (USFS and BLM 2011b). If special-status species are present (except for birds), they would be captured and relocated to a suitable area in consultation with the resource agencies.

- Exclusion Measures for Special-Status Wildlife. Construction areas, including staging areas and access routes, would be fenced with orange plastic snow fencing to demarcate work areas. The approved biologist would confirm the location of the fenced area prior to habitat clearing, and the fencing would be maintained throughout the construction period. Additional exclusion fencing or other appropriate measures would be implemented in consultation with the resource agencies to prevent use of construction areas by special-status species during construction.
  - To prevent entrapment of wildlife that do enter construction areas during activities, all excavated, steep-walled holes or trenches in excess of ~~2~~two feet deep would be inspected by a biologist or construction personnel approved by the resource agencies at the start and end of each working day. If no animals are present during the evening inspection, plywood or similar materials would be used to immediately cover the trench, or it would be provided with one or more escape ramps set at no greater than 1,000 foot intervals and constructed of earth fill or wooden planks. Trenches and pipes would be inspected for entrapped wildlife each morning prior to onset of activity. Before such holes or trenches are filled, they would be thoroughly inspected for entrapped animals. Any animals so discovered would be allowed to escape voluntarily, without harassment, before activities resume, or removed from the trench or hole by a qualified biologist approved by the resource agencies and the animals would be allowed to escape unimpeded. A biologist approved by the resource agencies would be responsible for overseeing compliance with protective measures during clearing and construction activities within designated areas throughout the construction activities.
- General Requirements for Construction Personnel include the following:
  - The contractor would clearly delineate the construction limits and prohibit any construction-related traffic outside these boundaries.
  - Construction crews would be required to maintain a 20 miles per hour (mph) speed limit on all unpaved roads to reduce the chance of wildlife being harmed if struck by construction equipment.
  - All food-related trash items such as wrappers, cans, bottles, and food scraps generated during construction, subsequent facility operation, or permitted operations and maintenance activities of existing facilities would be disposed of in closed containers only and removed at least once a week from the site. The identified sites for trash collection would be fenced to minimize access from wildlife.
  - No deliberate feeding of wildlife would be allowed.
  - No pets would be allowed on the project site.

- No firearms would be allowed on the project site.
- If vehicle or equipment maintenance is necessary, it would be performed in the designated staging areas.
- Any worker who inadvertently injures or kills a federally or ~~state~~State listed species, bald eagle, or golden eagle, or finds one dead, injured, or entrapped would immediately report the incident to the construction foreman or biological monitor. The construction foreman or monitor would notify the resource agencies within 24 hours of the incident.

These elements of the Proposed Action would avoid or reduce mortality and harm to special-status invertebrate, amphibian, and reptile species during construction.

~~In addition to direct mortality and harm, the initial release of sediment from behind the dams could result in impacts on western pond turtle if it causes turtles to move away from underwater refugia and thus become more vulnerable to predators. Increased sediment following dam removal is anticipated to be a short-term effect immediately following dam removal. Western pond turtles utilize deep pools and low velocity areas with underwater refugia to hide from predators. Increased sediment may actually benefit turtles by providing substrate turtles burrow into for cover (Reese and Welsh 1998). Other important habitat features, such as availability of basking sites, are not anticipated to be adversely affected by the release of sediment. In the long term, sediment released during dam removal would be flushed out of downstream reached during subsequent high flow events. Dam removal is anticipated to result in benefits to western pond turtle by restoring a more natural flow regimes that increases slow-flowing pool habitat near the river banks and habitat heterogeneity overall (Reese and Welsh 1998). Therefore, there would be no adverse effects on western pond turtle from short-term sedimentation following dam removal.~~ **Therefore, impacts on special-status invertebrate, amphibian and reptile species during construction would be less than significant.**

Construction activities could result in adverse impacts on birds, including special-status bird species, during construction. Potential impacts on migratory birds, including several special-status species, could occur through nest abandonment due to noise and human activity during construction periods.

It is anticipated that dam demolition activities (including blasting) would begin in January 2020 and mobilization of construction equipment would begin in the late fall of 2019. Construction activities that could result in noise and disturbance impacts on birds would include dam demolition, clearing of access and haul roads, upload staging and disposal sites, and restoration activities. While it would not be possible to exclude all birds from these construction areas throughout the construction period, the Proposed Action incorporates specific construction measures to avoid or reduce impacts on birds, as described below. These measures were developed in coordination with USFWS (Strassburger 2011).

It is important to note that analysis of effects to northern spotted owl and other federally~~-~~ listed species that could be affected by the Proposed Action ~~will be~~were

evaluated in a Biological Assessment (BA) under Section 7 of the ~~federal Endangered Species Act~~Federal ESA. Avoidance measures and project design standards ~~will be~~were detailed in the description of the Proposed Action in the BA (Reclamation 2012b).

Northern Spotted Owl

Based on the analysis conducted in support of the Biological Assessment, no current activity centers are located within the disturbance distance of the anticipated construction activities analyzed (Reclamation 2012b). Suitable habitat which has the potential to support future nesting spotted owl pairs is present within the disturbance distance of the following Proposed Action activities:

1. Copco No 1 Reservoir
    - Improving and use of haul routes at Copco No. 1 Reservoir

- J.C. Boyle
  - Improving and use of haul routes for dam demobilization and reservoir revegetation monitoring and maintenance
  - Removal of the concrete stoplogs and spillway gates
  - Mobilization; excavation of dam embankment; removal of spillway gates and crest structure, fish ladder, steel pipes, canal intake screen structure, left concrete gravity section, power canal (flume), shotcrete slope protection, forbay spillway control structure, tunnel inlet portal structure, surge tank, penstocks (including supports and anchors), tunnel portals, powerhouse gantry crane and substructure, tailrace flume walls, switchyard, warehouse, and support buildings; backfill tailrace channel area and canal spillway scour area; and demobilization
  - Modification or removal of 2.2-mile-long power canal (or flume)
  - Removal of the 64-kV transmission lines

The Proposed Action incorporates specific ~~elements~~minimization measures that would avoid or reduce impacts on northern spotted owls during construction. The northern spotted owl typically nests from February through September in the project area. Suitable northern spotted owl nesting and roosting habitat does not occur within one mile of the dams, and none is expected to grow by 2019 (~~personal communication with L.~~ Roberts~~, USFWS, June 27,~~ 2011). In addition, since mobilization of construction equipment would begin in November 2019, noise and human presence would likely discourage northern spotted owls from initiating nesting near construction areas. Therefore, impacts on this species from the Proposed Action would be limited to disturbance during aerial hydroseeding that would occur during restoration activities. All landings, staging areas and flight paths would avoid suitable northern spotted owl nesting or roosting habitat by 0.25 mile. The following minimization measures for the northern spotted owl were proposed in the Biological Assessment (Reclamation 2012b). Final versions of the measures are anticipated in the Biological Opinion and would be implemented as part of the Proposed Action:

- ~~In addition~~Measure NSO 1: Prior to initiating any construction activities, potential impacts of ground-disturbing construction activities will be evaluated for northern spotted owl and its habitat, and construction plans will be modified as appropriate, with an overall goal of preventing or minimizing impacts. Locations of the individual components of the Proposed Action, noise disturbances, and habitat geographic information system (GIS) layers will be reevaluated using the best available data at the time of construction to determine whether or not additional measures are needed.
- Measure NSO 2: Protocol-level surveys will be conducted within suitable nesting and roosting habitat (assessed by using best available GIS information, aerial photos, and consultation with the USFWS) that occur within the northern spotted owl disturbance distance of the construction activity. If no nesting is observed, no seasonal restriction would be required. If nesting is observed, a California seasonal restriction (February 1–September 15) or Oregon seasonal restriction (March 1–September 30) will be followed or

activity will be delayed as late as possible into the late breeding season for California (July 10–September 15) or Oregon (August 11–September 30) to minimize the disturbance to young prior to fledging.

- Measure NSO 3: To prevent direct injury of young resulting from aircraft, no helicopter flights will occur within or at an elevation lower than 0.8 km (0.5 mi) of suitable nesting and roosting habitat during the entire breeding season unless protocol level surveys identify no activity centers.
- Measure NSO 4: No component of suitable nesting, roosting, foraging, or dispersal habitat will be modified or removed during the removal of transmission lines or installation or removal of fencing.

As part of Measure NSO 2 described above, prior to construction, a biologist approved by the resource agencies (USFWS, ODFW, and/or CDFG) would conduct protocol surveys endorsed by USFWS for northern spotted owls in all areas supporting suitable nesting and roosting habitat that may be affected by construction, including along access roads and haul routes. If, during preconstruction surveys, an active nest of northern spotted owl is identified, a restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed from construction. This would include evaluation of noise levels at the nesting site.

Bald Eagle

Bald eagles are protected under the Bald and Golden Eagle Protection Act and are fully protected under California law. The Proposed Action incorporates specific elements that would avoid or reduce impacts on bald eagles during construction[1]. Bald eagle nesting trees are known to exist within or near to construction areas for the Proposed Action, and bald eagles often use the same nests in multiple years. Prior to construction, all necessary permits in compliance with the Bald and Golden Eagle Protection Act would be obtained. Measures incorporated into the Proposed Action to reduce impacts on bald eagles (and golden eagles) from loss of nesting habitat will include the following:

- Complete a two-year survey for eagle use patterns prior to construction activities. Surveys will be conducted by a qualified avian biologist and will include any facilities to be removed or modified to determine bird use patterns. Surveys will be conducted during the time of year most likely to detect eagle usage.

- Prior to construction, conduct at least one focused survey for bald eagle nests within 2 miles of construction areas, including along access roads and haul routes, during the early bald eagle breeding season (January 15 through February 28). Three additional surveys would be conducted; two between March 1 and April 1, and one after April 1. Additional survey visits would be conducted to determine if eagles are nesting within 2 miles of the construction area. Before commencing

[1] The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in ~~Appendix~~ Appendix B.

construction activities during the early breeding season, at least one survey would be conducted within two weeks prior to beginning operations.

- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January 15 through August 15~~);~~).
- If active nests are present within 2 miles of construction areas, a 0.5-mile restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed. If active bald eagle nests are present within 0.5 miles of construction areas, construction activities would be halted until approval is obtained from the resource agencies to resume. If a nest is not within line of site of the project, meaning that trees or topographic features physically block the eagle's view of construction activities, the buffer could be reduced to 0.25 miles~~-~~.

Golden Eagle

Golden eagles are protected under the Bald and Golden Eagle Protection Act and are fully protected under California law. The Proposed Action incorporates specific elements that would avoid impacts on golden eagles[2]. Golden eagles are known to have historically nested in cliffs within the project area. Golden eagles are also known to nest within pine, juniper and oak trees.

Measures incorporated into the Proposed Action to reduce impacts on golden eagles ~~from loss of nesting habitat~~during construction will include the following:

- Complete a two-year survey for eagle use patterns prior to construction activities. Surveys will be conducted by a qualified avian biologist and will include any facilities to be removed or modified to determine bird use patterns. Surveys will be conducted during the time of year most likely to detect eagle usage.
- Prior to construction, at least one protocol survey for golden eagle nests ~~would be~~ would be conducted within 5 miles of construction areas, including along ~~access~~ access roads and haul routes, during the breeding season (January through July~~).~~). Before commencing construction activities during the early breeding season, at least one focused survey would be conducted within two weeks prior ~~to~~ to beginning operations. Additional survey visits would be conducted to determine if eagles are nesting within 2 miles of the construction area.
- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January through July).
- If active nests are present within 2 miles of construction areas, a 1-mile restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed. If active golden eagle nests are present within 1 mile of

[2] Please note that the discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate compliance with the Bald and Golden Eagle Protection Act. These BMPs are repeated in Appendix B.

construction areas, construction activities would be halted until approval is obtained from the resource agencies to resume. If an active nest is not within line of site of the project, meaning that trees or topographic features physically block the eagle's view of construction activities, the buffer could be reduced to 0.5 miles.

It is noted that USFWS is not currently issuing permits authorizing take for golden eagles under the Bald and Golden Eagle Protection Act.

Osprey

The Proposed Action incorporates specific elements that would avoid or reduce impacts on ospreys during construction. Known osprey nests are located within or near to construction areas for the Proposed Action. Some osprey nests are located on transmission line poles or other man-made platforms that would be removed during construction for the Proposed Action, or are located within areas where construction noise or human presence would cause disturbance to the birds. To avoid nesting disturbance, the nests located within or near to construction areas would be removed prior to the breeding season and replaced with nesting platforms following construction on a 1:1 basis. In addition, a search for osprey nests within 0.25 mile of construction areas, including along access roads and haul routes, would be conducted prior to beginning operations and during the breeding season, which begins in February. If active nests are present, a 0.75-mile restriction buffer would be established and delineated on maps and resource agencies would be consulted to obtain concurrence prior to conducting construction activities.

Willow Flycatcher

The Proposed Action incorporates specific elements that would avoid or reduce impacts on willow flycatcher during construction. Prior to construction during the nesting season of June 1-August 31, a focused survey for willow flycatcher would be conducted within construction areas, including along access roads and haul routes. The survey would follow the established protocol described in Bombay et al. (2003). If active willow flycatcher nests are detected, a 0.5-mile restriction buffer would be established and delineated on maps and resource agencies would be consulted to obtain concurrence prior to conducting construction activities.

Peregrine Falcon

Peregrine falcons, a fully protected species, are known to occur along the J.C. Boyle bypass reach, and have the potential to occur elsewhere in the project area. Specific elements described below (see Other Migratory Birds) would be incorporated during construction, including nesting surveys, to avoid or reduce impacts on peregrine falcons. If nesting peregrine falcons are detected, a restriction buffer would be established prior to conducting construction activities.

Greater Sandhill Crane

Greater sandhill cranes, a fully protected species, are known to occur in the project area, and have been documented nesting along the J.C. Boyle Reservoir. Specific elements described below (see Other Migratory Birds) would be incorporated during construction, including nesting surveys, to avoid or reduce impacts on greater sandhill cranes. If nesting sandhill cranes are detected, a restriction buffer would be established prior to conducting construction activities.

Other Migratory Birds

The Proposed Action incorporates the following specific elements that would avoid or reduce impacts on migratory birds from removal, destruction, or disturbance of active nests during construction:

- Removal or trimming of any trees or other vegetation for construction would be conducted outside of the nesting season (March 20 through August 20). This would include removal or trimming of trees along access roads and haul routes and within disposal sites.

- Where clearing, trimming, and grubbing work cannot occur outside the migratory bird nesting season, a qualified avian biologist will survey construction areas to determine if any migratory birds are present and nesting in those areas.

- For all raptors (other than eagles), inactive nests will be removed before nesting seasons begin, to the greatest extent practicable. For those nests where access is difficult, traffic cones or other deterrents will be placed in the nest platform to prevent nesting in the year of construction. All deterrents will be removed as soon as possible after construction crews have passed to a point beyond the disturbance buffer for that species. See **Mitigation Measure *TER-2*** (Section 3.5.4.4, Table 3.5-~~5~~6).

- If an active nest is located, a restriction buffer in accordance with **Mitigation Measure *TER-2*** (Section 3.5.4.4, Table 3.5-~~5~~6) would be established and the resource agencies would be consulted to obtain concurrence prior to conducting construction activities.

Incorporation of these elements into the Proposed Action and implementation of **Mitigation Measures *TER-2*** and ***TER-3*** would avoid or reduce impacts on birds during construction[~~3~~]. [4] **Therefore, impacts on birds, including special-status bird species, during construction would be less than significant.**

[~~3~~] ~~The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance~~

Construction Impacts on Plants

Construction activities could result in the loss of special-status plants during construction. Special-status plants occurring in construction areas could be destroyed by heavy equipment. Prior to the implementation of construction activities, a botanist approved by the resource agencies would conduct protocol-level surveys within construction areas for special-status plants during the peak blooming season prior to start of construction. If any special-status plants occur within the construction areas, locations of these plants would be clearly marked and/or fenced to avoid impacts from construction equipment and vehicles where possible.

In addition, to avoid or reduce impacts on special-status plants from the introduction of invasive plant species, construction vehicles and equipment would be cleaned with compressed water or air within a designated containment area to remove pathogens, invasive plant seeds, or plant parts and dispose of them in an appropriate disposal facility. The ~~Habitat Restoration Plan~~HRP would include details for the installation of native plants to re-vegetate all areas disturbed during construction. Long-term maintenance and monitoring to control invasive species would be included.

It is important to note that analysis of effects to Applegate's milk-vetch (*Astragalus applegatei*) and other federally~~-~~ listed plant species that could be affected by the Proposed Action are evaluated in a BA under Section 7 of the ~~federal Endangered Species Act~~Federal ESA. Determination of impact significance for federally~~-~~ listed plant species in this EIS/EIR is consistent with the findings of the BA.

Following any positive Secretarial Determination and during development of the Definite Plan, additional measures would be included as needed for ~~"~~"Survey and Manage" species to comply with the requirements of the applicable Land and Resource Management Plan for any activities on National Forest System lands.

Incorporation of these elements into the Proposed Action and implementation of **Mitigation Measures *TER-1*** and ***TER-4*** would avoid or reduce impacts on special-status plants during construction[5]~~.~~.[6] **Therefore, impacts on special-status plants during construction would be less than significant.**

~~documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in Appendix B.~~

[4] The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in Appendix B.

~~[5] The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in Appendix B.~~

[6] The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance

Construction activities could result in adverse impacts on wildlife from riparian habitat loss. Impacts from temporary loss of riparian habitat would affect wildlife that use this habitat, particularly several common amphibian species, such as Pacific giant salamander and several bird species, including several species of special-status riparian birds such as willow flycatcher, yellow warbler, and yellow-breasted chat. In addition, western pond turtle, a special-status reptile, could be affected by the loss of this habitat. As discussed below, there would be gains in riparian habitat at the reservoirs following dam removal and restoration. In addition, localized disturbance of riparian habitat downstream due to sedimentation is expected to be short-term, with colonization of riparian plant seedlings and subsequent re-vegetation of riparian areas within three years following implementation of the Proposed Action. **Therefore, impacts on wildlife using riparian habitat would be less than significant.**

Short-term Impacts of High Suspended Sediment Concentrations (SSC) on Special-Status Amphibians and Reptiles

The Proposed Action would result in the release of sediment from behind the dams, causing increased suspended sediment concentrations (SSC) within the mainstem of the Klamath River downstream from the dams. According to the EIS/EIR in Section 3.2.4.3.2, the Proposed Action would result in a large increase in SSC (>1,000 mg/L) between early January to February 2020 when Iron Gate and J.C. Boyle begin drawdown and Copco 1 enters phase 2 of drawdown. SSC remain very high (>1,000 mg/L) for approximately 3 months from January through April 2020 (see Figure 3.2-11 and Table 3.2-11). SSC are expected to be higher in reaches of the Klamath River located closer to the point of origin of the sediment (i.e., the former site of the dam) and to decline in a downstream direction due to dilution from tributaries (Stillwater Sciences 2009). Elevated SSC has the potential to adversely affect or cause mortality to sensitive life stages of amphibians and reptiles occurring in the Lower Klamath River mainstem.

According to Stillwater (2009) high SSC from dam removal could result in a worst-case scenario of 100% mortality of all amphibian eggs deposited in the Lower Klamath River mainstem. However, Stillwater (2009) did not undertake a detailed species-specific analysis of the timing of the increased SSC and the life history attributes and habitat utilization of the potentially affected amphibians and reptiles.

Increased SSC from dam removal has the potential to decrease food availability by effecting the growth and survival of food sources such as algae, diatom, and macroinvertebrate populations. This indirect impact of increased SSC would likely have some effect on all reptile and amphibian species utilizing the Lower Klamath River mainstem. However, this indirect impact is not considered a substantial adverse effect due to the timing of this impact and the life history attributes of affected species, particularly the seasonality of their habitat utilization. The potential impacts of high SSC on specific special-status amphibian and reptile species are discussed below.

---

documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in Appendix B.

Tailed Frog and Southern Torrent Salamander

Both the tailed frog and southern torrent salamander utilize high-gradient headwater stream habitat and have been documented in tributaries in the lower Klamath River. These species would not typically be expected to occur in the Lower Klamath River mainstem. The high short-term high SSC from dam removal would only affect the Klamath River mainstem. Sediment released from behind the dams would be transported downstream within the Lower Klamath River mainstem and tributary streams would not experience elevated SSC.

Under the Proposed Action, the short-term impact of increased SSC on the tailed frog and southern torrent salamander in the Lower Klamath River would be less than significant.

Northern Red-Legged Frog

The northern red-legged frog, breeds in still or low-velocity ponds, pools, side-channels and wetlands in the coastal areas of the Lower Klamath Basin, generally within 20 kilometers of the river mouth. Northern red-legged frogs lay their eggs on aquatic or submersed herbaceous emergent vegetation. Because their egg-laying habitat requires still water or very low flow, their breeding sites would typically be more up-slope and disconnected from the Lower Klamath River mainstem. These breeding sites would typically only be connected with the Lower Klamath River mainstem during extreme high-flow events, in which case egg masses would likely experience high rates of mortality. Adult northern red-legged frogs are mostly terrestrial and spend substantial time foraging in upland habitats. Thus, short-term high SSC in the Lower Klamath River mainstem are not expected to result in substantial negative effects on eggs, tadpoles, or adult northern red-legged frogs.

Under the Proposed Action, the short-term impact of increased SSC on the northern red-legged frog in the Lower Klamath River would be less than significant.

Foothill Yellow-Legged Frog

The foothill yellow-legged frog is known to breed in the mainstem of the Lower Klamath River as well as its major tributaries. According to Lannoo (2005), the foothill yellow-legged frog typically breeds between late April and June. In California, egg masses have been found between April 22-July 6, with an average of May 3 (Lannoo 2005). In the Trinity River, a major tributary to the Lower Klamath River, Ashton et al. (1998) found foothill yellow-legged frogs lay eggs throughout a three month period of April to June. As discussed in the EIS/EIR within Section 3.2.4.3.2, the Proposed Action would result in the highest SSC during the period of approximately January to April. The early period (late April) of the foothill yellow-legged frog breeding season potentially overlaps with the end period of high SSC from the Proposed Action. Thus, high SSC could have a short-term negative effect on this species by resulting in mortality in mainstem Klamath River egg masses laid earliest in the breeding season during the spring of 2020. This impact would decrease with distance downstream from Iron Gate Dam. SSC at Iron Gate Dam in excess of 1,000 mg/L would occur on a timescale of weeks to months (see Table 3.2-11 in Section 3.2 Water Quality), as compared to SSC (or Total Suspended Solids [TSS]) greater than 1,000 mg/L that can occur during winter storm events on a timescale of days to weeks under existing conditions in the Klamath River at Iron Gate Dam (see Appendix C, Section C.2.2.2). Predicted SSC would remain greater than or equal to 100 mg/L for 5-7 months following drawdown, and concentrations would remain greater than or equal to 30 mg/L for 6-10 months following drawdown (see Table 3.2-11 in Section 3.2 Water Quality). Model results also indicate that dilution in the Lower Klamath River would decrease SSC to 60-70 percent of their initial value downstream from Seiad Valley (RM 129.4) and to 40 percent of their initial value downstream from Orleans (~RM 59) and consequently impacts from the SSC become progressively smaller as they move downstream (Reclamation 2012). There would be no impact from high SSC on foothill yellow-legged frogs breeding in Klamath River tributaries.

It is uncertain how negatively SSC affects egg mass survival for this species, though it is anticipated that high SSC may result in some mortality for egg masses laid earliest in the breeding season (e.g. April). In his discussion of foothill yellow-legged frog conservation, Lannoo (2005) lists a wide range of environmental impacts that this species is susceptible to, and suspended sediment or turbidity are not one of them. Furthermore, according to Lannoo (2005), egg masses observed in the field frequently have silt accumulation on the outer surface. According to Lannoo (2005), it is unknown if silt accumulation affects egg development, but the silt makes the masses less conspicuous and may reduce predation by visual predators. Adult foothill yellow-legged frogs are much more aquatic than the northern red-legged frogs and spend considerably more time in or adjacent to the stream and river habitats in which they breed. However, being semi-terrestrial, they also inhabit adjacent riparian and wetland habitats and would have the ability to avoid the short-term impacts of high SSC by moving up-slope or up tributary channels. Thus, high adult mortality is not expected from high SSC in the Lower Klamath River mainstem.

Under the Proposed Action, the short-term impact of increased SSC on the foothill yellow-legged frog in the Lower Klamath River would be less than significant.

Western Toad

Western toads lay their eggs in still or barely moving water, typically in ponds, lakes, streams, and ditches (Lannoo 2005). Adults are primarily terrestrial, inhabiting upland areas during the non-breeding season. Although there are detections of western toads along the Klamath River (see Table 3.5-4), they would be unlikely to breed in the mainstem river, outside of the reservoirs. Consequently, aside from the reservoirs, western toad egg masses and tadpoles would typically only occur in off-channel and associated wetlands and ponds near the Klamath River mainstem, but not in the mainstem channel itself. The adults are terrestrial and would only incidentally and sporadically utilize the Klamath River mainstem for habitat. Given the habitat utilization of the western toad, eggs, tadpoles, and adults would have a very low probability of occurring in the Lower Klamath River mainstem, and therefore high SSC would have a low likelihood of substantially affecting this species.

Under the Proposed Action, the short-term impact of increased SSC on the western toad in the Lower Klamath River would be less than significant.

Western Pond Turtle

Western pond turtles in the Lower Klamath River utilize the mainstem channel as well as side-channels, backwaters, and adjacent wetland and riparian habitat. They often move to off-channel habitats, such as oxbows, or uplands during high flow events.

Although the western pond turtle is considered an aquatic species, they are known to spend a considerable portion of their lives in upland habitats. They may travel across terrestrial habitats as much as one kilometer from aquatic habitat and radio-tracking studies have recorded individuals occurring on land for up to seven months out of each year (Bury and Germano 2008). Some animals may be active year-round, while others

may enter terrestrial overwintering sites in October-November and reemerge in March-April (Bury and Germano 2008). Turtles from river and stream habitats often leave the watercourse in late fall and move up to 480 m into upland habitats to overwinter (Bury and Germano 2008).

Since eggs are laid in underground upland nests, their egg life stage would not be affected by high SSC in the river (Stillwater Sciences 2009). Hatchlings in northern California overwinter in their nests and emerge in the spring. This life history trait would also diminish the potentially negative effects of high SSC on emerging juveniles.

The increased SSC could result in impacts on the western pond turtle if it causes turtles to move away from underwater refugia and thus become more vulnerable to predators or if it diminishes foraging opportunities. Increased SSC following dam removal is anticipated to have a short-term, but unsubstantial effect on this species' foraging and habitat utilization because of their ability to forage in, and escape to, adjacent upland habitat if needed and because, as discussed in EIS/EIR Chapter 3.2, high SSC events are natural and commonly-occurring winter-spring events in the Lower Klamath River and this species is adapted to them. Other important habitat features, such as availability of basking sites, are not anticipated to be adversely affected by increased SSC.

Under the Proposed Action, the short-term impact of increased SSC on the western pond turtle in the Lower Klamath River would be less than significant.

Long-Term Habitat Loss and/or Modification

Permanent alteration of existing habitats would have long-term impacts on plants and animals that occur in these habitats, including special-status plants and wildlife species.

Loss of Aquatic Habitat at Reservoirs

Removal of reservoirs could result in impacts on wildlife from the permanent loss of aquatic habitat. Following dam removal, aquatic habitat at reservoirs would become riverine, riparian, and upland habitat depending on future hydrologic and physical (topographic) conditions. Water birds that use the reservoirs seasonally during migration and/or for overwintering would be affected by the loss of this aquatic habitat for nesting, foraging, loafing, and roosting. The loss of aquatic habitat would also reduce foraging opportunities for fish-eating birds including osprey, merganser, cormorant, egret, and heron. Changes in food availability for birds such as dabbling ducks that consume aquatic vegetation and invertebrates would occur. However, these species would utilize the river or other aquatic habitat outside the project area for foraging once the reservoirs are gone. Similarly, foraging habitat for swifts and bats would be reduced; however, swifts and bats would also feed in riverine habitat once the reservoirs are gone.

The loss of aquatic habitat at reservoirs would reduce habitat for western pond turtle. However, turtles would utilize future restored riverine habitat at the former reservoir areas as they do currently along the J.C. Boyle peaking reach, Iron Gate-Shasta River reach, and other areas. There are at least five known bald eagle nests near Copco and J.C. Boyle Reservoirs, and additional nest locations are located between these two areas

and upstream (~~personal communication with R.~~ Larson~~, USFWS, March 13,~~ 2011). Since bald eagles primarily use the Lower Klamath NWR for preying on waterfowl, there would be some anticipated effects on bald eagles from loss of this reservoir habitat. However, bald eagles would utilize riverine habitat or other aquatic habitat outside the project area for foraging. In addition, there may be an increase in foraging opportunities for raptors presented by the return of salmon to the riverine system that replaces the reservoirs.

PacifiCorp estimated that decommissioning and removal of the Four Facilities would result in the loss of a total of about 2,404 reservoir acres (FERC 2007). Compared to the large reservoirs and wetland complexes of Upper Klamath Lake (approximately 77,~~000~~ 000 acres), Tule Lake (approximately 13,000 acres), and Lower Klamath Lake (approximately 22,000 acres of which approximately 2,200 acres are permanently flooded), the project reservoirs represent a small amount of the available reservoir habitat in the Klamath Basin when wetland and aquatic habitat at the NWRs is at full capacity. Based on National Wetland Inventory data, there are approximately 380,000 acres of wetlands in the Oregon portion of the ~~upper~~Upper Klamath Basin (Larson and Brush 2010).

It is also important to note that under the Proposed Action, much of the aquatic reservoir habitat would be converted to upland and riparian habitat based on future hydrology and with active restoration activities (hydroseeding and planting) described above (~~DOI 2011a).~~ Reclamation 2011). Upland vegetation restoration would occur at a total of approximately 1,602 acres following reservoir drawdown: 195 acres at J.C. Boyle Reservoir, 632 acres at Copco 1 Reservoir, and 775 acres at Iron Gate Reservoir. Restoration of wetland/riparian habitat would occur at a total of 272 acres following reservoir drawdown: 52 acres at J.C. Boyle Reservoir, 170 acres at Copco 1 Reservoir, and 50 acres at Iron Gate Reservoir (~~DOI 2011a).~~

Reclamation 2011). This is discussed further below under Long-term Impacts on Wetlands.

At Copco 1 and Iron Gate Reservoirs there is approximately 1,400 acres of upland habitat types that are currently inundated by the reservoirs. These habitat types include grassland, juniper, oak woodland, mixed chaparral, pasture, orchard and agriculture (PacifiCorp 2004a). Removing the dams, specifically removal of Iron Gate and Copco 1 Reservoirs, would increase the amount of available acres of habitat within critical deer winter range in the long term, ~~benefitting~~benefiting deer by expanding winter range habitat (~~personal communication with J.~~ Hamilton~~, USFWS, January 7,~~ 2011).

In addition, based on historic maps and aerial photos, PacifiCorp (2004a) estimated historic aquatic habitat types at the reservoirs to be approximately 125 acres at J.C. Boyle Reservoir, 119 acres at Copco 1 Reservoir, and 108 acres at Iron Gate Reservoir (Copco 2 Reservoir was not mapped). Thus, a total of approximately 350 acres of aquatic habitat occurred historically and would be expected to be available for restoration following reservoir drawdown.

Therefore, while unavoidable impacts on wildlife, particularly waterfowl and other waterbirds, from the permanent loss of reservoir habitat would occur under the Proposed Action, these impacts would be less than significant.

Modification of Riparian Habitat

Dam removal could result in long-term impacts on riparian habitat from sedimentation in downstream reaches. After the dams are removed and if sediment is allowed to flush downstream, the steep riverbank slopes along the reservoirs would cause the new river channel to conform to the pre-dam river channel alignment (Gathard Engineering Consultants [GEC] 2006). Riverbank stabilization and re-vegetation of riverbank with native plantings would be conducted at each reservoir after the drawdown is complete. This restoration would occur in areas with slopes less than 20 percent, and would entail transplanting and pole-planting of trees and woody shrubs with interspersed seeding of herbaceous species. In addition to erosion control, restoration would exclude invasive plant species from colonizing un-vegetated areas exposed by reservoir drawdown.

Thus, riparian habitat at reservoirs would increase with restoration following drawdown. PacifiCorp estimated that decommissioning and removal of the Four Facilities would add about 184 acres of riparian vegetation. This estimate was based on the assumption of an average riparian corridor width of 100 feet along the 3.6-mile length of the J.C. Boyle Reservoir, the 4.5-mile length of the Copco Reservoir, the 0.3-mile length of the Copco 2 Reservoir, and the 6.8-mile length of the Iron Gate Reservoir (FERC 2007).

The establishment of woody species along the riparian corridor is expected to take several years, following which there would be benefits to terrestrial wildlife, particularly riparian-associated species. With control and monitoring of invasive plants, there would also be benefits to native plant species.

In downstream reaches of the Klamath River, no adverse erosion of riverbanks would be anticipated based on expected flow rates. However, based on modeling conducted using the DREAM-1 modeling software to simulate downstream sediment deposition following dam removal, sedimentation would be likely to occur, particularly if the number of intense storms or snowmelt were low during the 2019-2020 season and in subsequent years. This sedimentation would be limited to downstream reaches as far as Cottonwood Creek. If rain and snowmelt levels were high, less sedimentation in downstream reaches would occur, as there would be more water in the system to flush out sediment (Stillwater Sciences 2008).

Sediment sampling in the reservoirs has indicated that the majority of accumulated sediment is fine-grained (coarse sand and finer) (DOI 2010). If the sediment is allowed to move downstream naturally, it is likely that some sedimentation would occur in deep pools or channel margins downstream during low-flow periods and cover wetland/ riparian with a veneer of fine material (DOI 2011~~b~~). This short-~~-~~term wetland/riparian habitat alteration would be localized ~~-~~and would not be substantial. Additionally, this sediment would be flushed out during subsequent high flow events (see Section 3.11 Geology, Soils and Geologic Hazards). Sedimentation has the potential to create new

surfaces for riparian plants to colonize, and result in beneficial effects on riparian habitat (Shafroth et al. 2002). Effects on existing riparian habitat from sedimentation would be short-term in nature, as riparian vegetation would quickly be re-established through colonization by seedlings of willows, cottonwoods, and other riparian species. This colonization occurs following disturbance during peak flows that creates substrate for seedlings, followed by declining spring and summer flows that occur during seed dispersal. Under this natural process, new riparian vegetation would become established within 3-5 years after disturbance (Riparian Habitat Joint Venture 2009). Based on this assessment, no permanent loss of riparian habitat is anticipated to occur in any river reaches. There would be gains in riparian habitat (approximately 184 acres) at the reservoirs through restoration efforts following dam removal and reservoir drawdown. **Both short- and long-term impacts on riparian habitat would be less than significant.**

Long-term Impacts on Wetlands

Dam removal could result in loss of reservoir wetlands. A substantial amount of the historical wetlands of the Upper Klamath Basin have been lost to agricultural developments and water diversions (Larson and Brush 2010). As a result, there is less wetland habitat for waterfowl than there was prior to development, but abundant food for dabbling ducks and geese that feed on small grains in fields surrounding the wetlands (Jarvis 2002).

Under the Proposed Action, there would be unavoidable impacts on wetland habitat at the J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs (~~245~~244.4 acres, Table 3.5-2). However, much of these unavoidable impacts would be temporary, as wetlands would be expected to become reestablished in some areas along the new river channel with adequate hydrology, soils, and vegetation. As these areas would be prone to colonization by invasive plant species, management and control of invasives would be needed.

Based on the Reservoir Area Management Plan, restoration of wetland/riparian habitat would occur at a total of 272 acres following reservoir drawdown: 52 acres at J.C. Boyle Reservoir, 170 acres at Copco 1 Reservoir, and 50 acres at Iron Gate Reservoir (Reclamation 2011). These acreages were not based on jurisdiction wetland delineations of existing wetlands at the reservoirs. Rather, restored wetland/riparian acreages were determined using reasonable biological parameters with subsequent comparison to river geomorphic maps of the reservoirs developed from historical photography. Bathymetric data were adjusted for post dam removal desiccation and used to determine slopes. Height above river was determined by subtracting a modeled river elevation from the bathymetric elevations. Potential wetlands were modeled with slopes less than 2 percent and height less than one foot above the river. Bank riparian habitat was modeled using slope less than 5 percent and height above river less than 5 feet. All wetland and riparian area estimates were combined into one estimate of wetland/riparian acreages for planning purposes (Reclamation 2011).

With implementation of the Reservoir Area Management Plan (Reclamation 2011), permanent wetland loss at the reservoirs would be reduced. Table 3.5-5 provides the

acreages of historic and existing wetlands and wetland/riparian habitat to be restored at each reservoir.

Table 3.5-5. Estimates of Historic, Existing and Future Wetlands at the Reservoirs

Reservoir	Historic Wetland Habitat (PacifiCorp 2004a)	Existing Wetland Habitat (PacifiCorp 2004a)	Wetland/Riparian Habitat to be Restored** (Reclamation 2011)
J.C. Boyle	12.1	105.1	52
Copco 1*	20.3	79.2	170
Iron Gate	2.5	60.1	50
Total	34.9	244.4	272

Notes:

*PacifiCorp 2004a considered Copco 1 and Copco 2 Reservoirs together

**Acreages were estimated for wetland and riparian habitat together.

Estimates are preliminary and not based on jurisdictional wetland delineations. Acreages will be revised based on jurisdictional wetland delineations to be conducted for the Clean Water Act 404 permit once the Definite Plan is available.

Figure 3.5-6, Figure 3.5-7, and Figure 3.5-8 depict restored wetland and riparian habitat at J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir, respectively, following implementation of the Reservoir Area Management Plan (Reclamation 2011). Restored wetland and riparian habitats would be supported by the natural hydrological processes of the river channel and would be similar to those that existed historically, as depicted in Figure 3.5-3, Figure 3.5-4, and Figure 3.5-5. Restored wetlands would also benefit from marine-derived nutrients in salmon and other anadromous fish that would have access to Klamath River reaches within the project area once the dams are removed.

Dam removal would not result in impacts on wetland habitats located in other reaches of the Klamath River, including 14.1 acres along the J.C. Boyle bypass reach, 89.9 acres along the J.C. Boyle peaking reach, 13.5 acres along Fall Creek, and 4.5 acres along the Copco 2 bypass reach. In contrast, wetlands would benefit from increased water availability under the Proposed Action, particularly in areas such as the J.C. Boyle bypass reach where water availability is currently limited.

Impacts on wetlands under the Proposed Action would be a significant impact because of the historical loss of wetlands and the regulatory framework of laws and regulations for wetland protection. **Mitigation Measure *TER-5* would reduce this impact on wetlands to less than significant.** See Section 3.5.4.4.

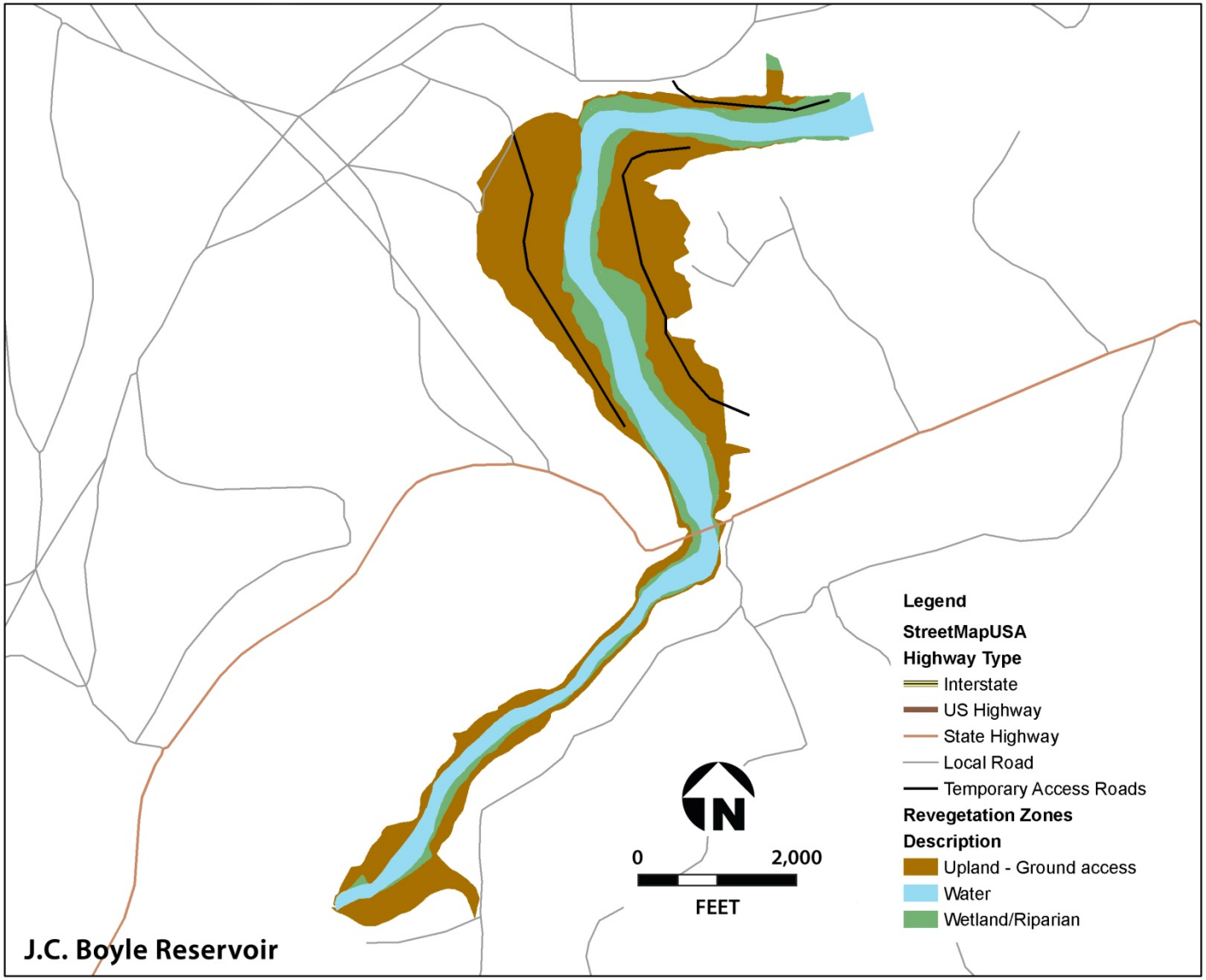


Figure 3.5-6. J.C. Boyle Reservoir Revegetation.

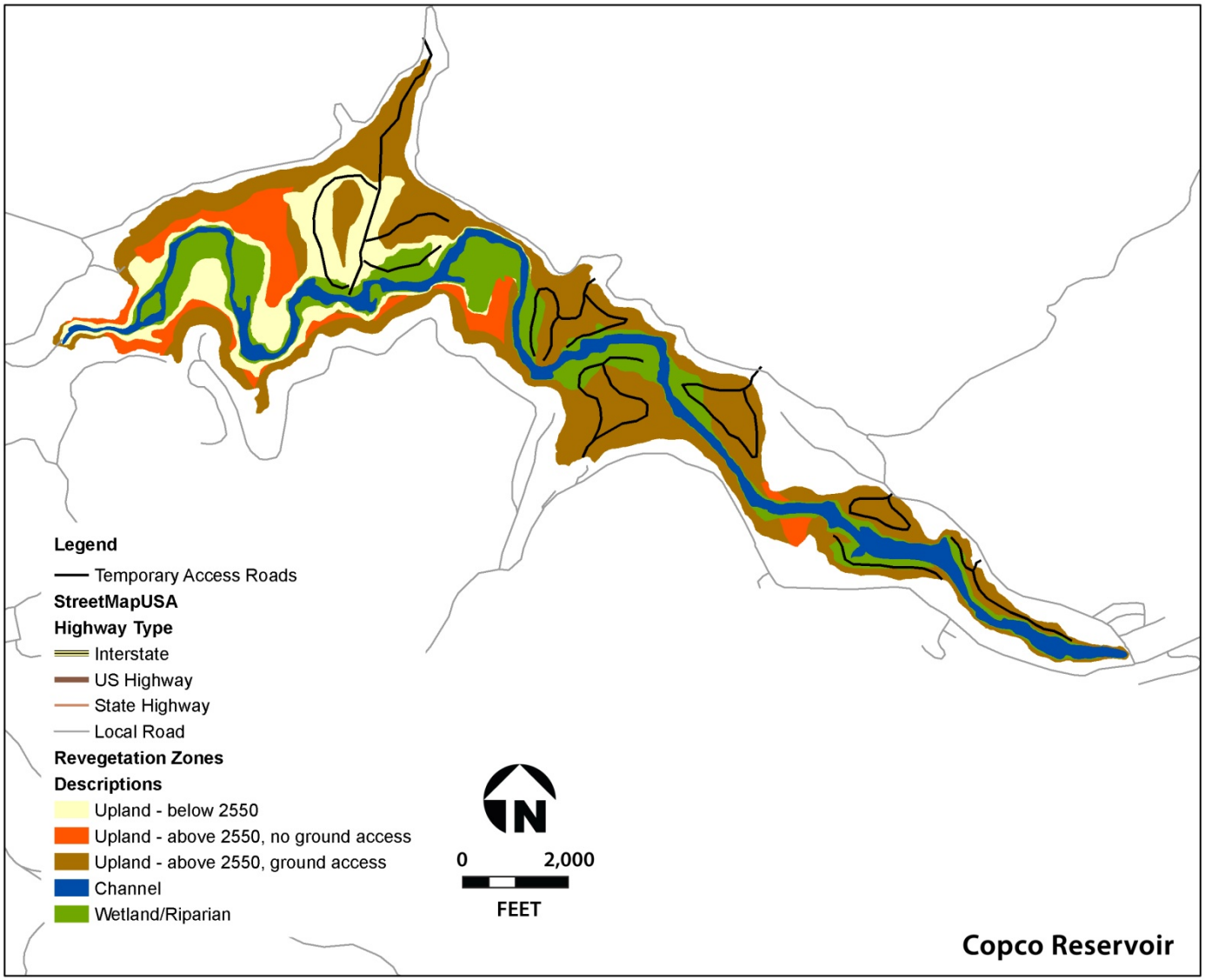


Figure 3.5-7. Copco Reservoir Revegetation.

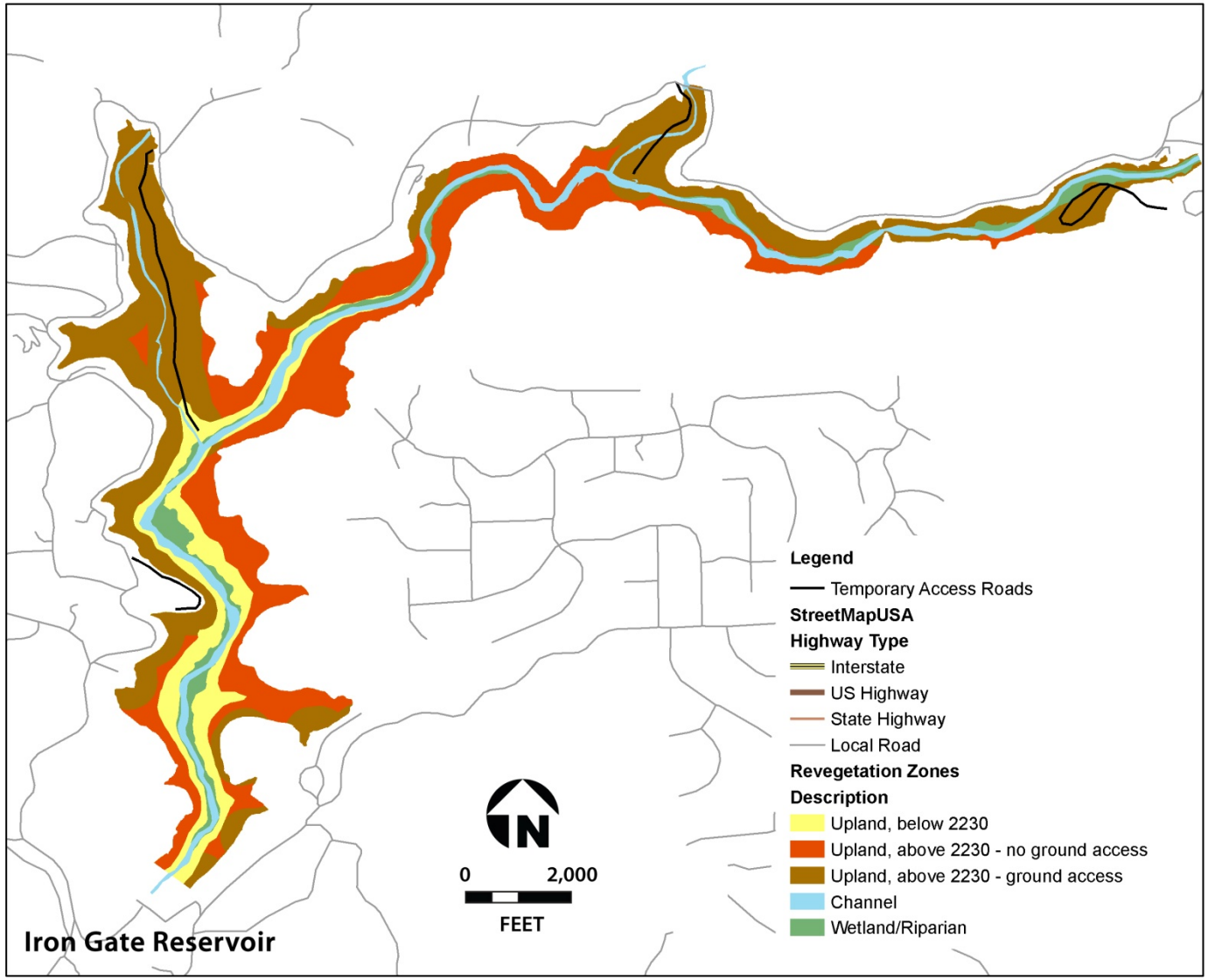


Figure 3.5-8. Iron Gate Reservoir Revegetation.

Long-term Impacts on Wildlife Habitat from Tree and Vegetation Removal

The Proposed Action would result in long-term impacts on wildlife habitat from tree and vegetation removal. During construction, some trees and other vegetation that provides habitat for birds and other wildlife would be removed at construction areas, upland disposal sites, equipment staging areas, and access and haul roads. Following construction, restoration of this habitat would be conducted through the planting of native vegetation in accordance with a ~~Habitat Restoration Plan~~HRP approved by the resource agencies. In addition, if known nesting trees or platforms used by osprey or other raptors (except eagles) are removed, they would be replaced on a 1:1 basis as part of the Proposed Action. No known nesting sites for bald or golden eagles or northern spotted owl would be removed under the Proposed Action; no component of suitable northern spotted owl nesting, roosting, foraging, or dispersal habitat would be modified or removed during the removal of transmission lines or installation or removal of fencing. **Therefore, long-term impacts on wildlife habitat from tree and vegetation removal would be less than significant.**

It is important to note that analysis of effects to northern spotted owl and other federally~~-~~listed species that could be affected by the Proposed Action are evaluated in a BA under Section 7 of the ~~federal Endangered Species Act~~Federal ESA. Determination of impact significance for the northern spotted owl and other federally~~-~~ listed species in this EIS/EIR is consistent with the findings of the BA.

Long-term Impacts on Wildlife Habitat from Reservoir Restoration

As part of the Proposed Action, revegetation and management of noxious and invasive weeds would occur on newly exposed land (e.g., reservoir shoreline). Long-term effects of the revegetation plan are anticipated to benefit bald or golden eagles, osprey, and northern spotted owl by enhancing future nesting, roosting, foraging, or dispersal habitat.

Northern spotted owl forage primarily on small mammals (e.g., mice, voles), golden eagles primarily on birds, reptiles, and insects, and bald eagles and osprey primarily fish, and it is plausible that the risk to these prey species may occur from direct or indirect spraying of herbicides. Herbicides will be used to control weeds through hand treatment; therefore the application is not intended to target plants or trees that currently support suitable habitat. Effects of glysophate and glyphosate-based herbicides with surfactant additives are analyzed below.

- Studies and assessments of glyphosate show ecological risks for focused, short-term eradication efforts are small (Monheit 2003).
- While highly toxic to plants, glyphosate is non-toxic to animals (Williams et al. 2000, as cited in Monheit 2003).
- Glyphosate is poorly absorbed by the digestive track and is excreted essentially unmetabolized (EXTOXNET database, Cornell University, both as cited in Monheit 2003; Williams et al. 2000).

- There is no evidence to support glyphosate is an immunotoxicant, neurotoxicant, or endocrine disruptor (Syracuse Environmental Research Associates [SERA] 2002, as cited in Monheit 2003).
- At typical application rates, none of the acute scenarios studied presented unacceptable risks to wildlife including predatory birds consuming small mammals (Bautista 2007).
- The majority of prey are arboreal and/or nocturnal and are not likely to be directly exposed to herbicides (U.S. Department of Agriculture [USDA], and U.S. Forest Service [USFS] 2010) and if consumption did occur, a Biological ~~Assessment~~Opinion (BO), Concurrence, and Conference Report on the Effects to 23 Species and 4 Critical Habitats from the U.S. Forest Service Pacific Northwest Region Invasive Plant Program (USFWS Reference Number 1-7-05-7-0653, as cited in USDA Forest Service. 2010) states: "The U.S. Forest Service found that the results of exposure scenarios to spotted owls indicate that no herbicide included in the Invasive Plant Program (which includes glyphosate) is likely to adversely affect spotted owls… There was no risk to spotted owls from eating contaminated small mammals because expected doses to predatory birds eating mammals for all herbicides, even with very conservative assumptions, are well below any known no observable adverse effects."

Glyphosate may be formulated with surfactants that increased efficacy. In some cases, toxicity data have indicated that surfactants added to the glyphosate are more toxic than the glyphosate itself. Studies conducted by the USDA Forest Service found no evidence that nonylphenolethoxylate-based surfactants lead to any level of concern for terrestrial wildlife (Bakke 2003, as cited in CINWECC 2004). All herbicide application would adhere to BMPs for herbicide handling as described in Appendix B. **Therefore, long-term impacts on avian habitat would be less than significant.** If another herbicide or herbicide base is chosen, it should meet similar characteristics of low toxicity to small mammals and birds.

Long-term Impacts on Bats from Loss of Roosting Habitat

The Proposed Action would result in long-term impacts on bats from loss of roosting habitat. Impacts on bats would occur from the loss of dam structures and associated facilities used as roosting habitat. Based on surveys conducted by PacifiCorp in 2003, bats roost in all four dams or in their associated facilities and structures (FERC 2007). Multi-species colonies of bats, which have been documented using these structures, are likely to contain one or more special-status bat species, and regardless of listing status, the loss of a bat colony site or adverse effects to an active colony would be a significant impact. **Mitigation Measure *TER-6* would reduce impacts on bats to less than significant.** See Section 3.5.4.4.

Long-term Impacts on Amphibian Habitat

Dam removal could result in long-term impacts on amphibians from habitat degradation due to sedimentation in downstream reaches of the Klamath River. Sediment inputs in downstream reaches could fill riffle substrate in some areas, reducing localized habitat

for the larval phases of amphibian species such as Pacific giant salamander. However, most sediment is expected to be flushed out during subsequent high flow events (Stillwater 2008, Bureau of Reclamation [Reclamation] 2011), and restoring a more natural sediment regime would be expected to benefit amphibian habitat in the long-term. In addition, removal of reservoirs would reduce populations of non-native bullfrogs which prey on native amphibians. **Therefore, long-term impacts on amphibian habitat would be less than significant.**

Long-term Impacts on Special-Status Species at the Reservoirs

The Proposed Action could result in impacts on special-status species from loss of aquatic habitat at reservoirs. Permanent loss of wetland and aquatic habitat at reservoirs would adversely affect special-status species populations that use these habitats. Specifically, western toad and western pond turtle have been documented at the four reservoirs in the project area, and over 25 species of special-status birds use aquatic and wetland habitat and the reservoirs.

Bald Eagles at the Reservoirs

Loss of aquatic habitat following reservoir drawdown would result in impacts on bald eagles that nest at the reservoirs. These eagles could use riverine habitat once the reservoirs are gone, or move to other aquatic habitat such as the large reservoirs of the NWRs. **Therefore, long-term impacts on bald eagles would be less than significant.**

Great Blue Heron Colony at Copco Reservoir

Under the Proposed Action the drawdown and conversion of reservoirs to riverine habitat may adversely affect a great blue heron colony documented at the Copco Reservoir. This colony would use riverine habitat once the reservoirs are gone, or move to other aquatic habitat nearby. **Therefore, long-term impacts on great blue heron would be less than significant.**

Special-Status Plants at the Reservoirs

Wetland habitat at reservoir margins supports several species of special-status plants (Table 3.5-4). Many of these plants, including Applegate's milk-vetch, short-podded thelypodium, Columbia yellow cress, and salt heliotrope, occur at only the Keno Impoundment which would not be drawn down under the Proposed Action. However, there is potential for special-status plants to occur at the reservoirs that would be drawn down, and therefore there would be loss of habitat for these species once the reservoirs are removed. Protocol-level surveys for special-status species would be conducted prior to construction to determine the location of special-status plants. If found, **Mitigation Measure *TER-4*** (Section 3.5.4.4) would be implemented to reduce impacts. **Therefore, long-term impacts on special-status plants would be less than significant.**

Impacts on Culturally Important Species

The Proposed Action could result in impacts on culturally important species. Willows, which are riparian-dependent plants, are culturally important to Indian Tribes who use

them for basket-making. As discussed above, riparian habitat is expected to increase in the long-term at the reservoirs, and any loss of riparian habitat from sedimentation downstream ~~of~~from the dams is anticipated to be short-term in nature. Since willows are one of the first species to re-colonize following disturbance (Riparian Habitat Joint Venture 2009), impacts on these culturally important plants are not anticipated to be significant. No effects on other culturally important plants are anticipated. **Therefore, impacts on culturally important species would be less than significant.**

Effects on Wildlife Corridors

The Proposed Action would result in impacts on wildlife corridors. The Proposed Action would be expected to provide beneficial effects on terrestrial wildlife movement. Removal of PacifiCorp structures and open water reservoirs and restoration of the pre-dam river channel would eliminate areas of wide deep water crossings that are a hindrance to large and small mammal movements from one side of the river to the other. More narrow and shallower water crossing points would be available for both large and small terrestrial species to cross the river. This would provide benefits in increasing the amount of habitat available for these species, making them less vulnerable to disease and other environmental stressors than before dam removal. Increased movement could also increase genetic diversity in previously separate populations. **Therefore, the Proposed Action would result in beneficial effects on wildlife corridors.**

Effects Related to Invasive Plant Species

The Proposed Action could result in native vegetation impacts related to invasive plants. Under the Proposed Action, there would be potential for invasive plant species to quickly re-colonize exposed reservoir bottoms and other disturbed soil areas and out-complete native plants. In addition, invasive plant seeds could be transported to downstream areas following removal of the dams, particularly those plants that disperse by water (Nilsson et al. 2010, Merritt ~~&~~ and Wohl 2002, ~~Meritt et al. 2010,~~ Merritt ~~&~~ and Wohl ~~2002~~2006, Merritt et al. 2010). A Reservoir Area Management Plan (~~DOI 2011a~~Reclamation 2011) would be implemented for restoration of native plants and habitat communities at the reservoirs. In addition, the ~~Habitat Restoration Plan~~HRP would be implemented for restoration of native habitats at upland areas disturbed by construction, including disposal sites, access and haul roads, and equipment staging areas. Other specific elements of construction include measures to prevent the introduction of invasive plant species. All construction vehicles and equipment would be cleaned with compressed water or air within a designated containment area to remove pathogens, invasive plant seeds, or plant parts and dispose of them in an appropriate disposal facility. Implementation of the Reservoir Area Management Plan and the ~~Habitat Restoration Plan~~HRP would include long-term maintenance and monitoring to control invasive species. See **Mitigation Measure *TER-1*** in Section 3.5.4.4.

It is noted that reed canarygrass, which is found along the margins of some of the reservoirs and in many riparian areas along the Klamath River, is an invasive plant that can colonize quickly and out-compete native plants. After draw down of the reservoirs, it is likely that populations of reed canarygrass along the reservoir margins would die (~~personal communication with R.~~ Larson~~, USFWS, March 13,~~ 2011).

In addition, seasonal high flows under the Proposed Action would contribute to improving the quality of riparian habitat in the J.C. Boyle bypass reach by decreasing the prevalence of reed canarygrass (Administrative Law Judge 2006).

Implementation measures during construction and restoration following construction in accordance with **Mitigation Measure *TER-1*** (Section 3.5.4.4) would avoid or reduce impacts related to invasive plants. **Therefore, impacts related to invasive plants would be less than significant.**

~~Installation of the Yreka Water Supply Pipeline~~
~~*The Proposed Action would require the Yreka water supply pipeline to be relocated, which could result in construction impacts on terrestrial resources.* The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the reservoir to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would either be suspended from a pipe bridge across the river near its current location, or rerouted along the underside of the Lakeview Road Bridge below Iron Gate Dam. Surveys are still required to determine if the bridge is adequate to support the pipeline and the construction traffic from the decommissioning activities. A detailed discussion of the traffic impacts and road conditions concerns is provided in Section 3.22, Traffic and Transportation, and Mitigation Measure TR-1 addresses these concerns. Construction of a pipe bridge in the existing location or placing the pipeline along an existing road and bridge would have temporary construction impacts on terrestrial resources within construction areas. Elements incorporated into construction and implementation of **Mitigation Measures *TER-1*** through ***TER-4*** (Section 3.5.4.4), as necessary, would avoid or reduce these impacts. Habitat restoration in accordance with **Mitigation Measure *TER-1*** (Section 3.5.4.4) would reduce long-term impacts in construction areas to less than significant. **Therefore, impacts on terrestrial resources would be less than significant.**~~

Replacement of the Iron Gate Fish Hatchery Water Supply Pipeline
Under the Proposed Action, the Iron Gate Fish Hatchery would remain in place, but the water supply pipeline from the penstock intake structure to the fish hatchery would be removed with the dam. Under the KHSA, PacifiCorp is responsible for evaluating hatchery production options that do not rely on the current Iron Gate Hatchery water supply. PacifiCorp is also responsible for proposing and implementing a post-Iron Gate Dam Hatchery Mitigation Plan (Hatchery Plan) to provide continued hatchery production for eight years after the removal of Iron Gate Dam; and this Hatchery Plan would be developed with information from PacifiCorp's evaluation. However, PacifiCorp is not required to propose a Hatchery Plan until six months following an ~~affirmative~~Affirmative Secretarial Determination. The Lead Agencies do not currently know what PacifiCorp will propose in the Hatchery Plan and are unlikely to know unless there is an ~~affirmative~~Affirmative Secretarial Determination. An impact analysis of a hatchery production option that does not rely on the current Iron Gate water supply would be purely speculative at this point. ~~-~~Therefore, the potential environmental effects of

implementing a hatchery production option that does not rely on the current Iron Gate water supply are not analyzed in this EIS/EIR.

Relocation of Recreation Facilities

The Proposed Action would require the relocation of existing recreation facilities, which would require the construction of new facilities along the river bank. Recreation facilities, such as campgrounds and boat ramps, currently located on the reservoir banks would be relocated down slope to be near the new river bed once the reservoir is removed. Impacts specific to the relocation of the Recreation Facilities are discussed in Section 3.20, Recreation. Temporary construction impacts on terrestrial resources could occur at the existing recreation facility sites from contact between wildlife and equipment and habitat disturbance. Elements incorporated into construction would avoid or reduce these effects, and **Mitigation Measures *TER-1*** through ***TER-4*** (Section 3.5.4.4) would be implemented, as necessary, to avoid or reduce impacts. The relocation would occur on lands that are currently inundated and provide no existing habitat to terrestrial species, and would not impede habitat restoration efforts. **Therefore, impacts on terrestrial resources would be less than significant.**

Keno Transfer

Implementation of the Keno Transfer could cause impacts to terrestrial resources. The Proposed Action includes the Keno Transfer, a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on terrestrial resources compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable laws and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and ~~***West Side***~~Westside Facility Decommissioning – Programmatic Measure

Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse effects to terrestrial resources. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA ~~will redirect~~would stop water flows currently diverted at Link River Dam into the two canals, back in to Link River. The decommissioning action would not be expected to result in the disturbance of any currently undisturbed habitat. **Therefore, implementation of the East and ~~West Side~~Westside Facility Decommissioning action would result in no change from existing conditions.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The Proposed Action would require the Yreka Water Supply Pipeline to be relocated, which could result in construction impacts on terrestrial resources. The existing water supply pipeline for Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the reservoir to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would be suspended from a pipe bridge across the river near its

current location. Surveys are still required to determine if the bridge is adequate to support the pipeline and the construction traffic from the decommissioning activities. A detailed discussion of the traffic impacts and road conditions concerns is provided in Section 3.22, Traffic and Transportation, and Mitigation Measure TR-1 addresses these concerns. Construction of a pipe bridge in the existing location or placing the pipeline along an existing road and bridge would have temporary construction impacts on terrestrial resources within construction areas. Elements incorporated into construction and implementation of **Mitigation Measures *TER-1*** through ***TER-4*** (Section 3.5.4.4), as necessary, would avoid or reduce these impacts. Habitat restoration in accordance with **Mitigation Measure *TER-1*** (Section 3.5.4.4) would reduce long-term impacts in construction areas to less than significant. **Therefore, impacts on terrestrial resources would be less than significant.**

KBRA - Programmatic Measures

Implementation of programs under the KBRA would increase the amount of water in the Klamath River and maintain the elevation of Upper Klamath Lake. Water allocations and delivery obligations would also be established for the Lower Klamath NWR and Tule Lake NWR. During implementation of KBRA actions described below, special-status species and their habitats would be protected through coordination with resource agencies for compliance with the ~~Endangered Species Act~~ESA and development of habitat conservation plans by non-~~federal~~Federal parties.

The KBRA has several programs that could result in impacts on terrestrial resources, including:

- Phases I and 2 Fisheries Restoration Plan
- Fish Entrainment Reduction
- Wood River Wetland Restoration
- Water Diversion Limitations
- On-Project Plan
- Water Use Retirement Program (WURP)
- Interim Flow and Lake Level Programs
- Mazama Forest Project

Fisheries Restoration Plan- Phase I and Phase II

Construction activities associated with the Fisheries Restoration Plan- Phase I and Phase II could result in impacts on terrestrial wildlife and/or habitat. The Fisheries Restoration Plan would include measures to restore riparian and floodplain vegetation throughout the Klamath Basin. Actions that could have impacts on terrestrial resources within the project area are described below.

Floodplain Rehabilitation

Floodplain rehabilitation may include activities such as riparian planting and understory thinning to facilitate the development of mature riparian stands. During construction, there could be adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of, and specific locations where these floodplain rehabilitation actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant. In the long term, terrestrial species that utilize riparian habitat are expected to benefit from floodplain rehabilitation and associated improvements to riparian habitat.**

Wetland and Aquatic Habitat Restoration

These activities may involve hydroseeding for creation of grass banks. During construction, there could be adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of and

specific locations where these habitat restoration actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts, and in the long term, terrestrial species that utilize wetland and aquatic habitat are expected to benefit from these habitat restoration actions. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant.**

Woody Debris Placement

These activities may involve the use of construction equipment to place large wood in the stream channel or along banks. During construction, there could be adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of, and specific locations where these woody debris placement activities could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant.**

Fish Passage Correction

These activities may include culvert upgrades or replacements. During construction, there could be adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of and specific locations where these fish passage correction actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant.**

Cattle Exclusion Fencing

This would entail the construction of fencing along riparian areas. During construction, there could be adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on

special-status plants if they occur in construction areas. The timing of and specific locations where these cattle exclusion fencing installation actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant. In the long term, terrestrial species that utilize riparian habitat are expected to benefit from the establishment of riparian vegetation.**

Mechanical Thinning and Prescribed Burning

The structure and species composition of many forested stands have been altered through fire exclusion and past and on-going timber management. This includes mixed conifer forests, oak woodlands, and aspen. The alteration of these stands has resulted in the degradation of habitat for species associated with these vegetative communities. Additionally, many of these stands exhibit high amounts of surface and ladder fuels, increasing the potential for uncharacteristically severe wildfire. The following best management practices can reduce the effects on plants and wildlife related to vegetation management:

- Small diameter thinning of overstocked upland forests to promote development of structurally diverse stands with desired species composition and variable densities, and to reduce the risk of uncharacteristically severe wildfire.
- Prescribed burning in upland forested habitats to promote the development of understory growth and reduce the amount of small to medium diameter surface fuels.
- In oak stands, small diameter thinning (typically < 9” dbh) of dense oaks to promote the development of large structurally diverse oak trees.
- Removal of encroaching juniper (up to 15” dbh).
- Installing fencing around aspen stands to exclude livestock and allow for the passive restoration of aspen trees combined with planting of native shrubs.

These activities are anticipated to result in benefits to terrestrial wildlife from ~~restoration~~ restoration of upland habitats. However, there could be adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment. There could be impacts on special-status bird species such ~~as~~ as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of and specific locations where these mechanical thinning and prescribed burning actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility

removal actions analyzed above. Measures implemented during construction as described described for the Proposed Action would avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant.**

Road Decommissioning

Construction activities associated with road decommissioning could result in adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of, and specific locations where these road decommissioning actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts, and in the long term, terrestrial species that utilize the restored habitats are expected to benefit from road decommissioning. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant.**

Gravel Augmentation

Placement of gravel in the stream using backhoes could result in adverse effects on terrestrial species, including special status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The timing of, and specific locations where these gravel augmentation actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant.**

Each of the actions under the Phase I Fisheries Restoration Plan would require separate project-level evaluations under National Environmental Policy Act (NEPA) and Federal Endangered Species Act (ESA), as appropriate.

Fish Entrainment Reduction

Construction activities associated with Fish Entrainment Reduction could result in impacts on terrestrial wildlife and/or habitat. Fish Entrainment Reduction would entail the installation of fish screens at various water diversion structures for the Klamath Reclamation Project. There could be adverse impacts on riparian vegetation and wildlife habitat within these localized construction areas. During construction, there could be

adverse effects on terrestrial species, including special-status amphibians and reptiles, from direct contact with construction equipment and loss of habitat. There could be impacts on special-status bird species such as bald and golden eagle and northern spotted owl from disturbance during nesting. There could also be impacts on special-status plants if they occur in construction areas. The geographic location and timing of fish screen installation reduces the potential for any negative terrestrial resource effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. Implementation of construction-related BMPs would occur during fish screen construction to avoid or reduce these impacts. **However, impacts would be potentially significant. Implementation of Mitigation Measures *TER- 1* through *TER- 4* would reduce these impacts to less than significant. Impacts on terrestrial resources from specific construction activities would be further analyzed as a part of future environmental compliance, as appropriate.**

Wood River Wetland Restoration

Modification of aquatic habitat from the Wood River Wetland Restoration project could result in impacts on terrestrial wildlife and/or habitat. Implementation of this project may reconnect subsided wetlands adjacent to Agency Lake to provide additional water storage. Therefore, this project is anticipated to benefit waterfowl, water birds, and other species that utilize wetlands and aquatic habitat through increased reliability of water to wetland habitat. The geographic location and timing of this project reduce the potential for any negative terrestrial resource effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. However, some adverse effects could also occur to some species, depending on whether habitats are managed as marsh or open water. **Impacts on terrestrial wildlife and/or habitat would be less than significant.**

Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Program

The Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs could result in impacts on terrestrial wildlife and/or habitat. In general, additional water supply would be expected to increase the numbers of waterfowl using the National Wildlife Refuges.

Using the Water Resource Integrated Modeling System (WRIMS), the USFWS (2010) conducted an analysis of the effects of the Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs on three NWRs (Lower Klamath NWR, Tule Lake NWR, and Upper Klamath NWR). The following paragraphs provide a summary of the findings of that analysis.

Lower Klamath NWR

<u>Impacts on Water Delivery Needed to Support Wetland Habitat</u>

Lower Klamath NWR water demand was modeled using WRIMS to estimate quantities of water delivered to the refuge under both the No Action/No Project Alternative and the Proposed Action Alternative through both the Ady Canal and D-Plant (USFWS 2010). For each time step in the model, the total refuge demand was approximated based on the

area of habitat and the water requirement for that habitat. Modeling results indicate water delivery to Lower Klamath NWR would be greater if KBRA was implemented than under the No Action/No Project Alternative. By estimating the amount of water needed per wetland habitat type, USFWS (2010) determined that the Refuge would support more wetland habitat if KBRA was implemented than under the No Action/No Project Alternative.

D-Plant pumping is critical to serving the needs of some marsh units at Lower Klamath NWR that cannot be reached from the Ady Canal. Due to recent increases in pumping costs coupled with shortages of agricultural water, D-Plant pumping, especially in the irrigation season, has been declining over time and water from D-Plant often does not arrive at Lower Klamath NWR in a timely manner and in the quantities needed (USFWS 2010). Implementation of the KBRA would allow Lower Klamath NWR water allocation to be delivered through either the D-Plant or the Ady Canal or a combination of both at the times and quantities needed for optimal management of wetland habitats (USFWS 2010).

In addition, there would be less uncertainty regarding water rights if the KBRA was implemented as compared to the No Action/No Project Alternative. Implementation of the KBRA would result in a higher potential for the NWRs to receive more water than under the No Action/No Project Alternative (USFWS 2010).

Impacts on Waterfowl

To determine impacts on migratory waterfowl, the fall carrying capacity for waterfowl on Lower Klamath NWR was approximated based on the assumption that food resources are the major component influencing waterfowl use of the refuge during the peak September and October migratory period. Estimates of food energy produced per acre in each wetland habitat type, the daily energy requirement per bird, the period of use, and the estimated acres flooded was used to determine the carrying capacity of the wetland for foraging dabbling and diving ducks. Results indicate that if the KBRA was implemented, Lower Klamath NWR would support a higher number of fall migratory dabbling and diving ducks, in addition to benefitting molting mallards, than under the No Action/No Project Alternative (USFWS 2010; Yarris et al. 1994).

Impacts on Nongame Waterbirds

An estimate of the numbers of nongame waterbirds (broadly defined as shorebirds, gulls, terns, cranes, rails, herons, grebes, egrets, and ibis) that would be supported with implementation of the KBRA was also conducted based on the approximate number of waterbirds that could be supported in late summer on the Refuge in different water year types. Using this method, the Refuge would support higher numbers of nongame waterbirds if the KBRA was implemented than the No Action/No Project Alternative. Furthermore, because wintering bald eagles in the Klamath Basin forage predominantly on waterfowl, the KBRA would result in higher numbers of wintering bald eagles than the No Action/No Project Alternative (USFWS 2010).

Impacts on Habitat Management

If the KBRA was implemented, lease land farming would continue, and 20 percent of ~~the~~ the net lease revenues would be available to the Refuge for habitat enhancement. In contrast, under the No Action/No Project Alternative, all lease revenues would ~~continue~~ continue to be under the jurisdiction of Reclamation, some of which may or may not ~~be~~ be available for habitat enhancement work on the Refuge (USFWS 2010).

Implementation of the Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs as part of the KBRA would result in beneficial effects on wetland habitat, waterfowl, nongame waterbirds, and habitat management at Lower Klamath NWR. The geographic location of Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs reduce the potential for any terrestrial resource effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. **Therefore, there would be beneficial effects on terrestrial resources from implementation of KBRA at Lower Klamath NWR.**

Tule Lake NWR

Impacts on Water Delivery Needed to Support Wetland Habitat

Water for wetland habitats in Sumps 1(A) and 1(B) of the Tule Lake NWR are primarily provided as return flows from private lands. With implementation of the KBRA, ~~water for refuge wetlands and agricultural habitats~~there would be ~~derived from the agricultural allocation and shortages are expected to occur relatively infrequently as~~greater flexibility in the draining and refill of Sumps 1(A) and 1(B) compared to the No Action/No Project Alternative~~, under which water shortages are expected in greater than 20 percent of years.~~ . This increased ability to manage sumps will mean improved habitat conditions for migratory waterfowl and nesting nongame birds. Thus, KBRA implementation would result in more wetland habitat than the No Action/No Project Alternative (USFWS 2010).

Impacts on Waterfowl

Waterfowl use of the refuge currently depends upon wetland habitats provided in Sumps 1(A) and 1(B) and the "Walking Wetlands" program, which incorporates wetlands into commercial crop rotations, and food provided from Refuge agricultural lands (USFWS 2010). If the KBRA was implemented, there would be less uncertainty in agricultural water deliveries to Refuge wetlands and agricultural lands than under No Action/No Project. There would also be more certainty in water for the "Walking Wetlands" program that provides wetland-related food and habitats for migratory dabbling ducks and geese. Therefore, if KBRA were implemented there would be more wetland habitat and food resources for migratory waterfowl (USFWS 2010). In contrast to the Upper Klamath, due to the change in the water regime with the KBRA, there would be a benefit to molting mallards (Yarris et al. 1994).

Impacts on Nongame Waterbirds

Nongame waterbirds are dependent on wetland habitats on Tule Lake NWR, which are dependent on agricultural return flows. Increased certainty of agricultural water deliveries with implementation of the KBRA would therefore have a beneficial effect on

wetland habitats and the nongame waterbirds that depend on them than the No Action/No Project Alternative (USFWS 2010).

Impacts on Habitat Management

With implementation of the KBRA, there would be less uncertainty in the ability to manage Sump 1(B) than under No Acton/No Project. In addition, 20 percent of the net lease revenues to the Refuge would be available for habitat enhancement with KBRA implementation (USFWS 2010).

Implementation of the Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs as part of the KBRA would result in beneficial effects on wetland habitat, waterfowl, nongame waterbirds, and habitat management at Tule Lake NWR. The geographic location of Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs reduce the potential for any terrestrial resource effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. **Therefore, there would be beneficial effects on terrestrial resources from implementation of KBRA at Tule Lake NWR.**

Upper Klamath NWR

Impacts on Wetland Habitat from Water Delivery

Based on modeled water elevations for future years, water elevations in Upper Klamath Lake would be low enough to leave refuge wetlands dry during the fall migration period (September-October) in 82 percent of years with implementation of the KBRA as compared to 68 percent of years under the No Action/No Project Alternative (USFWS 2010). Thus implementation of the KBRA ~~would actually~~could be an adverse impact compared to the No Action/No Project Alternative~~, if no~~; however, other measures ~~are taken~~described below would provide benefits to offset these potential issues..

Impacts on Waterfowl

Male and female mallards molt at slightly different times of the year and mallards of both sexes depend on wetlands to escape predators during molting. Male mallards begin the molt in mid July with females initiating the molt approximately 30 days later. During the 30 day molting period, mallards (and other waterfowl species) lose all wing feathers and are incapable of flight. Dry conditions can have an adverse effect on the survival of individuals. Based on modeled Upper Klamath Lake elevations, under the KBRA Alternative water is present in refuge wetlands in all but 3 percent of future years in July and 38 percent of future years in August. Under the No Action Alternative/No Project Alternative, refuge wetlands become dry more often in July (20 percent of years), and August (59 percent of years). Thus, implementation of the KBRA would have a beneficial effect on molting male mallards in July and August compared to conditions under the No Action/No Project Alternative.

For female mallards, the effect is somewhat reversed, since refuge wetlands would be dry in a higher proportion of years in September with KBRA implementation (82 percent of years) compared to the No Action/No Project Alternative (68 percent of years). It is important to note that breeding mallards are monogamous and females (due to lower survival rates) form a smaller proportion of the population. Thus, the welfare of female

mallards is more important to the viability of the species and this represents an adverse impact of KBRA implementation compared to the No Action/No Project Alternative (USFWS 2010). In addition, due to the large concentration of diving ducks and marine ducks in fall and winter, there may also be concern for effects of the KBRA on diving ducks and marine ducks in the fall and winter.

Impacts on Nongame Waterbirds

With KBRA implementation, water elevations in Upper Klamath Lake would be sufficient to support breeding nongame waterbirds in a higher number of future years than under the No Action/No Project Alternative. The primary breeding period for nongame waterbirds extends from March through July. For successful breeding, refuge wetlands must remain flooded during this time period. With KBRA implementation, water would be present in Refuge wetlands during more of this period than without KBRA implementation (USFWS 2010).

Implementation of the Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs as part of the KBRA would result in beneficial effects on nongame waterbirds at Upper Klamath NWR. The geographic location of Water Diversion Limitations, On-Project Plan, WURP, and Interim Flow and Lake Level Programs reduce the potential for any negative terrestrial resource effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. **While there is potential for adverse impacts on wetland habitat and some waterfowl, there would beneficial effects on other waterfowl and nongame waterbirds as compared to the No Action/No Project Alternative. Combined, these impacts would be less than significant.**

Juniper Removal under WURP

The WURP program could include juniper removal in order to increase inflow to Upper Klamath Lake. ~~-~~There could be adverse impacts on certain terrestrial wildlife, including nesting migratory birds, from removal of juniper trees; however, juniper removal would likely benefit other terrestrial wildlife species. The geographic location and timing of these juniper removal actions reduce the potential for any negative terrestrial resource effects generated by this action from contributing to the effects of the hydroelectric facility removal actions analyzed above. Measures implemented during construction as described for the Proposed Action would avoid or reduce this impact; however, this impact would be potentially significant. **Implementation of Mitigation Measure *TER-2* would reduce this impact to less than significant.**

~~-~~In the long-term, WURP is anticipated to result in long-term benefits to terrestrial wildlife, particularly waterfowl and waterbirds that utilize Upper Klamath Lake.

Mazama Forest Project

The Mazama Forest Project could result in adverse impacts on terrestrial resources. The Mazama Forest Project would transfer 90,000 acres of privately owned timberland back

to the Klamath Tribes. With ownership of the lands, the tribe could hunt, harvest timber, or use the land for other purposes. Additionally the Mazama Forest Project would not be

expected to contribute to any terrestrial resource effects generated by the hydroelectric facility removal action. **No changes to existing conditions for terrestrial resources are anticipated.**

3.5.4.3.3 Alternative 3: Partial Facilities Removal of Four Dams

Under the Partial Facilities Removal of Four Dams Alternative, only the primary structure of the four dams would be removed, while auxiliary dam and hydroelectric features would remain in place. Drawdown of reservoirs would still occur and sediment behind the dams would be flushed downstream by river flows. Following partial facilities removal, riverbank stabilization and replanting activities would be conducted and the KBRA would be fully implemented, as with the Proposed Action.

Temporary Construction Impacts

Temporary construction impacts on terrestrial resources under the Partial Facilities Removal Alternative would be very similar to those described for the Proposed Action. There would be temporary construction impacts that would adversely affect local populations of common plants and wildlife in construction areas. Elements incorporated into construction would avoid or reduce these effects. These effects would be short-term in nature and less than significant for most common species. Temporary construction impacts on special-status species would be similar to those under the Proposed Action. **Mitigation Measures *TER-1*** through ***TER-4*** (Section 3.5.4.4) would be implemented, as necessary, to avoid or reduce impacts as under the Proposed Action. **Therefore, temporary construction impacts on terrestrial resources from the Partial Facilities Removal Alternative would be less than significant.**

Long-Term Impacts

As with the Proposed Action, there would be the same adverse effects related to loss of aquatic and wetland habitat at the reservoirs under the Partial Facilities Removal Alternative. **Mitigation Measure *TER-5*** would reduce impacts from permanent loss of wetlands, if it occurs, to less than significant. **Mitigation Measure *TER-6*** would reduce impacts on bats from the loss of roosting habitat from the removal of structures to less than significant. See Section 3.5.4.4 for a description of Mitigation Measures.

As described above for the Proposed Action, there would also be benefits to wildlife from gains in upland and riparian habitat following establishment of newly planted areas and with control and monitoring of invasive plants. Riparian habitat at the reservoirs would be restored and any riparian habitat destroyed by sedimentation downstream would be expected to re-establish within a few years; therefore, impacts on riparian habitat would be less than significant. Remaining PacifiCorp facilities would still pose a barrier to terrestrial wildlife movement in some places; however, drawdown of the reservoirs would benefit some terrestrial species by eliminating those barriers. Impacts related to invasive plants at the reservoir sites and other construction areas would be reduced to less than significant with implementation of the Reservoir Area Management Plan and ~~Habitat~~

Restoration PlanHRP (**Mitigation Measure *TER-1***). **Therefore, long-term impacts on terrestrial resources from the Partial Facilities Removal Alternative would be less than significant.**

Keno Transfer
The effects of the Keno Transfer would be the same as those described for the Proposed Action.

East and ~~***West Side***~~Westside Facility Decommissioning – Programmatic Measure
The effects of the East and ~~West Side~~Westside Facilities removal would be the same as those described for the Proposed Action.

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure
The effects of the Yreka Water Supply Pipeline relocation would be the same as those described for the Proposed Action.

KBRA – Programmatic Measures
The Partial Facilities Removal Alternative would include full implementation of the KBRA. Therefore, impacts and benefits related to KBRA actions would be the same as under the Proposed Action, discussed above.

3.5.4.3.4 Alternative 4: Fish Passage at Four Dams
Under the Fish Passage at Four Dams Alternative, all four dams and hydroelectric facilities would remain in place and fish passage facilities would be constructed around each. Reservoirs would remain in place. The KBRA would not be implemented.

The provisions of the USFWS Biological Opinion (USFWS 2007) for the relicensing of the Klamath Hydroelectric Project may be in effect under the Fish Passage at Four Dams Alternative. These include a number of environmental measures to address impacts on terrestrial resources. One is a vegetation resource management plan for restoration of disturbed sites and riparian habitat restoration, protection of special-status plants, and long-term monitoring. In addition, a wildlife resource management plan would be required to provide: wildlife crossings, deer winter range management, a plan to address avian electrocution hazards, amphibian breeding habitat, bald eagle and osprey habitat, road closures, turtle basking sites, bat roosting structures, surveys for special-status species, and long-term monitoring (USFWS 2007).

Temporary Construction Impacts
Short-term construction activities would occur associated with the installation of fish passage at the four dams. Construction areas would likely be similar to, but smaller than those required for demolition of all four dams under the Proposed Action or the Partial Facilities Removal Alternative. The same or similar elements would be incorporated into construction activities to avoid or reduce impacts on wildlife and plants, including special-status species, and sensitive habitats. **Mitigation Measures *TER-1*** through ***TER-4*** (Section 3.5.4.4) would be implemented, as necessary, to avoid or reduce impacts as under the Proposed Action. **Therefore, temporary construction impacts on terrestrial resources from the Fish Passage at Four Dams Alternative would be less than significant.**

Long-Term Impacts

Under the Fish Passage at Four Dams Alternative, reservoirs would remain in place and there would be no anticipated sedimentation in downstream reaches that would affect riverine areas. As with the No Action/No Project Alternative, the KBRA would not be implemented under the Fish Passage at Four Dams Alternative. Therefore, there would continue to be uncertainty regarding water deliveries to the NWRs, and subsequent impacts on terrestrial resources within the Lower Klamath NWR, Tule Lake NWR, and Upper Klamath NWR.

Although detailed plans are not yet available, construction of the fish passage facilities would not likely result in permanent loss of wetlands. There would also be no anticipated long-term impacts on terrestrial wildlife, including special-status species, from operation of the fish passage facilities. Existing barriers to terrestrial wildlife movement presented by the dams and associated facilities would remain. There would be potential for impacts related to invasive species in areas disturbed by construction, although much less so than under the Proposed Action, the Partial Facilities Removal Alternative, and the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative where reservoirs are drawn down. Implementation of the ~~Habitat Restoration Plan~~HRP (**Mitigation Measure *TER-1*** (Section 3.5.4.4) in construction areas would avoid or reduce impacts related to invasive species. **Therefore, long-term impacts on terrestrial resources from the Fish Passage at Four Dams Alternative would be less than significant.**

3.5.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative includes the removal of two of the Four Facilities (Copco 1 and Iron Gate). Copco 1 Reservoir and Iron Gate Reservoir would be drawn down. This alternative also includes development and/or improvement of fish passage at Copco 2 and J.C. Boyle Dams. Since the J.C. Boyle and Copco 2 Reservoirs store much less sediment than do the Copco 1 and Iron Gate Reservoirs, the amount of sediment released to the river system would be similar under the Fish Passage at Two Dams Alternative as under the Proposed Action.

Temporary Construction Impacts

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative there would be temporary construction impacts similar to those of the Proposed Action at the Copco 1 and Iron Gate facilities. Construction impacts would also occur at Copco 2 and J.C. Boyle with the construction of fish passage facilities there. Construction areas would likely be smaller than those required for demolition of all four dams under the Proposed Action or the Partial Facilities Removal Alternative. The same or similar elements would be incorporated into construction activities to avoid or reduce impacts on wildlife and plants, including special-status species, and sensitive habitats. **Mitigation Measures *TER-1*** through ***TER-4*** (Section 3.5.4.4) would be implemented, as necessary, to avoid or reduce impacts as under the Proposed Action. **Therefore, temporary construction impacts on terrestrial resources from the Fish Passage at**

J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less than significant.

Long-Term Habitat Loss and Modification

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, two reservoirs would remain in place and two would be drawn down. As with the No Action/No Project Alternative, the KBRA would not be implemented under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative. Therefore, there would continue to be uncertainty regarding water deliveries to the NWRs, and subsequent impacts on terrestrial resources within the Lower Klamath NWR, Tule Lake NWR, and Upper Klamath NWR.

Although detailed plans are not yet available, construction of the fish passage facilities would not likely result in permanent loss of wetlands. **Mitigation Measure *TER-5*** (Section 3.5.4.4) would reduce impacts from permanent loss of wetlands, if it occurs, to less than significant. In addition, permanent loss of wetlands at Copco 1 and Iron Gate Reservoirs would be offset by restoration activities. As described above for the Proposed Action, there would also be benefits to wildlife from gains in upland and riparian habitat at Copco 1 and Iron Gate Reservoirs following establishment of newly planted areas and with control and monitoring of invasive plants.

As with the Proposed Action, there could be sedimentation in downstream reaches that would have impacts on riparian areas, although this is anticipated to be short-term and not considered a significant long-term impact (Stillwater 2008, Reclamation 2012). There would be impacts on terrestrial wildlife, including special-status species, from the loss of aquatic habitat at the Copco 1 and Iron Gate Reservoirs, but these impacts would be less than significant, as described for the Proposed Action. **Mitigation Measure *TER-6*** (Section 3.5.4.4) would reduce impacts on bats from the loss of roosting habitat to less than significant. Some vegetation that provides habitat for terrestrial species would be removed, but elements incorporated into construction and **Mitigation Measure *TER-1*** (Section 3.5.4.4) would avoid or reduce these impacts to less than significant, as with the Proposed Action. Existing barriers to terrestrial wildlife movement presented by the two remaining dams, Copco 2 and J.C. Boyle Dams, would remain. Implementation of the ~~Habitat Restoration Plan~~HRP in construction areas would avoid or reduce impacts related to invasive species. **Therefore, long-term impacts on terrestrial resources from the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less than significant.**

3.5.4.4 Mitigation Measures

3.5.4.4.1 Mitigation Measure by Consequence Summary

TER-1: Habitat ~~Restoration~~Rehabilitation Plan

To ~~restore~~ reestablish native vegetation communities and wildlife habitat in areas disturbed by construction, a ~~Habitat Restoration Plan~~HRP will be developed once the Definite Plan is prepared and construction areas are delineated. The ~~Habitat Restoration Plan~~HRP will be a stand-alone document separate from the Reservoir Area Management

Plan (DOI 2011a), whichReclamation 2011) that describes restorationrehabilitation of the reservoir areas. The Habitat Restoration PlanHRP will cover all areas disturbed by

construction, including upland sediment disposal sites, access and haul roads, pipeline corridors, and equipment staging areas. ~~The~~ Habitat ~~Restoration Plan will include maintenance and monitoring requirements to be conducted for a minimum~~rehabilitation of ~~three years following hydroseeding and/or planting of native species in areas disturbed by~~ construction~~. Measures to remove and control noxious weeds and other invasive plants~~ areas will take place in three general phases:

Phase 1: Rehabilitation/re-grading of site to restore pre-disturbance topography. Where present, topsoil and subsoil will be salvaged and replaced. The seedbed will be ~~included. The Habitat Restoration Plan will outline~~prepared to optimize plant establishment and physically stabilize the ~~performance standards~~site against erosion during the plant-establishment period. This process will include soil decompaction to prepare site for planting.

Phase 2: Establishment of a certified weed-free erosion-control seed mixture. Immediately following re-grading of a site and seedbed preparation, construction areas will be ~~met,~~seeded or hydroseeded (for steep slopes) prior to the rainy season with a fast-growing mixture of perennial species and an annual nurse crop (also certified weed-free). The proposed seed mixture will be from a local, native source where available and would be similar to that used by California Department of Transportation (Caltrans) on nearby rehabilitation sites. The seed mix is subject to approval by the appropriateStateor Federal agency. The standard Caltrans mix for the area includes the following species:

California brome (*Bromus carinatus*)
Squirrel tail (*Elymus elymoides*)
Barley (*Hordeum vulgare*)
Common yarrow (*Achillea millefolium*)
Silver bush lupine (*Lupinus albifrons*)
Antelope bitterbrush (*Purshia tridentata*)
California poppy (*Eschscholzia californica*)

Phase 3: Long-term Habitat Rehabilitation. A reference site of suitable size will be selected for each rehabilitation area to reflect pre-disturbed, native conditions with low to no cover of invasive species. The reference site will be located nearby to and consist of the same vegetation community and similar slope, aspect, and other physical features of the construction area. Rehabilitation of construction areas will be based on the percent of native plant cover, density, and richness found at the reference sites. Construction areas will be re-vegetated with seeding and installation of container plants (for shrubs) of native species. Where possible, seeds of native species will be collected from reference sites. Otherwise, seeds will be obtained from a local native seed supplier. In addition to the use of reference sites, aerial images of the impact sites will be collected prior to disturbance as an additional measure to meet rehabilitation goals.

A Maintenance and Monitoring Plan will be implemented to measure success of long-term rehabilitation as compared to reference sites. Maintenance and monitoring will be

conducted on average bi-weekly during the first six months following seeding, monthly during the next six months, bi-monthly during the next year, quarterly for years 2 and 3 of the 3-year maintenance period.

Maintenance activities will include removal of invasive, noxious, and other undesirable plants listed by the California Invasive Plant Council, California Department of Food and Agriculture, Oregon Invasive Species Council, Oregon Department of Agriculture (ODA), and local resource agency lists. Invasive, noxious, and other undesirable plants will be controlled using mechanical methods such as discing, mowing, and hand-weeding, and chemical herbicides where deemed appropriate in coordination with local resource agencies.

Monitoring will consist of qualitative characterization based upon visual analysis of the rehabilitation area and will focus on soil conditions (moisture and fertility), seed germination, presence of native and invasive/non-native species, and any problems (erosion, disease, pests) and the corrective actions to be taken~~if performance standards~~.

Following the maintenance period, the sites will be monitored annually to ensure that rehabilitation goals are ~~not~~being met. Due to the arid environment and low annual precipitation, plant growth rate is slow in and around the project area and vegetation development is expected to be relatively slow as well. Qualitative and quantitative monitoring will be conducted yearly after the growing season for measures including plant cover and density. Cover, density, and species richness will be calculated for the rehabilitated area and compared to the data collected from the reference sites. Rehabilitation goals will be as follows:

1. Establishment Period: Years 1 and 2

Assessment Schedule and Technique: Qualitative estimate made through visual reconnaissance of the reclaimed area at the end of each growing season.

- Cover of Seeded Plant Species: >75% of cover at reference site.
- Density of Seeded Plant Species: either >5 plants/ft^2 or >25% of the density at reference site.
- Native Species Richness: 5 plant species with >1% cover or >25% of the richness at reference site.
- Control of Invasive, Noxious, and Undesirable Species: 76-90%

Maintenance: Noxious and undesirable weed control and use of engineered best management practices for erosion control.

Compliance: When goals are met~~.~~, 80% of reclamation bond or retainage is released.

2. Monitoring Period: Years 3 to 5, or until performance criteria are met.

Assessment Schedule and Technique: Qualitative estimate made through visual reconnaissance of the reclaimed area during year 3 and 4, and quantitative measurements made after the 5th growing season using permanently staked transects.

- Cover of Seeded Plant Species: >75% of the amount of cover at reference site.
- Density of Seeded Plant Species: either >5 plants/ft^2 or >50% of the plant density at reference site.
- Native Species Richness: 5 plant species with >1% cover or >50% of the richness at reference site.
- Control of Invasive, Noxious, and Undesirable Species: 90-100%

Maintenance: Noxious and undesirable weed control and use of engineered best management practices for erosion control.

Compliance: When goals are met, 90% of reclamation bond or retainage is released.

TER-2: Nesting Bird Surveys[7]

If, during preconstruction surveys, an active nest of a special-status bird species (e.g., northern spotted owl, osprey, willow flycatcher) or migratory bird is identified, a restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed from construction. This may include evaluation of noise levels at the nesting site for special-status species such as northern spotted owl. Once the Definite Plan is prepared and construction areas are delineated, detailed plans for nesting bird surveys and measures to be implemented if active nests are found will be developed in consultation with USFWS, ODFW, and CDFG. See **Mitigation Measure *TER-3*** for mitigation related to bald and golden eagles.

Table 3.5-~~5~~6 lists the restriction buffers for many common raptor species with potential to occur within or near construction areas. This information was provided by USFWS (Strassburger 2011). *Buffer zones* are defined as seasonal or spatial areas of inactivity in association with individual nests or nesting territories. *Spatial buffers* are defined as radii from known occupied and unoccupied nest sites. *Seasonal buffers* are restrictions on the times when human activities may occur within the spatial buffers (USFWS 2002). All restriction buffers would be established as appropriate and in consultation with USFWS, ODFW, and CDFG.

[7] The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in ~~Appendix~~ Appendix B.

Table 3.5-~~5.~~6. No Surface-Disturbing Activity Spatial Buffers and Seasonal Timing Restriction Stipulations for Raptor Nests

Species	Spatial Buffer (miles)	Seasonal Timing Restriction
Bald eagle	1.00	Jan 1 – Aug 31
Golden eagle	1.00	Jan 1 – Aug 31
Northern goshawk	0.75	March 1 – Aug 15
Northern harrier	0.75	April 1 – Aug 15
Cooper's hawk	0.75	March 15 – Aug 31
Ferruginous hawk	1.00	March 1 – Aug 1
Red-tailed hawk	0.75	March 15 – Aug 15
Sharp-shinned hawk	0.75	March 15 – Aug 31
Swainson's hawk	0.75	March 1 – Aug 31
Turkey vulture	0.75	May 1 – Aug 15
Peregrine falcon	1.00	Feb 1 – Aug 31
Prairie falcon	0.75	April 1 – Aug 31
Merlin	0.75	April 1 – Aug 31
American kestrel	0.05 (300 feet)	April 1 – Aug 15
Osprey	0.75	April 1 – Aug 31
Burrowing owl	0.25 to 0.75	March 1 – Aug 31
Flammulated owl	0.75	April 1 – Sept 30
Great horned owl	0.75	Dec 1 – Sept 30
Long-eared owl	0.75	Feb 1 – Aug 15
Northern saw-whet owl	0.75	March 1 – Aug 31
Short-eared owl	0.75	March 1 – Aug 1
Northern pygmy-owl	0.75	April 1 – Aug 1
Western screech-owl	0.75	March 1 – Aug 15
Barn owl	0.062 to 0.25	Feb 1 – Sept 15

Source: USFWS 2002

When active raptor nests (with eggs or young) are located within the disturbance buffer for that species, and if construction is scheduled to occur in the vicinity during the nesting period, then additional considerations will include the following:

- Line-of-sight considerations- if the nest is visually obscured from construction activities by substantial vegetation (i.e., a forest or woodlot), or by geographic relief (e.g., a ridgeline), or any other type of visual barrier, then construction may continue. However, the nest will be monitored continuously throughout the nesting season to assure that the birds are not disturbed to a level that jeopardizes or alters the outcome of the nest. Initially, the birds will be monitored for signs of

disturbance, and bird behavior will be compared to pre-construction levels. Monitoring in these cases will include determining and reporting to USFWS the ultimate fate of the nest. Birds nesting in locations that are visually protected from the construction site are not automatically protected from disturbance; their level of response to disturbance will depend on the species, tolerances of individual birds, type of activity, noise level, and distance from the activity. If birds appear to be disturbed by construction, regardless of species, then the USFWS Migratory Bird Program will be contacted to seek solutions to this issue.

TER-3: Impacts to Nesting Habitat of Bald and Golden Eagle and Other Migratory Birds[8]

Mitigation to reduce impacts on Bald and Golden Eagle and Other Migratory Birds from loss of nesting habitat will include the following measures described below. This information was provided by USFWS (Strassburger 2011):

- Complete a two-year survey for bird use patterns prior to construction activities. Surveys will be conducted by a qualified avian biologist and will include any facilities to be removed or modified to determine bird use patterns. Surveys will be conducted during the time of year most likely to detect bird usage;

- Before approval of any site specific implementation plan, develop an Eagle Conservation Plan in coordination with USFWS;

- If deemed necessary and before approval of any site specific implementation plan, a permit from the USFWS will be obtained if project activities are anticipated to result in take under the Bald and Golden Eagle Protection Act.

Mitigation to Avoid Mortality and Disturbance
If surveys indicate part of the construction footprint or facilities slated for removal is utilized by bald or golden eagle or other migratory bird, then these mitigations will be employed to minimize disturbance and mortality to those birds:

- Where ever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January 15 through August 15);

- Where clearing, cutting, and grubbing work cannot occur outside the migratory bird nesting season (March 20 through August 20), a qualified avian biologist

[8] The discussion presented in this section includes both BMPs that would be incorporated during construction as well as mitigation measures in order to facilitate the development of compliance documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in ~~Appendix~~ Appendix B.

shall survey those areas to determine if any migratory birds are present and nesting in those areas;

- If nesting migratory birds/eagles are found, one of the following measures shall be taken to minimize impacts to nesting birds; 1) modification of the project footprint to avoid the nest permanently, 2) protection of the nest until the young have fledged, or 3) implementation of measures included in the Eagle Conservation Plan in coordination with USFWS.

Monitoring Measures to Determine Success and Corrective Action Measures
If project activities are anticipated to result in take under the Bald and Golden Eagle Protection Act, five years of monitoring by qualified avian biologists will be conducted following completion of deconstruction activities. The mitigation will be deemed successful if there is no net loss of eagles within the project area.

If this standard is not met, the Dam Removal Entity will consult with the USFWS and CDFG or ODFW, as appropriate, to ascertain the potential need for further mitigation.

TER-4: Special-Status Plants

Once the Definite Plan is prepared and construction areas are delineated, detailed plans for protocol-level surveys for special-status plants will be developed in consultation with USFWS, ODFW, and CDFG. If, during preconstruction surveys, any special-status plants are found to occur within the construction areas, the size and location of all identified occurrences would be mapped on the final construction plans, and impact acreages would be quantified based on proposed limits of disturbance. Compensation measures are expected to be a combination of the relocation, propagation, and establishment of new populations in conservation areas within the project site at a 1:1 ratio or at a 2:1 ratio in approved off-site habitat preservation areas, as determined in consultation with the resource agencies.

TER-5: Permanent Loss of Wetlands at Reservoirs

Under the Proposed Action, the Partial Facilities Removal Alternative, and the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, there would be loss of wetlands from the drawdown and permanent removal of reservoirs. Based on PacifiCorp surveys (PacifiCorp 2004a), there could be unavoidable impacts on ~~245~~244.4 acres of wetland habitat at the J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs, much of which would be restored with implementation of the Reservoir Area Management Plan (Table 3.5-~~2). If it is determined that under the~~ 5). In compliance with the Clean Water Act, a Section 404 Permit ~~is~~will be required~~,~~ and a Compensatory Wetland Mitigation Plan will be developed and implemented in accordance with the requirements of the United States Army Corps of Engineers (USACE~~)~~) and the Oregon Department of State Lands (DSL) in compliance with the Oregon Removal-Fill Law.

~~If one is required, the Compensatory Wetland Mitigation Plan will include creation and/or preservation of wetlands at an off-site conservation bank or other approved mitigation site in consultation with USACE and the resource agencies.~~The Compensatory

Wetland Mitigation Plan will be based on Federal and State no-net-loss policies with an emphasis on on-site and in-kind restoration and enhancement of wetlands. The Compensatory Wetland Mitigation Plan may also include creation or other potential mitigation strategies in compliance with the final 404 Permit and Oregon Removal-Fill Permit. Compensation wetlands will be required to meet or exceed the functions and quality of the wetland habitat lost at the reservoirs. A monitoring plan will be required to assess whether the compensation wetlands are functioning as intended. ~~Specific~~Based on the final 404 Permit and Oregon Removal-Fill Permit, specific performance standards for hydrologic, floral, and faunal parameters will be proposed to determine success of the ~~created wetlands.~~Compensatory Wetland Mitigation Plan. The monitoring plan would specify the corrective measures/ modifications to be implemented in the event that monitoring indicates that the performance standards are not being met. Monitoring will occur for at least five years and until success criteria are met, and as required by USACE, Oregon DSL, and the resource agencies in compliance with the final 404 Permit, Oregon Removal-Fill Permit and Federal and State no-net-loss policies.

In addition, a maintenance plan will be required ~~for the wetland preservation/mitigation areas~~as part of the Compensatory Wetland Mitigation Plan describing the measures to be implemented to assure ~~that they~~wetland habitats are maintained ~~as wetland habitat~~ in perpetuity. The maintenance plan will address buffering from adjacent uses, fencing, access erosion control, and weed eradication.

TER-6: Impacts on Special-Status Bats from Loss of Roosting Habitat

Mitigation to reduce impacts on special-status bats from loss of roosting habitat will include the following:

- For the two years immediately prior to construction activities, qualified bat biologists will conduct bat surveys at facilities to be removed or modified to determine bat use patterns. Surveys will be conducted during the time of year most likely to detect bat usage.

Mitigation to Avoid Mortality and Disturbance

If surveys indicate a facility is utilized as a bat roost, then one of two mitigations will be employed to minimize disturbance and mortality to roosting bats:

- The facility shall be removed or modified outside the bat roosting and breeding period (November 1 to March 1); or

- Bat exclusion methods to seal-up facility entry sites (e.g., blocking and netting or installing sonic bat deterrence equipment) will occur prior to March 1 of the year the facility will be removed or modified.

Mitigation for Loss of Roosting Habitat

To reduce impacts on bats from the permanent loss of roosting habitat, five free-standing bat roosts will be constructed in consultation with bat specialists and the resource agencies. Experienced contractors will perform the installation of bat roosts. The

structure will be placed in full sun at least 30 feet above ground. The structure will be concrete with high thermal mass and will meet the specifications of Bats in American Bridges (Keeley and Tuttle 1999) and California Bat Mitigation Techniques, Solutions, and Effectiveness (H.T. Harvey and Associates 2004).

Monitoring Measures to Determine Success and Corrective Action Measures

Five years of monitoring by qualified bat biologists will be conducted following installation of the bat roosts to determine the pattern and amount of use by bats. The mitigation will be deemed successful if one or more of the bat roosts, are utilized by at least 600 bats (combined use at all five facilities) as either day or night roosts, or some combination, for at least two years.

If this standard is not met, the Dam Removal Entity will consult with the USFWS and CDFG or ODFW, as appropriate, to ascertain the potential need for further mitigation.

Effectiveness of Mitigation in Reducing Consequence

Proposed mitigation measures would be effective in reducing impacts on terrestrial resources to less than significant. Effectiveness would be evaluated through monitoring incorporated into the mitigation measures. If monitoring results indicate that mitigation measures are not effective in reducing impacts, corrective action would be taken, as described in the mitigation measures.

Agency Responsible for Mitigation Implementation

The Dam Removal Entity will be responsible for implementing the mitigation measures.

Remaining Significant Impacts

With the implementation of mitigation measures, there would be no significant impacts to terrestrial resources.

Mitigation Measures Associated with Other Resource Areas

Several other mitigation measures involve construction work, including mitigation measures H-2 (flood-proof structures), GW-1 (deepen or replace affected wells), WRWS-1 (modify or screen affected water intakes), REC-1 (develop new recreational facilities and access to river), TR-6 (assess and improve roads to carry construction loads), and TR-7 (assess and improve bridges to carry construction loads). During these construction activities, there could be impacts on terrestrial resources, including impacts on special-status species, wetlands, or effects related to the spread of invasive plants. Elements incorporated into construction would avoid or reduce these effects, as described for the Proposed Action. **Mitigation Measures *TER-1*** through ***TER-5*** (Section 3.5.4.4) would be implemented, as necessary, to avoid or reduce impacts. **Therefore, impacts on terrestrial resources from mitigation measures associated with other resource areas would be less than significant.**

3.5.5 References

Administrative Law Judge. 2006. Decision in the matter of Klamath Hydroelectric Project, FERC Project Number 2082. Docket Number 2006-NOAA Fisheries Service-0001, September 27, 2006. Alameda, California. ~~Available at: http://www.fws.gov/yreka/P2082/20060927/2Klamath_DNO_Final.pdf~~ Available at: http://www.fws.gov/yreka/P2082/20060927/2Klamath_DNO_Final.pdf.

Bautista, S.L. 2007. "A summary of acute risk and four common herbicides to birds and mammals." In: Meeting the challenge: invasive plants in Pacific Northwest ecosystems. T.B. Harrington and S.H. Reichard, editors. pp. 77-82. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Bombay, H.L., Benson, T.M., Valentine, B.E., and Stefani, R.A. 2003. A Willow Flycatcher Survey Protocol for California. May.

~~California Department of Fish and Game. 2006. California Wildlife: Conservation Challenges: California's Wildlife Action Plan. Chapter 11: North Coast- Klamath Region. Prepared by the U.C. Davis Wildlife Health Center for the California Department of Fish and Game. Available at: http://www.dfg.ca.gov/wildlife/wap/report.html~~

~~California Natural Diversity Database. 2010. Administered by the California Department of Fish and Wildlife. Available on line at: http://www.dfg.ca.gov/biogeodata/cnddb/~~

~~Collom T. 2011. Oregon Department of Fish and Wildlife. Written communication with Jennifer Jones (via Chris Park), CDM. April 29, 2011.~~

~~Del Norte County. 2003. Del Norte County General Plan, Chapter 1: Natural Resources/Conservation. January.~~

~~Department of the Interior (DOI),~~ Bureau of Reclamation (Reclamation). ~~2010. Klamath River Sediment Sampling Program, Phase I – Geologic Investigations. September.~~

~~DOI, Reclamation. 2011a.~~ 2011. Reservoir Area Management Plan for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, ~~Klamath River, Oregon and California. Prepared by Scott O'Meara, Blair Greimann, and Jeanne Godaire (Reclamation), Brian Cluer (National Oceanic and Atmospheric Administration - National Marine Fisheries Service), and Renee Synder (Reclamation)~~Technical Report No. SRH-2011-19. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO.

~~DOI,~~ Reclamation. ~~2011b.~~ 2012a. "Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin

Restoration~~. April.~~," Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO.

Reclamation. 2012b. Final Biological Assessment and Final Essential Fish Habitat Fetermination on the Proposed Removal of Four Dams on the Klamath River.

Bury, R.B. and D.J. Germano. 2008. Actinemys marmorata (Baird and Girard 1852) western pond turtle, Pacific pond turtle. Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs.

California Department of Fish and Game (CDFG). 2006. California Wildlife: Conservation Challenges: California's Wildlife Action Plan. Chapter 11: North Coast-Klamath Region. Prepared by the U.C. Davis Wildlife Health Center for the California Department of Fish and Game. Available at: http://www.dfg.ca.gov/wildlife/wap/report.html

California Natural Diversity Database. 2010. Administered by the California Department of Fish and Wildlife. Available at: http://www.dfg.ca.gov/biogeodata/cnddb/.

Collom, T. 2011. Oregon Department of Fish and Wildlife. Written communication with Jennifer Jones (via Chris Park), CDM. April 29, 2011.

Del Norte County. 2003. Del Norte County General Plan, Chapter 1: Natural Resources/Conservation. January.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.

Gathard Engineering Consulting (GEC). 2006. Klamath River Dam and Sediment Investigation. Final Report to the California Coastal Conservancy and the Ocean Protection Council. November.

Green Diamond Resource Company. 2006. Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances. Prepared for National Marine Fisheries Service and U.S. Fish and Wildlife Service. ~~October.~~

~~Greimann, B.P., D. Varyu, J. Godaire, K. Russell, and Y. Lai. 2010. Draft Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. U.S. Bureau of Reclamation.~~ October.

Hamilton, J. 2011. U.S. Fish and Wildlife Service~~.~~ (USFWS). Written communication with Jennifer Jones (via Chris Park), CDM. January 7, ~~2010~~2011.

Hilderbrand, G.V., Farley, S.D., Schwartz, C.C., and Robbins, C.T. 2004. Importance of salmon to wildlife: Implications for integrated management. Ursus 15:1-9.

H.T. Harvey and Associates. 2004. California Bat Mitigation Techniques, Solutions, And Effectiveness. Prepared for California Department of Transportation Office of Biological Studies and Technical Assistance, Sacramento, California and Gene R. Trapp, Ph.D., Coordinator Professor Emeritus California State University Sacramento Foundation.

Humboldt County. 1984. Humboldt County General Plan. Volume I Framework Plan. ~~Available at: http://co.humboldt.ca.us/planning/genplan/framewk/index.htm~~ Available at: http://co.humboldt.ca.us/planning/genplan/framewk/index.htm.

Jarvis, R.L. 2002. Effects on Waterfowl of the 2001 Water Allocation Decisions. In: Water Allocation in the Klamath Reclamation Project, 2001: An Assessment of Natural Resource, Economic, Social, and Institutional Issues with a Focus on the Upper Klamath Basin. A report by Oregon State University and the University of California. December.

Karuk Tribe of California. 2003. Mid-Klamath Subbasin Fisheries Resource Recovery Plan, Working Draft. Klamath River Basin Fisheries Task Force. August.

Keeley, B~~.~~., and Tuttle, M. 1999. Bats in American Bridges. Bat Conservation International~~.~~, Inc. Resource Publication No. 4.

Klamath County. 2010. Comprehensive Plan for Klamath County. Klamath County Community Development- Planning Division. ~~Available at: http://www.co.klamath.or.us/comdevelopment/comprehensive_plan.htm~~Available at: http://www.co.klamath.or.us/comdevelopment/comprehensive_plan.htm.

Lannoo, M. (ed.) 2005. Amphibian declines. University of California Press, Berkeley, CA.

Larson, R~~.~~., and Brush, B.J. 2010. Upper Klamath Basin Wetlands: An Assessment. U.S~~.~~. Fish and Wildlife Service, Klamath Falls, Oregon.

Larson, R. 2011. U.S. Fish and Wildlife Service. Written communication with Jennifer Jones (via Chris Park), CDM. March ~~13~~14, 2011.

Leppig, G. 2010. California Department of Fish and Game. Written communication with Jennifer Jones, CDM. October 27, 2010.

Manning, J~~.~~., and Edge, W.D. 2002. Relationships Between Bald Eagle Biology and Federal Environmental Decisions on the Klamath Reclamation Project. In: Water

Allocation in the Klamath Reclamation Project, 2001: An Assessment of Natural Resource, Economic, Social, and Institutional Issues with a Focus on the Upper Klamath Basin. A report by Oregon State University and the University of California. December.

~~Nilsson C., Brown R.L., Jansson R.,~~ Merritt ~~D.M. 2010. The role of hydrochory in structuring riparian and wetland vegetation. Biological Reviews 85:837–858.~~

~~Merritt~~, D., ~~Nilsson C., Jansson R. 2010. Consequences of propagule dispersal and river fragmentation for riparian plant community diversity and turnover. Ecological Monographs, 80(4), 2010, pp 609-626. Ecological Society of America.~~

~~Merritt D.~~ and Wohl, E. 2002. Processes governing hydrochory along rivers: hydraulics, hydrology, and dispersal phenology. Ecological Applications, 12(4), 2002, pp. 1071-1087. Ecological Society of America.

Merritt, D~~.~~., and Wohl, E. 2006. Plant dispersal along rivers fragmented by dams. River Research and Applications, 22: 1-26. Whiley InterScience.

Merritt, D., Nilsson, C., Jansson, R. 2010. Consequences of propagule dispersal and river fragmentation for riparian plant community diversity and turnover. Ecological Monographs, 80(4), 2010, pp. 609-626. Ecological Society of America.

Merz, J.E., and Moyle, P.B. 2006. Salmon, Wildlife, And Wine: Marine-Derived Nutrients in Human-Dominated Ecosystems of Central California. Ecological Applications 16:999–1009.

Monheit, S. 2002. Glyphosate-based aquatic herbicides, an overview of risk. Noxious Times 4: 5–9.

Moore, J.W, Hayes, S.A., Duffy, W., Gallagher, S., Michel, C.J., Wright, D., and Jonsson, B. 2011. Nutrient fluxes and the recent collapse of coastal California salmon populations. Canadian Journal of Fisheries and Aquatic Sciences 68:1161-1170.

Nilsson, C., Brown, R.L., Jansson, R., Merritt, D.M. 2010. The role of hydrochory in structuring riparian and wetland vegetation. Biological Reviews 85:837–858.

Oregon Biodiversity Information Center. 2010. Previously known as the Oregon Natural Heritage Information Center, the Oregon Biodiversity Information Center is a program of the Institute for Natural Resources, based at Oregon State University. ~~Available on line at: http://orbic.pdx.edu/~~ Available at: http://orbic.pdx.edu/.

PacifiCorp. 2004a. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February.

PacifiCorp. 2004b. Terrestrial Resources Technical Report. Botanical and Wildlife Resources Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. October.

Point Reyes Bird Observatory. 2010. Waterbirds of the Klamath Basin. Point Reyes Bird Observatory Conservation Science. ~~Available at: http://www.prbo.org/cms/286#klamath~~ Available at: http://www.prbo.org/cms/286#klamath.

Reese, D.A., and Welsh, H.H. 1998. Habitat use by western pond turtles in the Trinity River, California. Journal of Wildlife Management 62(3):842-853.

Regional Ecosystem Office (REO). 2011. Northwest Forest Plan (NWFP) Overview-Standards and Guidelines. Available at: http://www.reo.gov/general/aboutNWFP.htm.

Riparian Habitat Joint Venture. 2009. California Riparian Habitat Restoration Handbook, Second Edition. July. ~~Available at: http://www.riverpartners.org/reports-and-articles/Restoration_Handbook_Final_Dec09.pdf.~~Available at: http://www.conservation.ca.gov/dlrp/watershedportal/InformationResources/Documents/Restoration_Handbook_Final_Dec09.pdf.

Roberts, L. 2011. U.S. Fish and Wildlife Service. Written communication with Jennifer Jones (via Chris Park), CDM. June 27, 2011.

Shafroth, P.B, Friedman, J.M., Auble, G.T., Scott, M.L., Braatne, J.H. 2002. Potential responses of riparian vegetation to dam removal. BioScience 52(8):703-712.

Shuford, W.D., Thomson, D.L, Mauser, D.M., and Beckstrand, J. 2004. Abundance, distribution, and phenology of nongame waterbirds in the Klamath Basin of Oregon and California in 2003. Point Reyes Bird Observatory Conservation Science. Report to U.S~~.~~. Fish and Wildlife Service, Klamath Basin National Wildlife Refuge Complex. July.

Siskiyou County. 1973. Conservation Element of the Siskiyou County General Plan. Siskiyou County Planning Department. ~~Available at: http://www.co.siskiyou.ca.us/PHS/planning/generalplan.aspx~~Available at: http://www.co.siskiyou.ca.us/PHS/planning/generalplan.aspx.

Stillwater Sciences. 2008. Technical Report – Klamath River Dam Removal Study: Sediment Transport DREAM-1 Simulation. Prepared for the Coastal Conservancy. October.

Stillwater Sciences. 2009. Technical Report – Effects of Sediment Release Following Dam Removal on the Aquatic Biota of the Klamath River. Prepared for the Coastal Conservancy, January.

Strassburger, M. 2011. Regional Migratory Bird Chief, U.S. Fish and Wildlife Service. Written communication with Jennifer Jones (via Chris Park), CDM. July 5, 2011.

Syracuse Environmental Research Associates (SERA). 2002. Neurotoxicity, immunotoxicity, and endocrine disruption with specific commentary on glyphosate, triclopyr and hexazinone. Final Report, TR 01-43-08-04a. Submitted to the USDA Forest Service.

U.S. Department of Agriculture (USDA), U.S. Forest Service (USFS). 2010. Biological assessment for the potential effects of invasive plant treatments on terrestrial wildlife species on the Fremont-Winema National Forests. Prepared by A. Markus, Wildlife Biologist, USDA Forest Service, Fremont-Winema National Forests, Lakeview, Oregon.

U.S. Department of the Interior (DOI), Reclamation. 2010. Klamath River Sediment Sampling Program, Phase I – Geologic Investigations. September.

U.S. Fish and Wildlife Service (USFWS). 1992. Investigations on the Lower Tributaries to the Klamath River. Klamath River Fisheries Assessment Program. Annual Progress Report FY 1991. February.
~~U.S. Fish and Wildlife Service.~~
USFWS. 2002. Utah Field Office Guidelines for Raptor Protection
From Human and Land Use Disturbances. Prepared by Laura A. Romin and James A. Muck. U.S. Fish and Wildlife Service, Utah Field Office, Salt Lake City. January 2002 update.

U~~.S. Fish and Wildlife Service.~~SFWS. 2007. Biological Opinion on the Proposed Relicensing of the Klamath Hydroelectric Project, FERC Project No. 2082, Klamath River, Klamath County, Oregon and Siskiyou County, California. Yreka Fish and Wildlife Office. Yreka, California. December.

U~~.S. Fish and Wildlife Service.~~SFWS. 2008a. Birds of Conservation Concern. U.S. Fish and Wildlife Service Division of Migratory Bird Management, Arlington, Virginia. December.

~~U.S. Fish and Wildlife Service.~~USFWS. 2008b. Final Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). USFWS Region 1, Portland, Oregon. May.

U~~.S. Fish and Wildlife Service.~~SFWS. 2009. Astragalus applegatei (Applegate's Milk-vetch)
5-Year Review Summary and Evaluation. Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon. January.

~~U.S. Fish and Wildlife Service.~~USFWS. 2010. Effects of the Klamath Basin Restoration Agreement on Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges. Prepared by Dave Mauser, Supervisory Wildlife Biologist, USFWS, Klamath

Basin National Wildlife Refuge, and Tim Mayer, Regional Hydrologist, USFWS, Water Resources Branch.

U~~.S. Fish and Wildlife Service~~SFWS. 2011. ~~Species Profile for the Siskiyou sideband (Monadenia chaceana). Available at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=G0E8~~90-Day Finding on a Petition To List 29 Mollusk Species as Threatened or Endangered With Critical Habitat. Federal Register 76: 61826-61853.

USFS and Bureau of Land Management (BLM) OR/WA. 2011a. Survey and Manage Species List: Categories from 2001 ROD, 2001-2003 ASR, and 2011 Settlement Agreement. Available at: http://www.blm.gov/or/plans/surveyandmanage/tools.php. Accessed on September 20, 2012.

USFS and BLM. 2011b. 2011 Settlement Agreement in Litigation over the Survey and Manage Mitigation Measure in Conservation Northwest et al. v. Sherman et al., Case No. 08-1067-JCC (W.D. Wash.). Available at: http://www.blm.gov/or/plans/surveyandmanage/files/20-2011_settle_agree.pdf. Accessed on September 20, 2012.

Williams, G.M., Kroes, R., and Munro, I.C. 2000. Safety evaluation and risk assessment of the herbicide roundup and its active ingredient, glyphosate, for humans. Regulatory Toxicology and Pharmacology 31: 117–165.

Yarris, G.-S., M. R. McLandress, M.R., and A. E. H. Perkins, A.E.H. 1994. Molt migration of postbreeding female mallards from Suisun Marsh, California. Condor 96:36-45.

Yurok Tribal Watershed Restoration Program. 2000. The Lower Klamath River Sub-Basin Watershed Restoration Plan. April.

Yurok Tribe Environmental Program. 2009. Klamath River Estuary Wetlands Restoration Prioritization Plan, Version 1.0. October.

3.6 Flood Hydrology

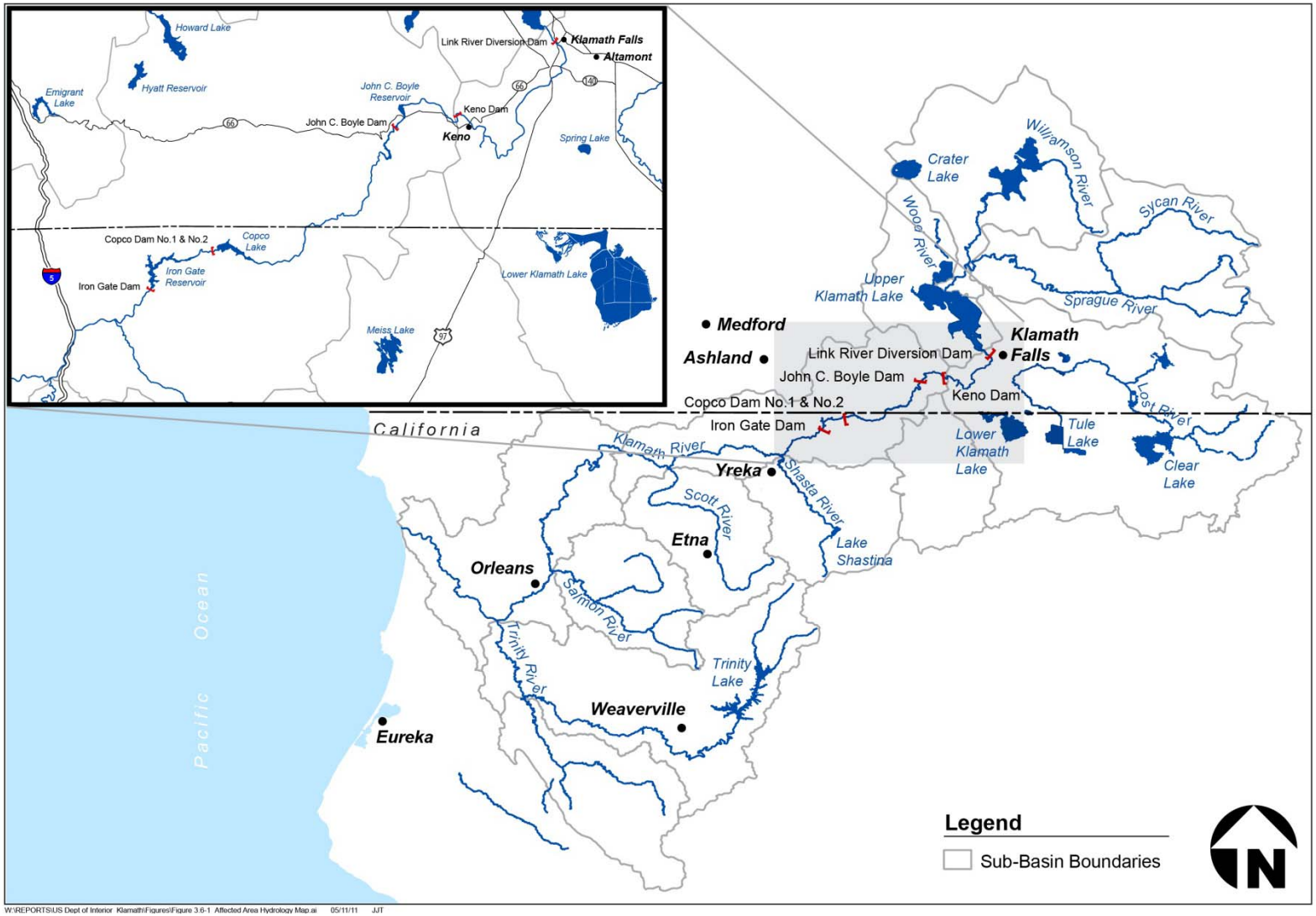
This section is focused on flooding effects from the Proposed Action and alternatives. The surface water hydrology within the Klamath Basin has a complicated and complex history; however, only elements of the hydrology related to the alternatives' potential flood impacts are described in this section. Other sections of the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) discuss groundwater (Section 3.7), water quality (Section 3.2), and water supply/water rights (Section 3.8).

3.6.1 Area of Analysis

The area of analysis for this section includes the Klamath River and tributaries that define the Klamath Basin, which lies in portions of three Oregon counties (Klamath, Jackson, and Curry) and five California counties (Modoc, Siskiyou, Del Norte, Humboldt, and Trinity). Upper Klamath Lake, formed by the Link River Dam, is in Oregon and releases water into the Link River. About one mile below the Link River Dam, the river flows into Keno Impoundment/Lake Ewauna. The Keno Impoundment/Lake Ewauna is controlled by the Keno Dam in Keno, Oregon. The Klamath River begins at the outlet of Keno Dam and flows over 250 miles into the Pacific Ocean near Klamath, California (see Figure 3.6-1).

The Upper Klamath Basin is upstream ~~from~~ of Iron Gate Dam and includes Upper Klamath Lake and its tributaries, Link River, the Keno Impoundment/Lake Ewauna, and the Hydroelectric Reach (from J.C. Boyle Dam to Iron Gate Dam). Several facilities control water supply in the Upper Klamath River, the Klamath Hydroelectric Project, and Reclamation's Klamath Project via several diversions from the Upper Klamath River (Federal Energy Regulatory Commission [FERC] 2007).

The Lower Klamath Basin includes the areas of the Klamath Basin downstream ~~of~~ from Iron Gate Dam to the Pacific Ocean. Tributaries to the Lower Klamath Basin include the Shasta, Scott, Salmon, and Trinity Rivers. The Klamath Estuary, on the northern California coast, completes the system and eventually outlets to the Pacific Ocean (FERC 2007). Section 3.6.3.2 describes basin hydrology in more detail. The areas downstream from J.C. Boyle Reservoir are discussed in more detail because they may experience project-level impacts from the Klamath Hydroelectric Settlement Agreement (KHSA) (or alternatives). Upstream areas are discussed in less detail because these areas are upstream of the proposed dam removal activities associated with the KHSA. The potential Klamath Basin Restoration Agreement (KBRA) impacts are analyzed at a program level in this EIS/EIR.



W:\REPORTS\US Dept of Interior Klamath\Figures\Figure 3.6-1 Affected Area Hydrology Map.ai 05/11/11 JJT

Figure 3.6-1. Flood Hydrology Affected Area.

3.6.2 Regulatory Framework

Flood hydrology within the area of analysis is regulated by several ~~federal, state~~Federal, State, and local laws and policies, which are listed below.

3.6.2.1 Federal Authorities and Regulations

- National Flood Insurance Program

3.6.2.1.1 National Flood Insurance Program

The National Flood Insurance Program (NFIP) is regulated by the Flood Insurance and Mitigation Administration under the Federal Emergency Management Agency (FEMA). The program was established as part of the National Flood Insurance Act of 1968 and includes three components: Flood Insurance, Floodplain Management and Flood Hazard Mapping (FEMA 2002).

Through the voluntary adoption and enforcement of floodplain management ordinances, U.S. communities participate in the NFIP. The NFIP makes available federally backed flood insurance to homeowners, renters and business owners in participating communities. The NFIP promotes regulations designed to reduce flood risks through sound floodplain management. NFIP maps identify floodplains and assist communities when developing floodplain management programs and identifying areas at risk of flooding.

In 1973, the Flood Disaster Protection Act was passed by Congress. The result of this was the requirement for community participation in the NFIP to receive ~~federal~~Federal financial assistance for acquisition or construction of buildings and disaster assistance in floodplains. It also "required ~~federal~~Federal agencies and federally insured or regulated lenders to require flood insurance on all grants and loans for acquisition or construction of buildings in designated Special Flood Hazard Areas" within participating communities (FEMA 2002).

Later, in 1994, the two acts were amended with the National Flood Insurance Reform Act, which included a requirement for FEMA to assess its flood hazard map inventory at least once every 5 years. FEMA prepares floodplain maps based on the best available science and technical information available. However, changes to the watershed or the availability of new information may cause the need for a map revision. When a revision is required, the applicable community works with FEMA to develop the map revision through a Letter of Map Amendment (LOMA) or a Letter of Map Revision (LOMR) (FEMA 2002).

In order for communities to participate in the NFIP they must adopt and enforce floodplain management criteria. The local counties in which dam removal would cause hydrologic effects, Klamath County in Oregon and Siskiyou County in California, participate in the NFIP (FEMA 2002).

3.6.2.2 Affected County Flood Codes and Ordinances

- Klamath County Code (Klamath County Land Development Code Article 59) (Klamath County)
- Siskiyou County Code (Article 54, Chapter 6) (Siskiyou County)
- Siskiyou County Code (Policy 27, Chapter 10) (Siskiyou County)

3.6.2.2.1 Klamath County, Oregon

Article 59 of the Klamath County Land Development Code includes the Flood Hazard Overlay in accordance with the NFIP. It includes provisions for development within and around designated flood hazard areas and defines those areas according to the Flood Insurance Rate Map prepared by FEMA. It also includes provisions for alterations of watercourses and waterway development that preclude any diminishment of the flood carrying capacity of a water course (Klamath County 2010a). The *Klamath County Comprehensive Plan* (2010b) establishes goals and policies for areas subject to natural disasters and hazards; this includes identifying flood prone areas on maps to protect life and property from natural disasters and hazards. The Comprehensive Plan specifies that "the County will continue to participate in the FEMA NFIP."

3.6.2.2.2 Siskiyou County, California

Siskiyou County has policies related to flood hazards within its County General Plan (1997). These policies refer to flood boundaries shown on FEMA flood hazard maps and regulate development within and near flood hazard areas (Siskiyou County 1997). Article 54 of the Siskiyou County Zoning Ordinance (Chapter 6) further defines the regulations within District F (Floodplain Combining Districts) where areas experience inundation by periodic overflow and backwater (Siskiyou County 1986). Chapter 10 of Planning and Zoning Code addresses Flood Damage Prevention and provides for requirements to notify the Federal Insurance Administration of alteration or relocation of watercourses and also addresses other issues related to Flood Damage Prevention. Land Use Policy 27 states the following:

> "No residential or industrial development shall be allowed on water bodies. Exceptions may be considered for water supply, hydroelectric power generation facilities, public works projects necessary to prevent or stabilize earth movement, erosion, and the enhancement of migratory fish and other wildlife, light commercial, open space, non-profit and non-organizational in nature recreational uses, and commercial/recreational uses." (Siskiyou County 1990)

3.6.3 Existing Conditions/Affected Environment

This section describes the hydrologic conditions of surface water and wetlands in the Klamath Basin. Figure 3.6-1 shows the area of analysis. The setting section includes a description of basin hydrology including precipitation, reservoirs, major rivers and tributaries; lakes; springs and seeps providing measurable flow; historic stream flows;

and flood hydrology. Available data of existing average daily and monthly river flows and their relationship to Reclamation's Klamath Project and PacifiCorp's Klamath Hydroelectric Project are also described throughout this section.

3.6.3.1 Historical Hydrologic Conditions

3.6.3.1.1 Pre-Dams and Pre-Klamath Project Hydrology

Several studies have been conducted to determine the natural flow conditions of the Klamath Basin hydrology (Bureau of Reclamation [Reclamation] 2005); however, these studies are limited by a lack of data. Prior to development of dams and implementation of Reclamation's Klamath Project, the Upper Klamath Basin contained lakes and large areas of marshes and wetlands. The Upper Klamath Lake was not much larger than its current size; however, Tule Lake and Lower Klamath Lake were much larger. Springs, snowmelt, and groundwater dominated rivers carrying water from the Cascades and other highlands in the Upper Basin contributed greatly to Upper Klamath Lake, the Klamath River, and the wetlands and marshes in that area (Akins 1970). The elevation of Upper Klamath Lake was originally controlled by a natural rock reef dam at the outlet of the lake. Water then flowed 1.3 miles down the Link River to Keno Impoundment/Lake Ewauna. Within this stretch of river, Keno Impoundment/Lake Ewauna developed because of a natural rock reef dam near Keno, Oregon. This was and still is the beginning of the Klamath River.

During high flow events out of Upper Klamath Lake, some water was captured and would flow down the Lost River Slough and into Tule Lake, another natural sump and wetland area. Water that flowed into the Klamath River reached another split near Keno (Akins 1970).

During flood conditions, water would also back up from the Keno Reef (near Keno, Oregon) and flow into the Klamath Straits and down to Lower Klamath Lake. The Lower Klamath Lake and Tule Lake areas once contained large areas of wetlands and marshes. The Lost River flowed from Clear Lake to Tule Lake. Now, a diversion provides water from the Lost River to the Klamath River (Akins 1970). Figure 3.6-2 shows the historic wetlands and configuration of the Upper Basin.

The presence of both historic Tule and Lower Klamath Lake influenced flows in the Klamath River. Lower Klamath Lake (approximately 30,000 acres of open water and 55,000 surface acres of marsh) was connected to the Klamath River through the Klamath Straits. When the river began to rise in the spring during high water flow events, water overflowed into this lake and marsh and, as the river fell in the fall some of the water flowed back out of the lake (Weddell et al. Undated). Lower Klamath Lake provided some short term storage by reducing the total volume of water leaving the upper watershed as well as delaying the peak flow. Tule Lake received overflow during high flow periods from the Klamath River near Klamath Falls, Oregon. Tule Lake was a terminal lake system; the overflow through the Lost River Slough reduced peak flows in the Klamath River in late winter and spring (Abney 1964).

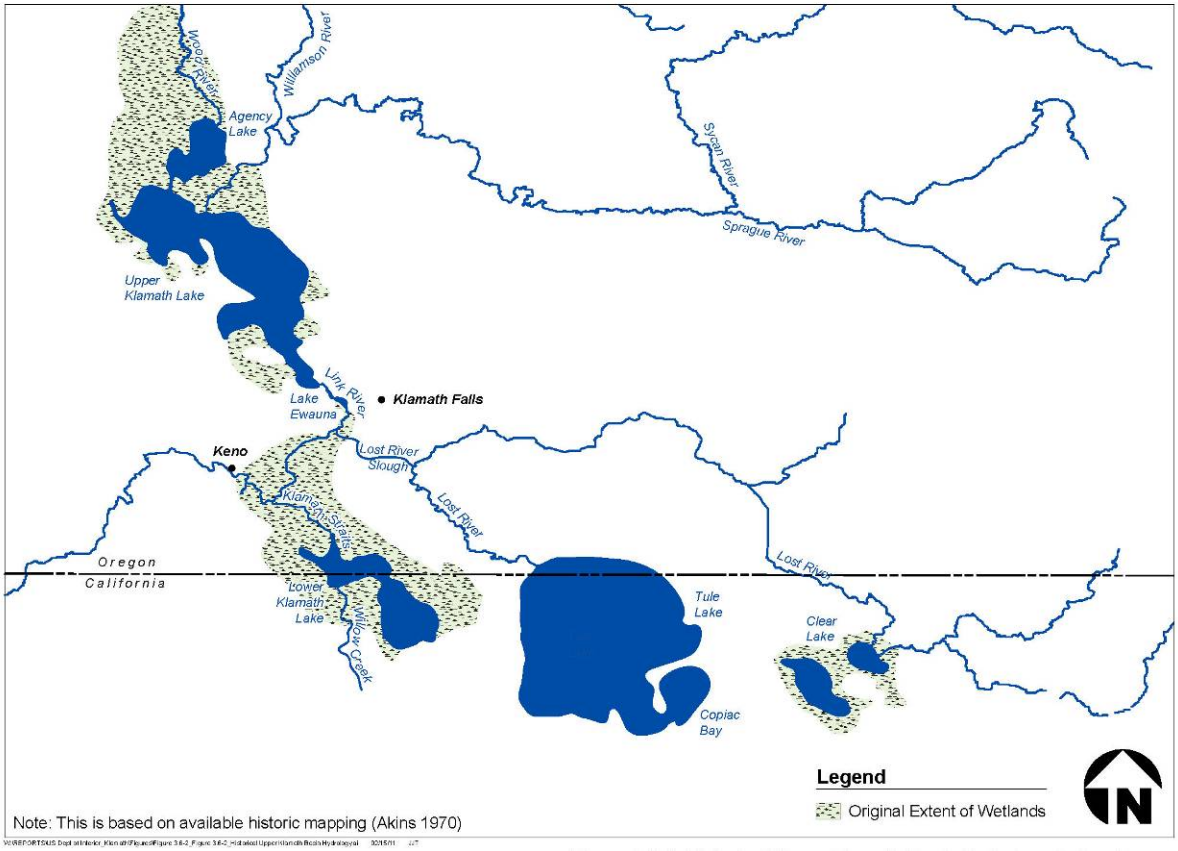
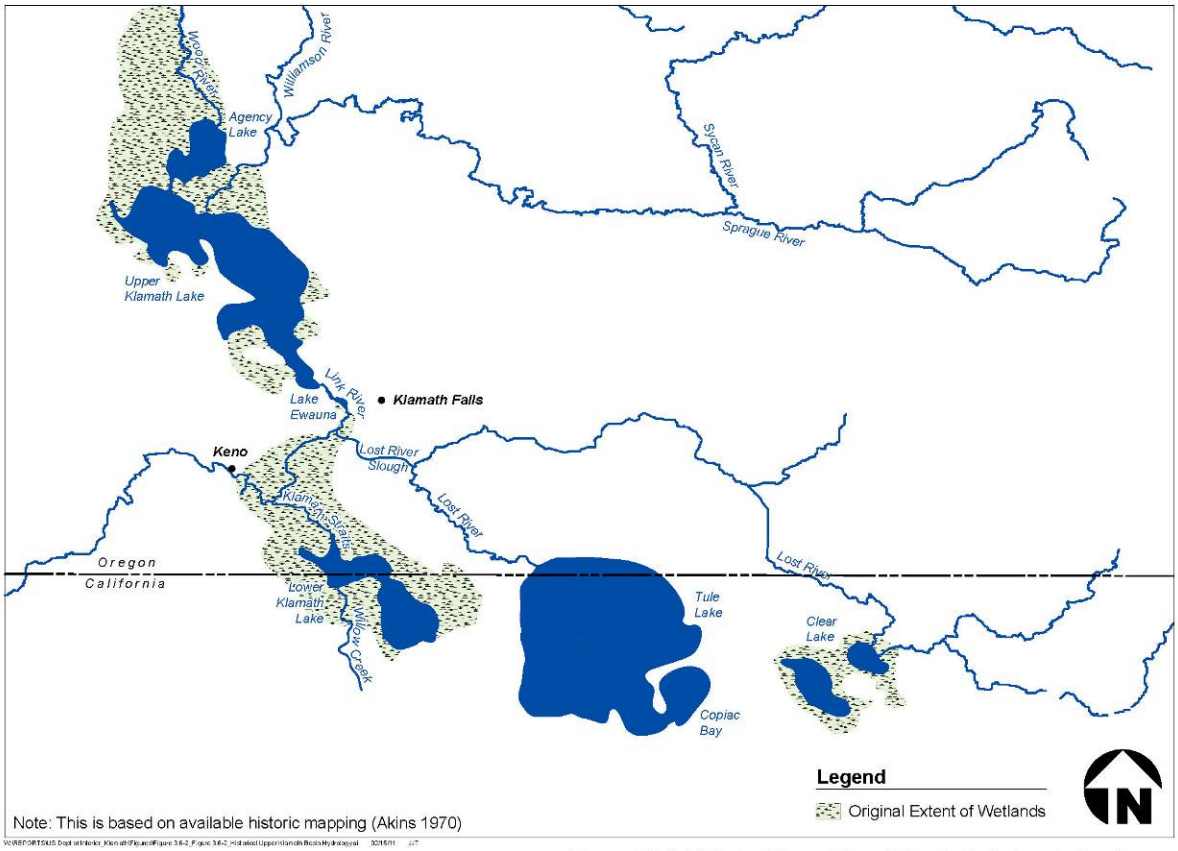


Figure 3.6-2. Historical Upper Klamath Basin Hydrology Before Dams, National Wildlife Refuges, and Reclamation's Klamath Project.

Below the Keno Reef, the Klamath River flowed freely with no dam controls. The J.C~~.~~. Boyle, Copco and Iron Gate Reservoirs did not exist. Dams along major tributaries entering the river also did not exist and the water flowed to the river, then to the Klamath Estuary and eventually to the Pacific Ocean.



~~Figure~~ 3.6-.3.1.2~~. Historical Upper Klamath Basin Hydrology Before Dams, National Wildlife Refuges, and Reclamation's Klamath Project~~

Historical Uses Affecting River Flows

During the early part of the 19th century, the Klamath Basin was home to seven Indian Tribes (see Section 3.13, Cultural and Historic Resources). These tribes depended on the Klamath River to produce salmon, steelhead, and other fish, which contributed to their survival and culture. During this time period, the river system had no dams, and the wetland areas of the ~~upper basin~~ Upper Basin including Upper Klamath Lake, Tule Lake and Lower Klamath Lake had not been altered (FERC 2007).

The discovery of gold in California in 1848 prompted a dramatic influx of European immigrants to California and other areas, including the Klamath Basin. Euroamerican settlement in the Klamath River watershed continued throughout the 19th Century.

Sustained logging enterprises appeared in the 1880s, and the first hydroelectric development in the Klamath Basin was established in 1891 in the Shasta River Canyon below Yreka Creek.

When the U.S. Congress passed the Reclamation Act of 1902 and ~~the~~ Reclamation's Klamath Project was authorized in 1905, ~~the first major~~ additional hydrologic changes to the mainstem of the Klamath Basin occurred. The Reclamation Act supported development in the "arid West" by allowing the ~~federal government~~Federal Government to fund irrigation projects (Department of the Interior [DOI] 2011b), and settlers reclaimed wetlands for agricultural use during the period of 1917 to 1949 (FERC 2007). In 1905, the Oregon and California legislatures and the U.S. Congress passed the Cessation Act for all necessary legislation to begin Reclamation's Klamath Project (DOI 2011a). Afterwards, Reclamation began building its Klamath Project, which led to the construction of the Link River Dam, several hundreds of miles of irrigation ditches and large canals and pumping plants to divert water from the Klamath River watershed for agricultural use (FERC 2007).

In 1908, President Roosevelt created the Lower Klamath Lake National Wildlife Refuge (NWR). Later, in 1928, the Tule Lake and Upper Klamath Lake NWRs were also created, and a portion of the water from the Upper Klamath Lake was diverted to these NWRs (FERC 2007). Historic wetland areas were drained to accommodate agricultural development; however, some of the historic wetland areas around Upper Klamath Lake have more recently been returned to Upper Klamath Lake.

Development of hydroelectric plants in the Klamath Basin began as early as 1891 in the Shasta River ~~canyon~~Canyon to provide electricity for the City of Yreka. In 1895, another facility was constructed on the east side of the Link River supplying power to Klamath Falls, Oregon. Additional power suppliers developed facilities in the area on Fall Creek and the West Side plant on the Link River (FERC 2007). Chapter 1 provides additional historical detail regarding the Klamath Hydroelectric Project.

Concern over the effects of these dams on salmon and suckers grew over the years. The shortnose and Lost River suckers were listed as endangered under the Endangered Species Act in 1988 (FERC 2007). The Southern Oregon/Northern California Coast coho salmon were reviewed in 1996 and listed as threatened in 1997. Oregon Coast coho salmon were listed in 1998. The listings were reaffirmed and uplisted to endangered in 2005 (National Oceanic and Atmospheric Administration [NOAA] Fisheries Service 2005). Section 3.3, Aquatic Resources, provides background information and an analysis of effects on these endangered species.

3.6.3.2 Basin Hydrology

This section describes reservoirs, rivers, and creeks in the affected environment and ~~lists~~ lists historic average stream flows. Various springs and seeps occur in the vicinity ~~of~~ of Iron Gate, Copco and J.C. Boyle Dams and contribute flows to surface water. ~~Springs~~ Springs around Upper Klamath Lake provide inflow to many of the streams feeding ~~the~~ the lake and also provide stability for area wetlands (Akins 1970). Section 3.7.3.1,

describes the locations of springs and seeps in more detail. Some measurable ~~inflows~~ inflows from springs and seeps to various surface waters are described below. ~~Figure~~ Figure 3.6-1 shows the major reservoirs and rivers in the Klamath Basin.

3.6.3.2.1 Precipitation and Runoff

The Upper Klamath Basin receives rain at all elevations and snow at elevations above 4,000 feet during the late fall, winter, and spring. Snow is the primary form of precipitation in the upper watershed. Depending on the elevation and location, the amount of precipitation ranges from approximately 10 to more than 50 inches per year. From 1907 through 1997 the average annual precipitation at Klamath Falls was 13.4 inches and from 1959 to 2009 it was 20 inches at Copco 1 Dam (DOI 2011b). Peak stream flows generally occur during snowmelt runoff around March through May. After the runoff has stopped, flows drop to low levels in the late summer or early fall. Fall storms may increase flows compared with the lower summer flows. Generally, conditions in the Upper Klamath Lakes area are drier than the area where the Klamath River reaches the ocean. The reaches downstream ~~of~~ from the Klamath River's confluence with the Shasta River receive higher levels of precipitation than other reaches in the Klamath Basin (FERC 2007). Average annual precipitation is 49 inches at Happy Camp from 1914 to 2010 and 80 inches at Klamath between 1948 and 2006 (Desert Research Institute ~~Website~~Web Site 2011).

3.6.3.2.2 Upper Klamath Basin

Upper Klamath Lake and Link River Dam

Link River Dam was constructed by PacifiCorp for Reclamation in 1921 at the natural outlet of Upper Klamath Lake. This dam is operated by PacifiCorp under an agreement with Reclamation. Upper Klamath Lake has an active storage capacity ranging from 502,347 acre feet at the existing reservoir to 597,817 acre feet including areas restored by levee and dike breaches at Agency Lake, Barnes Ranch, Tulana Farms, and Goose Bay (~~Greimann~~Reclamation, 2011, Appendix E). Currently, Reclamation manages Upper Klamath Lake in accordance with United States Fish and Wildlife Service (USFWS) and NOAA Fisheries Service biological opinions based on current and expected hydrologic conditions (~~DOI 2011c).~~

Reclamation 2011).

Outlets from Upper Klamath Lake include the Reclamation A Canal, PacifiCorp's East and West Side development canals and the Link River Dam. Water that passes through the East and West Side development canals re-enters the Link River downstream ~~of~~ from the dam where it eventually enters Keno Impoundment/Lake Ewauna (FERC 2007).

Reclamation's Klamath Project

Operation of Reclamation's Klamath Project affects Klamath River flows and Upper Klamath Lake water surface elevations. Section 3.8, Water Supply/Water Rights, describes the scope of Reclamation's Klamath Project in more detail, including the water supply diversions and amount of water diverted. Reclamation is required to implement a management plan to address biological opinions and fish concerns. To help accomplish

this, Reclamation issues an annual operations plan describing flow requirements at various exceedance levels stated in biological opinions (Reclamation 2010). The biological opinions include requirements for targeted flows for Iron Gate Dam releases and water surface elevations in Upper Klamath Lake. Annual operations plans for Reclamation's Klamath Project must plan for flows and water surface elevations that are adequate for the continued existence of salmon and suckers. This is accomplished, in part, by using the fall and winter flow variability program "to enhance flow variability to mimic the natural hydrologic response that would naturally occur" (NOAA Fisheries Service 2010) and increased spring discharge in select average and wetter exceedances. Table 3.6-1 describes flow release requirements in cubic feet per second (cfs) from 2010 to 2018 measured below Iron Gate Dam under the biological opinion (NOAA Fisheries Service 2010). Each year, under the flow variability program, the hydrology exceedance is determined based on watershed modeling that considers "hydrologic and climatological information, including data from tributaries within the PacifiCorp Hydroelectric Project Reach (Keno Dam to Iron Gate Dam)." A team comprised of representatives from NOAA Fisheries Service ~~(NMFS)~~, NOAA Weather Service, USFWS, United States Geological Survey (USGS), California Department of Fish and Game, the Karuk, Hoopa Valley and Yurok Tribes, PacifiCorp and Reclamation make this determination. Exceedance level calculations are affected by many factors including water use upstream of Upper Klamath Lake and Reclamation's Klamath Project demand when sufficient water supply is available (NOAA Fisheries Service 2010).

The "Exceedance Level" column represents hydrologic conditions ranging from very dry to very wet conditions. A 90 percent exceedance level represents a flow that is exceeded 90 percent of the time (dry conditions). A 10 percent exceedance level represents a ~~flow~~ flow that is exceeded only 10 percent of the time (wet conditions). Exceedance level calculations are affected by many factors including water use upstream of Upper Klamath Lake and Reclamation's Klamath Project demand when sufficient water supply is available (NOAA Fisheries Service 2010).

The flow requirements included in Table 3.6-1 describe the flow release requirements during the corresponding year type during the time periods indicated. As Table 3.6-1 shows, the flow release rate allowed under the biological opinion for releases from Iron Gate Dam in July of a very dry year (represented by a 90 percent exceedance) would be 840 cfs. Reclamation is required to release adequate flows from Upper Klamath Lake and regulate these flows at Keno Dam to allow PacifiCorp to meet these flow requirements at Iron Gate Dam.

Keno Impoundment/Lake Ewauna and Keno Reach

Keno Impoundment/Lake Ewauna existed before the construction of Keno Dam due to a natural blockage (Akins 1970). The Keno Dam is owned and operated by PacifiCorp. Before the dam, in 1908, water from the Keno Impoundment/Lake Ewauna was reported to overflow the natural blockage and enter the Lost River Slough when the water surface elevation was at approximately 4,085 feet (FERC 2007). The currently normal water surface elevation is 4,085 feet (USGS 2009a) at the Keno Impoundment/Lake Ewauna. The Keno Impoundment/Lake Ewauna is a long and narrow lake that begins where the

Link River ends, 1.3 miles downstream from the Link River Dam, and ends at Keno Dam.

Table 3.6-1. Biological Opinion Requirements for Iron Gate Dam Releases (cfs)

Exceedance Level	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug. 1-5	Aug. 16-31	Sept.
95%	1,000	1,300	1,260	1,130	1,300	1,275	1,325	1,175	1,025	805	880	1,000	1,000
90%	1,000	1,300	1,300	1,245	1,300	1,410	1,500	1,220	1,080	840	895	1,000	1,000
85%	1,000	1,300	1,300	1,300	1,300	1,450	1,500	1,415	1,160	905	910	1,001	1,000
80%	1,000	1,300	1,300	1,300	1,300	1,683	1,500	1,603	1,320	945	935	1,005	1,006
75%	1,000	1,300	1,300	1,300	1,300	2,050	1,500	1,668	1,455	1,016	975	1,008	1,013
70%	1,000	1,300	1,300	1,300	1,300	2,350	1,500	1,803	1,498	1,029	1,005	1,014	1,024
65%	1,000	1,300	1,300	1,300	1,323	2,629	1,589	1,876	1,520	1,035	1,017	1,017	1,030
60%	1,000	1,300	1,300	1,309	1,880	2,890	2,590	2,029	1,569	1,050	1,024	1,024	1,041
55%	1,000	1,300	1,345	1,656	2,473	3,150	2,723	2,115	1,594	1,056	1,028	1,028	1,048
50%	1,000	1,300	1,410	1,751	2,577	3,177	3,030	2,642	1,639	1,070	1,035	1,035	1,060
45%	1,000	1,300	1,733	2,018	2,728	3,466	3,245	2,815	1,669	1,077	1,038	1,038	1,066
40%	1,000	1,300	1,837	2,242	3,105	3,685	3,485	2,960	1,682	1,082	1,041	1,041	1,071
35%	1,000	1,300	2,079	2,549	3,505	3,767	3,705	3,115	1,699	1,100	1,050	1,050	1,085
30%	1,000	1,434	2,471	2,578	3,632	3,940	3,930	3,225	1,743	1,118	1,053	1,053	1,089
25%	1,000	1,590	2,908	2,627	3,822	3,990	4,065	3,390	2,727	1,137	1,058	1,058	1,097
20%	1,000	1,831	2,997	2,908	3,960	4,160	4,230	3,480	2,850	1,152	1,066	1,066	1,135
15%	1,000	2,040	3,078	3,498	4,210	4,285	4,425	3,615	2,975	1,223	1,093	1,093	1,162
10%	1,000	2,415	3,280	3,835	4,285	4,355	4,585	3,710	3,055	1,370	1,126	1,126	1,246
5%	1,000	2,460	3,385	3,990	4,475	4,460	4,790	3,845	3,185	1,430	1,147	1,147	1,281

Source: NOAA Fisheries Service 2010
Notes:
cfs: cubic feet per second

~~**Keno Impoundment/Lake Ewauna and Keno Reach**~~

~~Keno Impoundment/Lake Ewauna existed before the construction of Keno Dam due to a natural blockage (Akins 1970). The Keno Dam is owned and operated by PacifiCorp. Before the dam, in 1908, water from the Keno Impoundment/Lake Ewauna was reported to overflow the natural blockage and enter the Lost River Slough when the water surface elevation was at approximately 4,085 feet (FERC 2007). The currently normal water surface elevation is 4,085 feet (USGS 2009a) at the Keno Impoundment/Lake Ewauna. The Keno Impoundment/Lake Ewauna is a long and narrow lake that begins where the Link River ends, 1.3 miles downstream of the Link River Dam, and ends at Keno Dam.~~

The majority of the water entering Keno Impoundment/Lake Ewauna comes from Upper Klamath Lake through the Link River. Several facilities upstream of Keno Dam transport

water to or from the river including: the Lost River Diversion Channel, North Canal, Klamath Straits Drain, and the Ady Canal. Additional facilities that divert water for private agricultural lands are also on the reach between Keno Dam and J.C. Boyle Reservoir (FERC 2007).

J.C. Boyle Reservoir

J.C. Boyle Reservoir is approximately 5 miles downstream ~~of~~ from Keno Dam. PacifiCorp operates J.C. Boyle Reservoir to produce hydroelectric power. Current operations of the reservoir follow Interim Measures from the Interim Conservation Plan effective as of February 2010. Water is spilled from the dam during high flow months of January through May and when inflow "exceeds the capacity of the J.C. Boyle powerhouse and low flow requirements" (FERC 2007).

J.C. Boyle Bypass Reach

The J.C. Boyle Bypass Reach is a 4.3-mile section of the Klamath River between the J.C. Boyle Dam and Powerhouse; it flows at a steep grade. At 0.5 miles downstream ~~of~~ from the dam, flows are increased by groundwater entering the bypass reach. There is currently a 100 cfs minimum required release from J.C. Boyle Reservoir into the J.C. Boyle Bypass Reach (NOAA Fisheries Service 2010). The average accretion due to groundwater inflow/spring inflow is an additional 220 to 250 cfs and varies seasonally and from year to year (FERC 2007).

J.C. Boyle Peaking Reach

The J.C. Boyle Peaking Reach is downstream ~~of~~from the J.C. Boyle powerplant, so flows vary based on releases from the plant. Typically, the reach has high flows during the day as a result of powerhouse flows used to provide peak energy demand. The powerhouse flows may be reduced to zero at night when J.C. Boyle Reservoir is refilled. The powerhouse ramps up flow for either a one-unit operation (up to 1,500 cfs) or a two-unit operation (up to 3,000 cfs). Normal daily average flows in the peaking reach during periods with no power generation range from 320 to 350 cfs (80 cfs from the fish ladder, 20 cfs from the juvenile fish bypass system). A minimum monthly flow rate of 302 cfs has been recorded in the month of August based on data from 1959 to 2010 (USGS 2011). Additional water enters the reach from springs.

Commercial whitewater rafting and boating occurs during the same months as peak power demands, May through October. The water supply for this unique rafting opportunity during the summer tourist season is from the peaking operations of J.C. Boyle powerhouse. Under PacifiCorp's current annual FERC license, upramping and downramping occur at a rate of 9 inches per hour for both (FERC 2007). PacifiCorp diverts some water from this reach for irrigation purposes (FERC 2007).

Copco 1 Reservoir

PacifiCorp operates Copco 1 Reservoir for hydroelectric power generation through Copco 1 Dam. With the most active storage volume of all the project reservoirs of 6,235 acre feet for power production, Copco 1 Reservoir has a total storage capacity of

46,867 acre feet (~~DOI 2011c).~~Reclamation 2012b). This reservoir is deeper than both Keno Impoundment/Lake Ewauna and J.C. Boyle Reservoir (FERC 2007).

Copco 2 Reservoir and Bypass Reach

Copco 2 Reservoir, a small impoundment, receives discharge from Copco 1 Reservoir through Copco 1 Dam and provides flow to Copco 2 Powerhouse through a 1.5-mile bypass reach. The maximum hydraulic capacity is 3,200 cfs in the powerhouse flowline controlling flows from Copco 1 Reservoir to Copco 2 Reservoir. Copco 2 Dam controls the flow from the reservoir, and only spills when inflow from the reservoir exceeds storage capacity. Spillage from the dam is rare and typically only happens from November through April. PacifiCorp releases between 5 to 10 cfs at the bypass reach under normal conditions. Copco 2 Powerhouse discharges water to Iron Gate Reservoir (FERC 2007).

Iron Gate Reservoir

Iron Gate Reservoir is downstream from the Copco 2 Dam and also receives water from Jenny and Fall Creeks, which are tributaries to the Klamath River downstream ~~of~~ from Copco 2 Dam and Iron Gate Reservoir. PacifiCorp operates Iron Gate Dam and Reservoir as a re-regulating facility for peaking operations at the other three hydroelectric power dams. Iron Gate Reservoir is the deepest of the four reservoirs in the Hydroelectric Reach. The total storage at this reservoir is approximately 58,794 acre feet of which 3,790 acre feet is available for power production (~~DOI 2011c~~Reclamation 2012b). Iron Gate Powerhouse, at the base of the dam, has a maximum hydraulic capacity of 1,735 cfs. Cool water is diverted from the reservoir to the Iron Gate Fish Hatchery, downstream ~~of~~from the dam (FERC 2007). USGS gage station 11516530 on the Klamath River, downstream ~~of~~from Iron Gate Dam, provides flow monitoring data regarding compliance with NOAA Fisheries Service biological opinions. Bogus Creek and effluent from the hatchery enter the river upstream of the gage and downstream ~~of~~from the dam (USGS 2009b). Table 3.6-1 lists the flow requirements measured downstream ~~of~~from Iron Gate Dam.

Lower River Basin

The Lower Klamath Basin includes the river area downstream from Iron Gate Dam, which includes 190 miles of river flowing to the Klamath Estuary and then to the Pacific Ocean. The major tributaries entering the river include the Shasta, Scott, Salmon and Trinity Rivers. The Klamath Basin is heavily influenced by these four rivers because 44 percent of the average annual runoff is provided by them (FERC 2007). Below are brief descriptions of these four rivers and other reaches along the Lower Klamath River.

Shasta River

The Klamath River receives water from the Shasta River approximately 13.5 miles downstream ~~of~~from Iron Gate Dam. The watershed includes high mountain peaks, forested terrain and agricultural land. Peak flows, near the Shasta River's confluence with the Klamath River, are in the winter with minimum flows during July and August. Dwinnel Dam, approximately 25 miles upstream of its confluence with the Klamath

River, resulted in the creation of Lake Shastina. Additional diversion dams and smaller dams are located between Dwinnel Dam and the Klamath River (FERC 2007).

Scott River

The Klamath River receives water from the Scott River approximately 33.6 miles downstream ~~of~~from the Klamath River's confluence with the Shasta River. The watershed includes the Salmon Mountains, which are heavily forested creating a rain shadow for the rest of the watershed. The valley is comprised of land for grazing and agriculture. Average monthly flows entering the Klamath River from the Scott River are 4 to 5 times higher in the winter and spring months than from the Shasta River; however, minimum flows are similar during August and September (FERC 2007).

Klamath River at Seiad Valley

A USGS flow gage is on the Klamath River at Seiad Valley, downstream ~~of~~from its confluence with the Scott River. During the low flow months of August through November, approximately 75 percent of the water flowing past this gage is attributed to Iron Gate Dam releases. During the high flow months of April through June approximately 50 percent of the water flowing past this gage is attributable to Iron Gate Dam releases (FERC 2007).

Salmon River

Approximately 77 miles from the Klamath River's confluence with the Scott River, the Salmon River enters the Klamath River. The Salmon River flows through the Klamath National Forest and many designated wilderness areas. The region surrounding the Salmon River is forested with some agricultural activity. High monthly average flows (3,375 cfs) occur in January, which is the winter peak for flooding as rain and rain on snow events occur. In April and May, the Salmon River has a high monthly average flow (2,660 and 2,630 cfs, respectively) from snowmelt at higher elevations. The Salmon River has its lowest monthly average flow at about 200 cfs in September, which is later than for other tributaries upstream including the Shasta River where lowest monthly average flow occurs in July (FERC 2007).

Klamath River at Orleans

USGS gage no. 11523000 is at Orleans, downstream ~~of~~from the Klamath's confluence with the Salmon River and other smaller tributaries within the Lower Klamath watershed. This area receives a high amount of precipitation compared to other reaches upstream of the Shasta River; therefore, higher flows than in upstream reaches occur here in the winter and spring months. Iron Gate Dam releases account for approximately 20 percent of the flow during these high flow periods and over 50 percent of the flow during the late summer and fall (FERC 2007).

Trinity River

The Trinity River is the largest tributary to the Klamath River and is downstream ~~of~~from the Klamath River's confluence with the Salmon River and Orleans. It is heavily forested and receives a heavy amount of precipitation. Peak average monthly flows into the Klamath River occur in February and March at approximately 11,000 cfs and flows decrease to a low of 500 cfs in September (FERC 2007).

Klamath River at Klamath

A USGS gage no. 11530500 is at the mouth of the Klamath River where it meets the estuary within the Lower Klamath watershed. During low flow periods, the releases from Iron Gate Dam account for approximately 40 percent of flow during September to October. However, the area surrounding the Klamath River reach downstream ~~of~~ from its confluence with the Trinity River receives a heavy amount of precipitation, and during the winter months approximately 85 percent of the flow comes from other sources than Iron Gate Dam releases (FERC 2007).

Klamath River Estuary

The Klamath River estuary is within the Redwood National Park and spans approximately 4 to 5 miles upstream of the mouth. The tidal influence normally extends approximately 4 miles upstream ~~from~~of the mouth during high tides greater than 6 feet upstream of the U.S. Highway 101 bridge. Past studies have observed the formation of a sill at the river mouth in late summer or early fall causing a standing water backup up to 6 miles upstream. During high tides saltwater was observed in the summer and early fall from the mouth upstream ranging approximately 2.5 to 4 miles depending on the time period samples were taken. The saltwater recedes during low tides (Wallace 1998).

3.6.3.3~~–~~ Historic Stream Flows

The USGS operates several stream gages on the Klamath River (Table 3.6-2 and ~~Figure~~ Figure 3.6-3). As noted above, summer and early fall periods (July through October) generally have much lower flows than the months of the spring runoff. Tributaries downstream ~~of~~ from Iron Gate Dam contribute substantial amounts of flow. Figure 3.6-4 shows historical daily average stream flows at several locations on the river using USGS monitoring data from 1961-2009 (USGS 2011). Flows are substantially higher during wet years; Table 3.6-3 shows historic average monthly flows during wetter years (represented by flows exceeded ten percent of the time) using the same USGS data (USGS 2011).

Table 3.6-2. USGS Gages on the Klamath River

USGS Gaging Station	Station Name	Drainage Area (miles^2)	Latitude	Longitude	Gage Elevation (feet)	Period of Record (Water Years)
11509500	Klamath River at Keno, OR	3,920	42°08'00"	121°57'40"	3,961	1905-1913 1930-2009
11510700	Klamath River below John C. Boyle Power Plant near Keno, OR	4,080	42°05'05"	122°04'20"	3,275	1959-2009
11512500	Klamath River below Fall Creek near Copco, CA	4,370	41°58'20"	122°22'05"	2,310	1924-1961
11516530	Klamath River below Iron Gate Dam, CA	4,630	41°55'41"	122°26'35"	2,162	1961-2009
11520500	Klamath River near Seiad Valley, CA	6,940	41°51'14"	123°13'52"	1,320	1913-1925 1952-2009
11523000	Klamath River at Orleans, CA	8,475	41°18'13"	123°32'00"	356	1927-2009
11530500	Klamath River near Klamath, CA	12,100	41°30'40"	123°58'42"	5.6	1911-1927 1932-1994, 1996, 1998-2009

Source: ~~DOI 2011c~~ Reclamation 2012b.

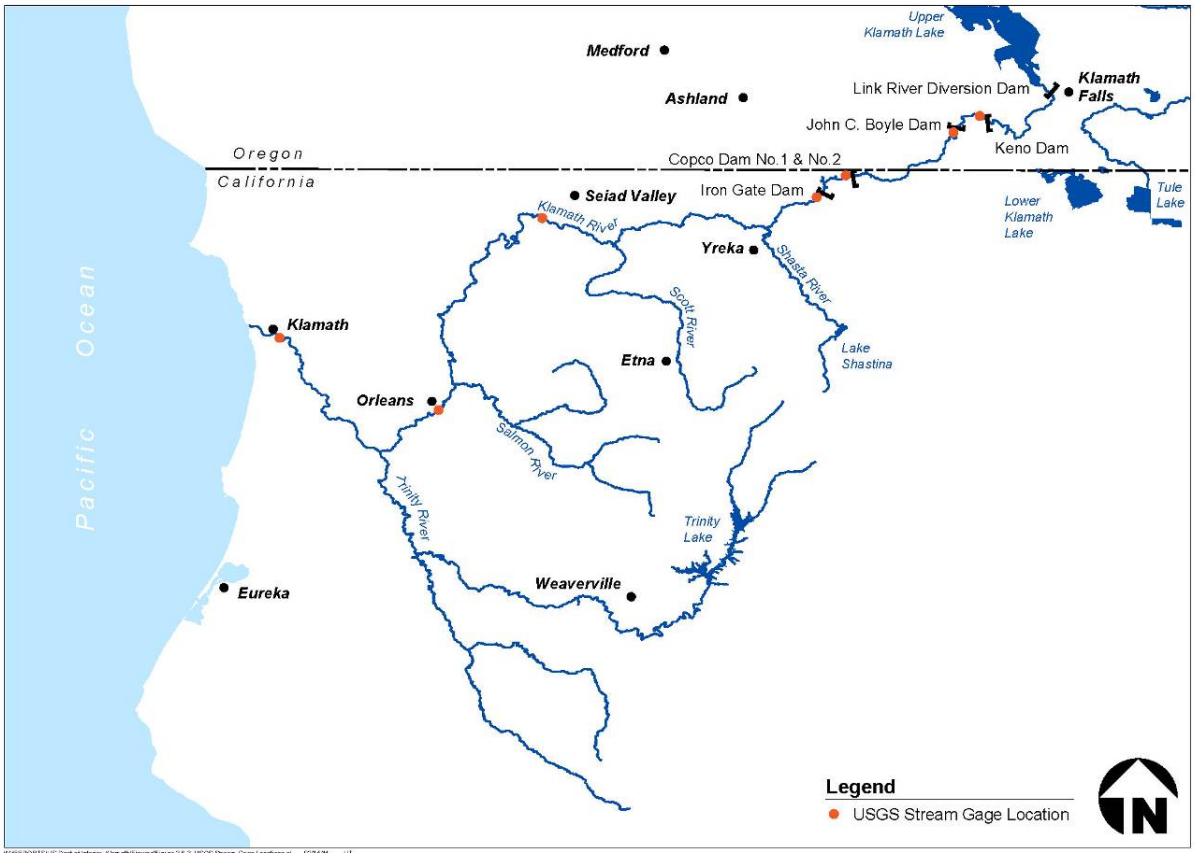
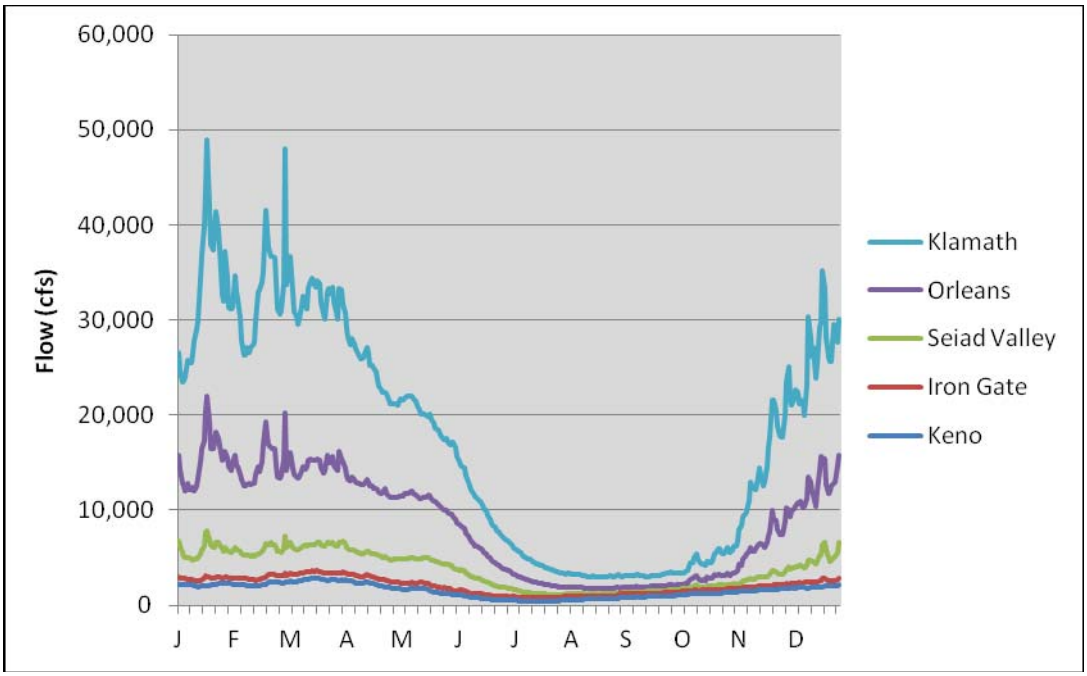


Figure 3.6-3. USGS Stream Gage Locations.



Source: USGS 2011

Figure 3.6-4. Daily Average Flows at Five USGS Stream Gages on Klamath River.

Table 3.6-3. Historic Monthly Average Flows (cfs) in Wetter Years (10% Exceedance Level) during Water Years 1961-2009 on the Klamath River

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.
Keno Dam	2053	2625	3304	3645	4703	5691	4543	3046	1525	755	788	1225
J.C. Boyle Dam	2271	2824	3449	3720	4727	5741	4766	3346	1823	1010	1035	1441
Iron Gate Dam	2447	3047	3994	4544	5567	6429	5487	3918	2003	1059	1094	1582
Seiad Valley	3070	4606	9372	11866	11129	11658	9516	8077	5262	1985	1461	1903
Orleans	4031	11635	28185	33198	23710	25697	20345	18408	11277	4060	2343	2418

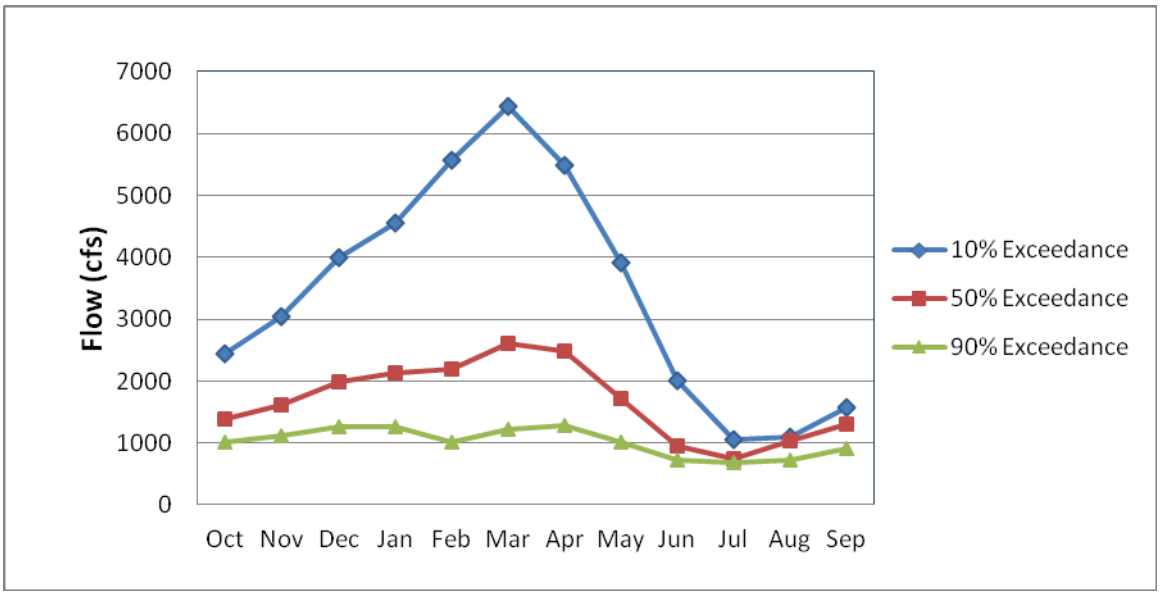
Source: USGS 2011

Table 3.6-4 shows the daily average flows at the four dams. The column indicating "% of time equaled or exceeded" indicates the hydrologic conditions, with 99 percent being an extremely dry ~~year~~conditions and 1 percent being an extremely wet ~~year~~conditions. Figures 3.6-5 and 3.6-6 show average daily flows in different ~~year types~~conditions downstream from Iron Gate and J.C~~.~~. Boyle Dams. The gage downstream ~~of~~ from J.C. Boyle Dam is also downstream ~~of~~from the return of flow from the J.C. Boyle power plant.

Table 3.6-4. Annual and Seasonal Daily Flows

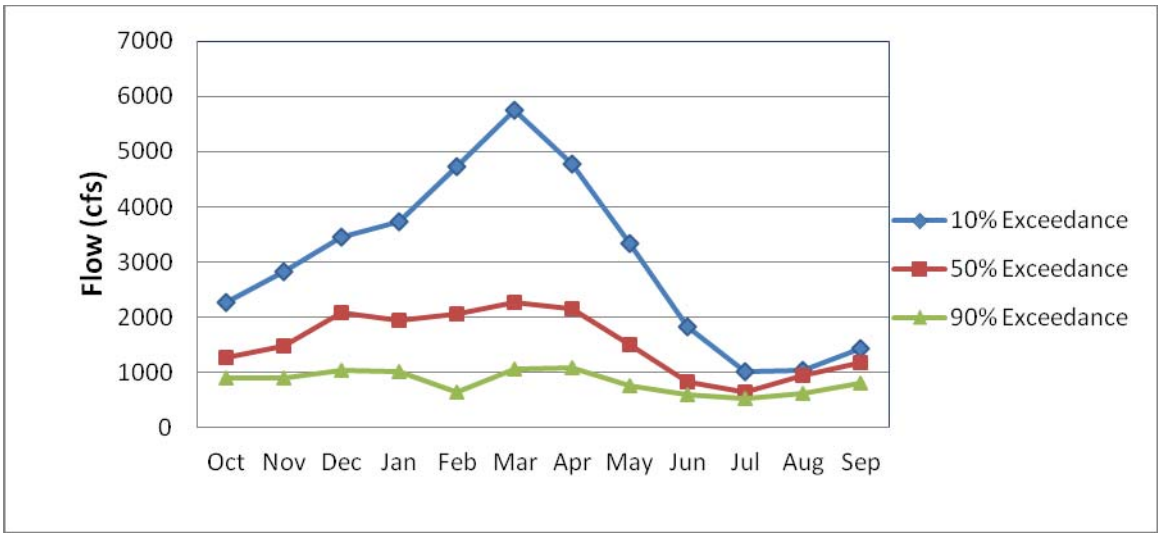
% of time equaled or exceeded	Discharge (cfs)							
	Annual				Seasonal (July 1 – Nov 31)			
	Keno	Boyle	Copco	Iron Gate	Keno	Boyle	Copco	Iron Gate
99	152	331	290	528	147	325	294	441
95	297	522	529	716	292	473	524	701
90	431	635	643	741	417	592	604	725
80	645	802	882	955	621	725	823	846
70	821	962	1,088	1,040	737	856	973	1,000
60	990	1,130	1,269	1,320	901	960	1,150	1,030
50	1,180	1,260	1,483	1,360	1,020	1,060	1,273	1,130
40	1,440	1,480	1,730	1,700	1,180	1,180	1,470	1,320
30	1,800	1,810	2,104	1,977	1,390	1,280	1,670	1,350
20	2,390	2,660	2,640	2,980	1,580	1,490	1,905	1,510
10	3,120	3,200	3,350	3,870	1,960	1,890	2,300	1,840
5	4,320	4,530	4,486	5,500	2,450	2,710	2,720	2,920
1	6,875	7,660	7,295	9,167	3,300	3,970	3,536	4,350

Source: ~~DOI 2011c~~Reclamation 2012b



Source: USGS 2011

Figure 3.6-5. Stream Flows Downstream from Iron Gate Dam in Wet, Average, and Dry ~~Years~~Conditions.



Source: USGS 2011

Figure 3.6-6. Stream Flows Downstream from J.C. Boyle Dam in Wet, Average, and Dry ~~Years~~

Conditions.

Table 3.6-5 shows the flows associated with different flood levels in the basin. Peak flows at Iron Gate Dam are substantially greater than peak flows at J.C. Boyle Dam, because of the tributaries that enter the Klamath River in the Hydroelectric Reach, and peak flows continue to increase substantially as tributaries enter the Klamath River. The 10~~-yr~~ year discharge at Seiad Valley, which is downstream ~~of~~from the Scott River, is 56,500 cfs. The 10~~-yr~~ year discharge at the mouth is close to 300,000 cfs.

Table 3.6-5. Flood Frequency Analysis on Klamath River for 10-yr to 100-yr Floods based upon Full Period of Record[1] of Each Gage

Gaging Station	Drainage Area (miles^2)	Discharge (cfs)				
		~~Gage Base~~	~~10-yr~~	~~25-yr~~	~~50-yr~~	~~100-yr~~
~~Keno~~	~~3,920~~	~~4,000~~	~~8,642~~	~~10,350~~	~~11,200~~	~~11,800~~
~~Boyle~~	~~4,080~~	~~4,000~~	~~9,058~~	~~11,050~~	~~12,220~~	~~13,150~~
~~Copco~~	~~4,370~~	~~5,400~~	~~10,750~~	~~12,720~~	~~13,730~~	~~14,470~~
~~Iron Gate~~	~~4,630~~	~~N/A~~	~~15,610~~	~~21,460~~	~~26,280~~	~~31,460~~
~~Seiad~~	~~6,940~~	~~N/A~~	~~56,540~~	~~93,400~~	~~131,000~~	~~179,300~~

~~Orleans~~	~~8,470~~	~~N/A~~	~~163,100~~	~~230,300~~	~~287,000~~	~~348,900~~
~~Klamath~~	~~12,100~~	~~N/A~~	~~298,300~~	~~392,900~~	~~466,900~~	~~543,300~~
		10-yr	**25-yr**	**50-yr**	**100-yr**	
Keno	3,920	8,642	10,350	11,200	11,800	
Boyle	4,080	9,058	11,050	12,220	13,150	
Copco	4,370	10,750	12,720	13,730	14,470	
Iron Gate	4,630	15,610	21,460	26,280	31,460	
Seiad	6,940	56,540	93,400	131,000	179,300	
Orleans	8,470	163,100	230,300	287,000	348,900	
Klamath	12,100	298,300	392,900	466,900	543,300	

Source: ~~DOI 2011c~~Reclamation 2012b

Notes:

[1] Keno Dam 1905-1913, 1930-2009; J.C. Boyle Dam 1961-2009; Copco 1 Dam 1930-1961; Iron Gate Dam 1961-2009. Data for all gages except Iron Gate Dam was extended using equations to match the period of record for Keno Dam.

Key:

cfs: cubic feet per second

3.6.3.4 Flood Hydrology and River Flood Plain

The active storage capacity at Upper Klamath Lake is approximately 597,817 acre-feet and includes areas restored by levee and dike breaches at Agency Lake, Barnes Ranch, Tulana Farms, and Goose Bay (~~Greimann~~Reclamation, 2011~~).~~, Appendix E). Active storage at Keno, J.C. Boyle, Copco 1, Copco 2 and Iron Gate reservoirs totals approximately 12,~~244~~ 244 acre-feet (FERC 2007). Approximately 98 percent of the active surface water storage along the Klamath River is provided by Upper Klamath Lake behind Link River Dam. Keno, J.C. Boyle, Copco 1, Copco 2 and Iron Gate Dams provide approximately ~~2~~ 2 percent of the active storage on the river.

During extremely wet years, increased flows occur in the Klamath River and its tributaries, and surface water elevations rise in Upper Klamath Lake. Agency Lake, Barnes Ranch, and the Nature Conservancy-owned lands provide over 108,000 acre feet of storage area due to breaching of dikes and levees. During these periods, there is little surplus storage at the four dams to help control flooding. Decreased irrigation demands may allow for more water in Upper Klamath Lake to be stored for future use depending on the decisions to balance spring flushing flows with fall migration flows. The biological opinions included provisions for average and wet years that increase minimum flow requirements at Iron Gate Dam and surface water elevations at Upper Klamath Lake and Agency Lake/Barnes Ranch to reflect the natural flow conditions during wetter years and provide storage for surplus water. The Klamath River overtops its banks during flood years and inundates the floodplain. Additional descriptions of area geomorphology are in Section 3.11, Geology, Soils and Geologic Hazards.

FEMA has prepared flood risk mapping for portions of the Klamath River in Siskiyou, Del Norte and Humboldt Counties and provides access to these maps via their ~~web~~Web mapping service or can be downloaded from their ~~website.~~Web site. The revised Flood Insurance Rate Map (FIRM) and Flood Insurance Study for Siskiyou County was released on January 19, 2011, however, this update did not include new flood analysis

along the Klamath River. FEMA flood analysis for the river is based on studies and cross sections developed prior to 1985 and later revised in 1987.

3.6.3.5 Risks of Dam Failure

Dams are manmade structures and do exhibit some risks of failure that could result in flooding downstream. According to the Association of State Dam Safety Officials (ASDSO), dams fail due to one of five reasons (ASDSO 2011).

- Overtopping caused by water spilling over the top of dam;
- Structure failure of materials used in dam construction;
- Cracking caused by movements like the natural settling of dam;
- Inadequate maintenance and upkeep; or
- Piping – when seepage through a dam is not properly filtered and soil particles continue to progress and form sink holes in the dam.

In California, weighted point systems are used during inspections to classify both the hazard or damage potential and condition of the dam. Once classified, the frequency of inspection and return period for hydrology studies is selected. The classifications used for damage potential are extreme, high, moderate and low and refer to the possibility of loss of life and property downstream ~~of~~from the dam if it were to fail. The classifications of the condition of the dam are poor, fair, good, and excellent and are determined based on the age, general condition, geologic and seismic setting. Dams may be reclassified after improvements or other changes have occurred (ASDSO 2000).

Siskiyou County is in the process of developing a Multi-Jurisdictional Hazard Mitigation Plan which will address, among other issues, flood and dam failure hazards. Maps are currently available which describe dam inundation areas at J.C. Boyle and Iron Gate dams as well as a domino effect, depicting the inundation area if multiple dams were to fail at the same time (Siskiyou County ~~Website~~Web Site 2011). The FERC staff have conducted safety inspections of the dam structures as part of the licensing program over the past 50 years. Every five years J.C. Boyle, Copco 1 and Iron Gate dams are inspected and evaluated by an independent consultant and reports documenting the evaluation are submitted to the FERC for review (FERC 2007).

3.6.4 Environmental Consequences

The flood hydrology section of the EIS/EIR will discuss the changes to river flows that would occur during implementation of the alternatives, including the Proposed Action.

3.6.4.1 Environmental Effects Determination Methods

The No Action/No Project Alternative would include operations similar to current operations. PacifiCorp would operate the Klamath Hydroelectric Project as it did before the Secretarial Determination process began, under the operational requirements of the March 2010 biological opinion. The action alternatives would vary operations by removing facilities or installing fish ladders to provide fish passage.

The assessment of the environmental impacts on flood hydrology that would result from implementation of the alternatives determines whether changes in stream flows could cause flooding or inundation areas in the watershed. The impact assessment is based on the hydrologic modeling completed by the Lead Agencies. The modeling covered the No Action/No Project Alternative and the Proposed Action. The Lead Agencies used a one-dimensional HEC-RAS model that assessed hydrologic conditions for these two alternatives. The Lead Agencies also analyzed modeling output to determine how frequently the current FEMA floodplain is inundated and how the floodplain could change under the Proposed Action. This information was included within the *Draft Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration* (~~DOI 2011c~~Reclamation 2012b). The model results under the No Action/No Project Alternative and the Proposed Action provide adequate information to estimate the relative effects of the other alternatives not modeled.

The model results included predictions of the river flows that would occur if the Four Facilities were removed. The river flows would be the same for long-term future conditions for the Partial Facilities Removal of Four Dams Alternative as those modeled for the Proposed Action. The Fish Passage at Four Dams Alternative, however, would leave the dams in, but would include fish passage at each facility. Flows downstream ~~of~~from Iron Gate Dam would be the same under the Fish Passage at Four Dams Alternative as the No Action/No Project Alternative; however, flows within the hydroelectric reach would change to account for flows through fish ladders and flows in the bypass reaches. The predicted flows under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to the No Action/No Project Alternative at the two remaining dams and less than modeled flows under the Proposed Action at the removed dams. The flows within the hydroelectric reach for the Fish Passage at Four Dams and the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Dam alternatives are addressed qualitatively because the model does not simulate these flows. The modeling effort provided useful information for assessing the impacts on flood hydrology in the long-term, but provides limited information about the construction period. Flood risks associated with dam removal activities are described qualitatively and quantitatively using the HEC-RAS and SRH-1D modeling results completed by DOI, and the analysis includes the measures incorporated to reduce these risks.

3.6.4.2 Significance Criteria

For the purposes of this EIS/EIR, impacts would be significant if they would substantially increase the risks of exposing people or structures to loss, injury or death involving flooding as measured by changes in the FEMA 100-year floodplain.

3.6.4.3 Effects Determinations

3.6.4.3.1 Alternative 1: No Action/No Project

The No Action/No Project Alternative could alter river flows and result in changes to flood risks. Under the No Action/No Project Alternative (a Negative Determination), the Four Facilities would remain in place and operations similar to the current operations

would be in effect. The PacifiCorp Klamath Hydroelectric Project and Reclamation's Klamath Project would be operated as they were before the Secretarial Determination process began, including operation requirements under the March 2010 biological opinion. PacifiCorp would operate ~~indefinitely~~ under annual FERC licenses until a long-term license is issued. For the purpose of this EIS/EIR, however, the No Action/No Project Alternative includes operations that would be similar to current operations.

Table 3.6-6 shows modeled average monthly wet year flows at multiple points along the river under the No Action/No Project Alternative. Wet year flows are represented by the modeled 10 percent exceedance (flows are exceeded only ten percent of the time). The No Action/No Project Alternative flows are based on model results and the affected environment flows (Table 3.6-3) are based on historic monitoring data. The monthly flows described in the two tables (Tables 3.6-6 and 3.6-3) vary because the sources used to develop the data are different, but the flows are generally similar. Peak flows would likely exceed the average monthly flows in Table 3.6-6; however, the peak flows would be similar to those currently experienced because the No Action/No Project Alternative would not change operations.

Table 3.6-6. Modeled Average Monthly Flows (cfs) in Wetter Years (10% Exceedance Level) on the Klamath River under the No Action/No Project Alternative

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.
Keno Dam	1022	1925	2867	3113	3859	4979	4752	3003	2493	894	794	901
J.C. Boyle Dam	1249	2159	3054	3396	4099	5265	5102	3482	2948	1178	1033	1113
Iron Gate Dam	1372	2351	3383	3939	5150	6145	5835	3910	3184	1344	1149	1207
Seiad Valley	1822	3898	7747	9511	10523	10987	9911	8486	6435	2388	1534	1482
Orleans	3283	10977	26536	29451	22477	26116	19837	18272	13067	4540	2415	2115

In addition to the model results described above, the Lead Agencies also modeled flood events that meet criteria for a 100-year flood ~~using daily average flows~~ under the No Action/No Project Alternative condition and the Proposed Action (Appendix J). The "WithDams_100yr" shown on the maps in Appendix J depicts the No Action/No Project Alternative condition (~~DOI Undated~~Reclamation, 2011, Appendix G). All of the areas depicted on this map are within Siskiyou County. The FEMA 100-year flood area corresponds fairly closely with the Lead Agencies' modeling of flood risks both with and without dams which reinforces the fact that the four dams were not constructed for the purpose of flood risk reduction. However, there are some differences between the FEMA and the Lead Agencies' No Action/No Project Alternative 100-year inundation zones. These differences are attributable to the use of different hydrographic base data for flood events and the use of enhanced elevation data by the Lead Agencies. The Lead Agencies' analysis is based on LiDAR data with elevation values sufficient to support 2 foot contours along the reach of the Klamath River from Iron Gate to Happy Camp.

Detailed imagery was used to identify structures within the modeled No ~~Acton~~Action/No Project Alternative 100-year inundation zone. Structures include mobile homes, houses, farm sheds, bridges, and other features large enough to cast a shadow, including hay stacks. Imagery from 2010 and 2009 was used and compared which revealed that many of the structures are mobile homes that move annually or seasonally. Within the FEMA 100-year floodplain, there are 481 structures that include bridges. The Lead Agencies' modeling of the 100-year flood inundation area under the No Action/No Project Alternative revealed 671 structures to be at risk.

The No Action/No Project Alternative includes operations that are the same as the existing operations; therefore, the No Action/No Project would not cause any changes to flooding from the affected environment. Although the Lead Agencies' mapping of the 100-year inundation area varies compared to FEMA mapping, this difference can be attributed to the use of different base data and the Lead Agencies' use of enhanced elevation data. FEMA is in the process of updating FIRMs using enhanced elevation data, but has not accomplished this near the Klamath River. Under the No Action/No Project Alternative, the Four Facilities would not be removed and the actual 100-year

flood inundation area would not change. The risks of dam failure would be same under the No Action/No Project alternative as under the existing conditions. **There would be no change from existing conditions from flood risk.**

Ongoing restoration actions could affect flood hydrology. Under the No Action/No Project Alternative, some restoration actions in the Klamath Basin are currently underway and would be implemented regardless of the Secretarial Determination on the removal of the Four Facilities. Table 3.6-7 lists the restoration actions affecting flood hydrology that would occur under the No Action/No Project Alternative. Several of these projects involve breaching levees and dikes upstream and around Upper Klamath Lake, thereby re-establishing hydrologic connections and providing additional storage that could potentially absorb some flood-related increases in inflows. The hydrologic model used to determine effects to flood hydrology under the No Action/No Project Alternative considered the expanded storage capacity described in Table 3.6-7 specifically related to evaporation and changes to consumptive use (~~DOI 2011c).~~Reclamation 2012b). **Overall, the ongoing restoration actions would cause no change from existing conditions from flood hydrology related to the affected environment.**

Table 3.6-7. No Action/No Project Alternative Resource Management Actions Affecting Flood Hydrology on the Klamath River

Component	Implemented Actions	Effects on Flood Hydrology
Williamson River Delta project	Restore wetlands for endangered fish and improve water quality in Upper Klamath Lake. The project involved breaching levees where the river flows into Upper Klamath Lake. Two miles of levees were breached in 2007 restoring approximately 3,500 acres of wetlands. Another 1,400 acres were flooded in 2008. Project would provide 28,800 AF of additional storage in Upper Klamath Lake. No additional levee breaching is proposed under this project	No impact, measures have already been implemented and are described as an existing condition.
Agency Lake and Barnes Ranches	Project to use the diked and drained portions of the ranches as interim pumped storage and ultimately to reconnect to Agency Lake by breaching dikes to add 63,770 AF of additional storage to Upper Klamath Lake. Actions include 1) complete land transfer between Reclamation and USFWS, 2) USFWS to study options to enhance water management flexibility for water storage and fish and wildlife habitat, and 3) complete NEPA analysis and ESA consultation on preferred option. Agency Lake Ranch and Barnes Ranch together comprise approximately 9,796 acres between Agency Lake and the Upper Klamath NWR. Options for water management could include using diked areas for pumped storage or breaching levees to reconnect former wetland areas to Agency Lake. Specific options to be developed and studied under separate NEPA evaluation.	Beneficial effect because more incidental flood protection could be provided.

Key:
AF: acre feet
ESA: Endangered Species Act
NEPA: National Environmental Policy Act
NWR: National Wildlife Refuge
USFWS: United States Fish and Wildlife Service

Dam failure could inundate areas in the downstream watershed. The Four Facilities, collectively, store over 169,000 acre-feet of water when they are full. The dams are inspected regularly, and the probability for failure has been found to be low. However, if a dam failed, it could inundate a portion of the downstream watershed (Siskiyou County Web Site 2011). The risk of failures may or may not increase as the facilities age (maintenance could reduce failure risk), and PacifiCorp's inspection procedures (described on page 3.6-19) would likely reduce the likelihood of dam failure. **The dam failure risk associated with the Four Facilities would have less-than-significant impacts to flood hydrology.**

3.6.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

Drawdown of reservoirs could result in short-term increases in downstream surface water flows and result in changes to flood risks. Reservoir drawdown activities would begin on November 1, 2019 at Copco 1 Dam, and on January 1, 2020 at J.C. Boyle and Iron Gate Dams, at which times hydroelectric power generation would cease. At Copco 2 Dam, reservoir drawdown activities would begin on June 1, 2020 to allow for continued hydroelectric power generation at this site until dam removal must begin. Releases at all of the dams during reservoir drawdown periods would be in accordance with Dam Removal Plans developed by the Lead Agencies and with applicable biological opinions and operation plans. The Dam Removal Entity (DRE) would control the releases that would vary by reservoir depending on the type of dam, discharge capacity, water year type, and the volume of water and sediment within the reservoir. The resultant reservoir water surface elevation after the initial drawdown would be generally higher in a wetter year than in a drier year at all the dams.

The reservoir drawdown plans were made with consideration for minimizing flood risks downstream. The DRE would carefully control drawdown to maintain flows that would not cause flood risks. Drawing down the reservoirs would increase storage availability ~~in~~ in J.C. Boyle, Copco 1, and Iron Gate Reservoirs. If a flood event occurred during drawdown, the DRE would retain flood flows using the newly available storage capacity and continue drawdown after flood risks have ended. Existing conditions do not allow these reservoirs to assist in flood prevention in this manner.

At J.C. Boyle Dam, the DRE would begin reservoir drawdown activities in January while streamflows were still high. Controlled releases would initially be through the gated spillway and power penstock at normal release rates, depending on year type, plus additional flow of up to 100 cfs for reservoir drawdown. These releases would continue until the reservoir water surface elevation decreased to the lowest level possible for the streamflow occurring at that time. The DRE would then remove the stoplogs from one of two low-level culverts beneath the spillway, temporarily releasing additional water downstream at flows between approximately 1,900 and 2,700 cfs depending upon reservoir level. Penstock releases could be reduced if necessary to limit the total sudden increase in streamflow to between approximately 500 and 1,000 cfs. Once the reservoir water surface is stabilized at a lower level, the DRE would remove the stoplogs from the second low-level culvert, temporarily releasing additional water downstream at flows

between approximately 1,000 and 1,900 cfs than the current flows at the time. After this, the reservoir would reach the lowest water surface elevation possible prior to removal of the dam embankment.

While the controlled releases during reservoir drawdown would be higher than simulated No Action/No Project Alternative releases during the same time period, they would not be likely to increase flood risks because they would be within the range of historic flows. A 10-year storm at J.C. Boyle results in an estimated flow of 9,058 cfs (see Table 3.6-5), and the maximum daily winter flow (January through March) is in excess of 8,000 cfs (USGS 2011). The average monthly flow below J.C. Boyle Dam from 1961-2009 was about 2,380 cfs in January, 2,450 cfs in February, and 2,890 cfs in March. Increasing the flow temporarily during reservoir drawdown by up to an additional 1,900 cfs over the No Action/No Project Alternative by removal of the stoplogs from the diversion culverts would not cause flood damage downstream. The concrete spillway crest structure would be removed once the reservoir water surface elevation was drawn down sufficiently, to provide additional flood release capacity and avoid reservoir refill. The embankment dam crest and left abutment wall would be retained for flood protection until removal.

Removal of the J.C. Boyle Dam embankment would begin at the end of May 2020. By then, the minimum reservoir drawdown level would have been achieved and inflow would have decreased to summer levels averaging less than 1,000 cfs. Within four to six weeks, the majority of the embankment would be removed except for a portion of the upstream toe which would serve as an upstream cofferdam. The upstream cofferdam would be armored with rockfill to allow a controlled breach between about water surface elevation 3758 and the channel bottom at elevation 3740, to fully drain the reservoir by July 2020. Reservoir releases would temporarily exceed inflow by up to approximately 5,000 cfs, depending upon the rate of breach development, but would remain below the downstream channel capacity. Although the breach flow would quickly attenuate as it moved downstream due to the very small reservoir volume, the Iron Gate cofferdam would be breached before breaching J.C. Boyle as a precaution.

Although limited drawdown of Copco 1 Reservoir would begin in November 2019 to permit early removal of the spillway gates and crest structure, the primary drawdown and sediment release of Copco 1 Reservoir would begin at the same time as the J.C. Boyle Dam reservoir drawdown in January 2020 and would be affected by the additional upstream releases. Average inflow to Copco 1 Reservoir would be no more than 100 cfs greater than normal streamflow for drawdown between reservoir water surface elevations 2590 feet and 2529 feet over a five to six week period, resulting in a total reservoir release from the diversion tunnel averaging up to 400 cfs above streamflow. A 10-year storm is estimated to result in flows of approximately 10,750 cfs (see Table 3.6-5), and the average daily flow has exceeded 9,000 cfs (USGS 2011).

The concrete dam would be removed in 8-foot lifts while the reservoir was being drawn down, removing concrete in the dry by blasting as the water surface elevation lowered. The diversion tunnel would pass the entire streamflow for as long as possible, but its discharge capacity would continue to decrease as the reservoir head is reduced. When

additional discharge capacity is required, notches would be blasted in the concrete dam near the left abutment to allow for overtopping flows. The extent of notching would be affected by the water year type: wet years would require more notching than normal or dry years. The sudden increase in reservoir releases during notching may be controlled by reducing the diversion tunnel discharge if necessary. Drawdown between reservoir water surface elevations 2529 and 2484 would occur within 30 days. By March 12, 2020 the reservoir would be drained to the normal level of Copco 2 Reservoir (elevation 2484) and a large portion of the concrete dam would have been removed. The final portion of the concrete dam would be removed following drawdown of Copco 2 Reservoir and during the summer low flow period.

Copco 2 Dam does not provide any meaningful storage and the reservoir is very small compared to the other reservoirs, with little or no impounded sediment. Normal streamflow would be diverted downstream from Copco 2 Dam to the bypassed river reach beginning in mid-May 2020 when dam removal would begin. No additional releases would be made from the upstream reservoirs during this time as they would have already been mostly drained. The DRE would use cofferdams to isolate areas of the small concrete dam during demolition and would remove them once they were no longer needed.

Reservoir drawdown at Iron Gate Dam would occur simultaneously with reservoir drawdown at J.C. Boyle and Copco 1 Dams. Normal inflows to the reservoir in January and February 2020 would be increased by up to an estimated 500 cfs due to upstream reservoir drawdown releases. Reservoir drawdown between water surface elevations 2328 and 2202 would occur within a 10½-week period by controlled releases through the modified diversion tunnel, at an average drawdown rate of 3 feet per day. The maximum downstream flow during drawdown of Iron Gate Reservoir could exceed normal streamflow at the site by up to 1,800 cfs. The average monthly flow below Iron Gate Dam from 1961-2009 was about 2,830 cfs in January, 2,940 cfs in February, and 3,~~430~~ 430 cfs in March (USGS 2011). A 10-year storm is estimated to discharge approximately 15,610 cfs (see Table 3.6-5), and average daily winter flows have exceeded 10,000 cfs (USGS 2011). Increasing the flow during reservoir drawdown by up to an additional 1,800 cfs would not cause flood damage downstream. The modified diversion tunnel discharge capacity would range between approximately 3,200 and 8,~~500~~ 500 cfs during reservoir drawdown. Should a large flood event occur during drawdown, the outlet capacity would be exceeded and the reservoir could partially refill. This would be similar to existing operations during a flood event.

The Dam Removal Plan requires that sufficient freeboard be maintained for the dam embankment at all times to prevent potential flood overtopping and embankment failure. The amount of freeboard would be determined according to water year type and surface water elevation during removal operations. Excavation of the dam embankment would begin in June 2020, during a period of reducing streamflow and with a minimum reservoir release capacity of approximately 7,500 cfs. During this time, the embankment dam crest would be lowered 55 feet from elevation 2348 to elevation 2293. In July, excavation of the dam embankment would continue at an average rate of between 14,~~000~~

000 and 18,000 cubic yards per day, lowering the dam crest from elevation 2293 to elevation 2250, with a minimum reservoir release capacity of approximately 5,800 cfs. The majority of the dam embankment volume would be excavated during the following ~~8~~ 8 weeks, while maintaining a portion of the upstream toe at elevation 2205 to serve as an upstream cofferdam. This would provide a minimum flood release capacity in excess of 3,000 cfs in both August and September, which is greater than the maximum historical streamflow during this period and far exceeds the average monthly flow rates for August and September of 980 cfs and 1,250 cfs, respectively (USGS 2011). By late September, the reservoir would be drawn down to the maximum possible extent, minimal streamflow would be occurring, and drawdown releases from upstream reservoirs would have ended. The upstream cofferdam would be armored with rockfill to allow a controlled breach between about water surface elevation 2189 and the channel bottom at elevation 2165, to fully drain the reservoir by September 2020. Reservoir releases would temporarily exceed inflow by up to approximately 5,000 cfs, depending upon the rate of breach development, but would remain below the downstream channel capacity. The breach flow would quickly attenuate as it moved downstream due to the very small reservoir volume. The upstream cofferdam at J.C. Boyle would not be breached until the natural river channel has been restored at the Iron Gate site.

This analysis uses the reservoir drawdown release rates at Iron Gate Dam to determine the level of significance of adverse impacts downstream because Iron Gate Dam has the largest reservoir, provides the highest amount of discharge, and is the most downstream ~~of~~ from all of the dams that would be removed. The release rates that would occur during drawdown of the reservoir would be in accordance with the historical flow during an extremely wet year (1 percent exceedance capacity). Figure 3.6-5 shows historic and maximum flows at Iron Gate Dam under wet year, average year and dry year types. While the release rates that would occur during reservoir drawdown would be greater than the flows at the same time under the No Action/No Project Alternative, and in some months, above the historic monthly maximum flow (September), they would be lower than the overall peak flows in each reach. Because the flows would stay below historic peak flows, they would not change the floodplain or flood risks in comparison to the No Action/No Project Alternative. **Therefore, the impact from drawing down the reservoirs on flood risk would be less than significant.**

The release of sediment stored behind the dams and resulting downstream sediment deposition under the Proposed Action could result in changes to flood risks. Approximately ~~41~~27 to ~~65~~51 percent of sediment behind J.C. Boyle Dam, ~~46~~45 to ~~81~~76 percent of sediment behind Copco 1 Dam, and ~~25~~24 to ~~38~~32 percent of sediment behind Iron Gate Dam would be eroded and flushed down the river during removal activities (~~DOI 2011c).~~Reclamation 2012b). The remaining sediment would be left in place after dam removal above the active channel. The Lead Agencies conducted an analysis of future geomorphology and sediment transport during and after dam removal for dry, median and wet start year scenarios. Most of the erosion would occur during the drawdown period from January 1, 2020, to March 2020 and afterwards the river bed in the reservoir reaches is expected to stabilize. Minor deposition would occur in some of

the reaches downstream ~~of~~ from dam removal activities, however none is expected downstream ~~of~~ from Shasta River (~~DOI 2011c).~~Reclamation 2012b). The Geology and Soils analysis considers the effects of sediment deposition in more detail (see Section 3.11.4.3). Sedimentation would occur downstream from the Four Facilities, but the quantity would vary depending on year type. The magnitude of sediment deposition is relatively small compared to sediment loading from other existing sources along the Klamath River. The only measurable sedimentation will occur in the reach from Bogus Creek to Cottonwood Creek. From Willow Creek to Bogus Creek, there is about 1.5 feet of deposition and from Cottonwood to Willow Creeks there is less than 1 foot of deposition. Downstream from Cottonwood Creek deposition would not be appreciable. Additionally, the sedimentation ~~would be short-term following dam removal~~will occur in primarily pool and not in the riffle and bedrock sections that tend to control surface elevations. Because the sediment deposition would be ~~short-term and~~ small in comparison with the No Action/No Project Alternative, it would not affect stream characteristics in a way that would substantively affect flood inundation or flood risks. **Therefore, sediment deposition would have a less than significant effect on flood risk. However, even though its effect was considered less than significant, the increase in bed elevations due to sedimentation was included in the mapping of the 100 year floodplain inundation areas downstream from Iron Gate Dam described in the next section.**

Under the Proposed Action, the 100-year floodplain inundation area downstream ~~of~~from Iron Gate Dam could change between River Mile 190 and 171. Table 3.6-8 describes modeled flows on the Klamath River under the Proposed Action in wet ~~water years~~conditions (10 percent exceedance level) at multiple points on the river. These flows include all aspects of the Proposed Action, and the primary difference from the No Action/No Project Alternative is related to implementation of the KBRA. The bold numbers represent flows higher than the wet ~~year flows~~conditions under the No Action/No Project Alternative described in Table 3.6-6. Flows during wet ~~years~~conditions would be higher under the Proposed Action when compared to the No Action/No Project Alternative at all of these sites during the months of January and February and July to September. The Figures 3.6-7 to 3.6-11 graphically describe the comparisons in flows at 10, 50 and ~~90~~ 90 percent flow exceedances between the No Action/No Project Alternative and the Proposed Action.

Table 3.6-8. Flood Flow Exceedance: Modeled Wet ~~Water Year Flows~~Conditions on the Klamath River under the Proposed Action

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.
Keno Dam	923	929	2,259	**3,258**	**4,349**	4,809	**4,845**	2,917	2,191	**1,465**	**920**	**1,067**
J.C. Boyle Dam	1,160	1,117	2,508	**3,481**	**4,562**	5,189	**5,233**	3,399	2,544	**1,780**	**1,155**	**1,320**
Iron Gate Dam	1,304	1,305	2,908	**4,192**	**5,219**	5,957	**5,960**	**3,966**	2,806	**1,939**	**1,292**	**1,449**
Seiad Valley	1,770	3,196	**8,319**	**11,090**	**10,803**	**11,025**	9,904	**8,509**	6,124	**3,018**	**1,695**	**1,724**

Orleans	3,195	10,153	**27,098**	**30,998**	**22,727**	**26,485**	**19,973**	**18,614**	12,629	**4,993**	**2,574**	**2,306**

Notes:
Bold numbers represent flows that are greater than the No Action/No Project Alternative.

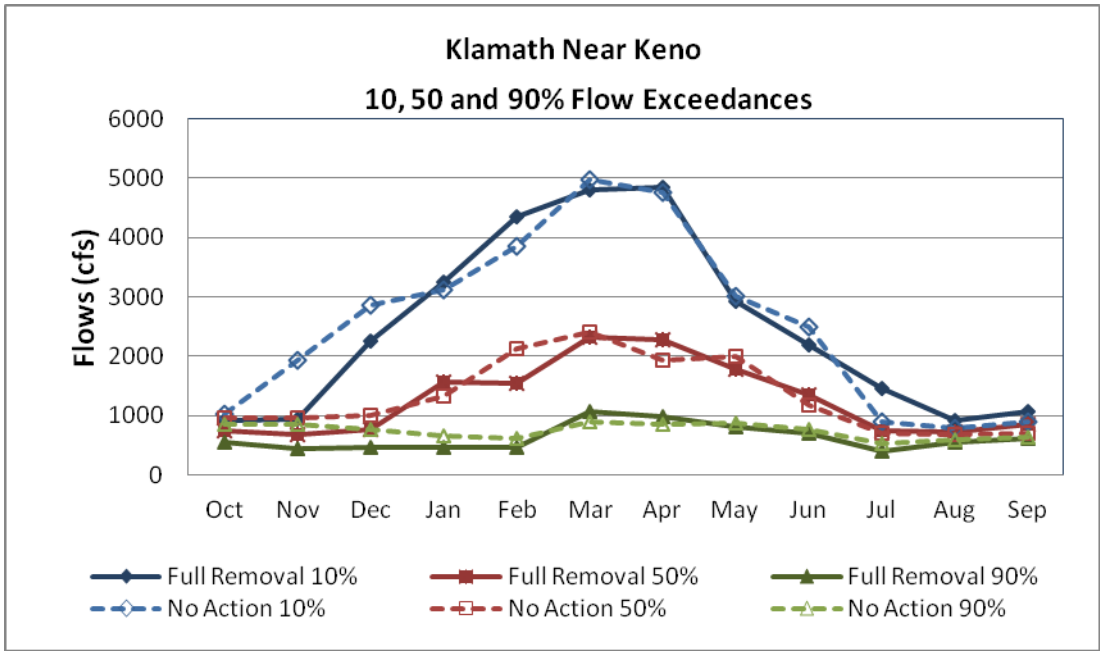


Figure 3.6-7. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Near Keno Dam.

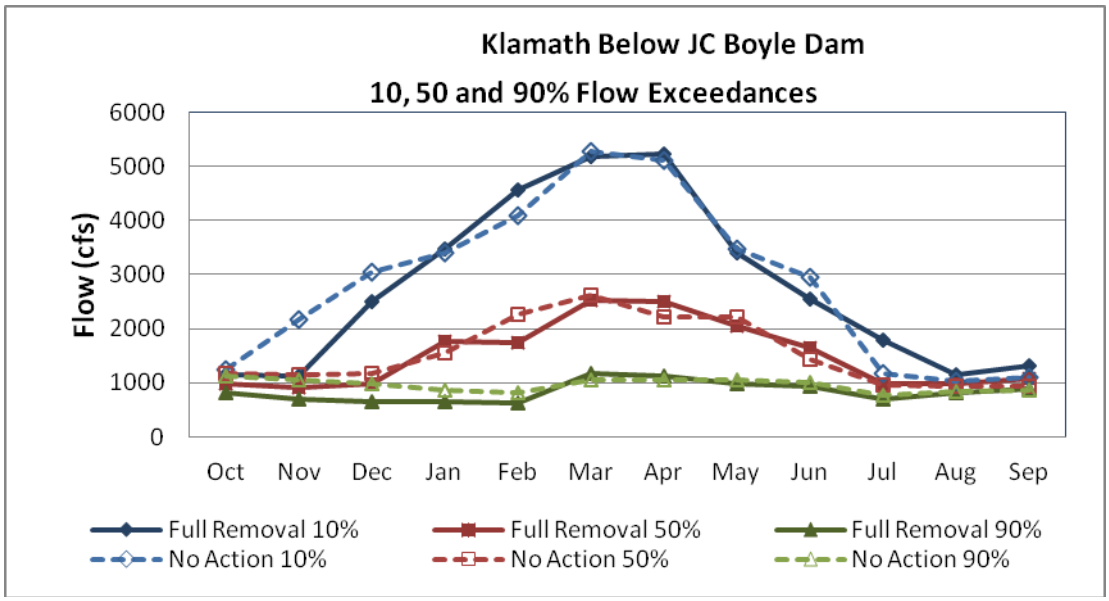


Figure 3.6-8. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Below J.C. Boyle Dam.

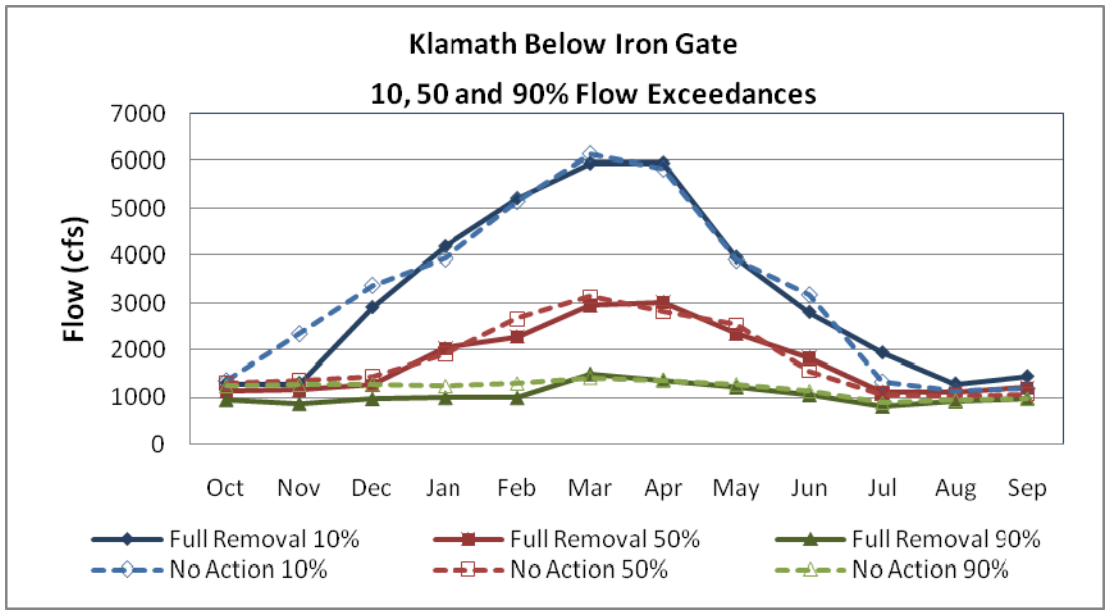


Figure 3.6-9. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Below Iron Gate Dam.

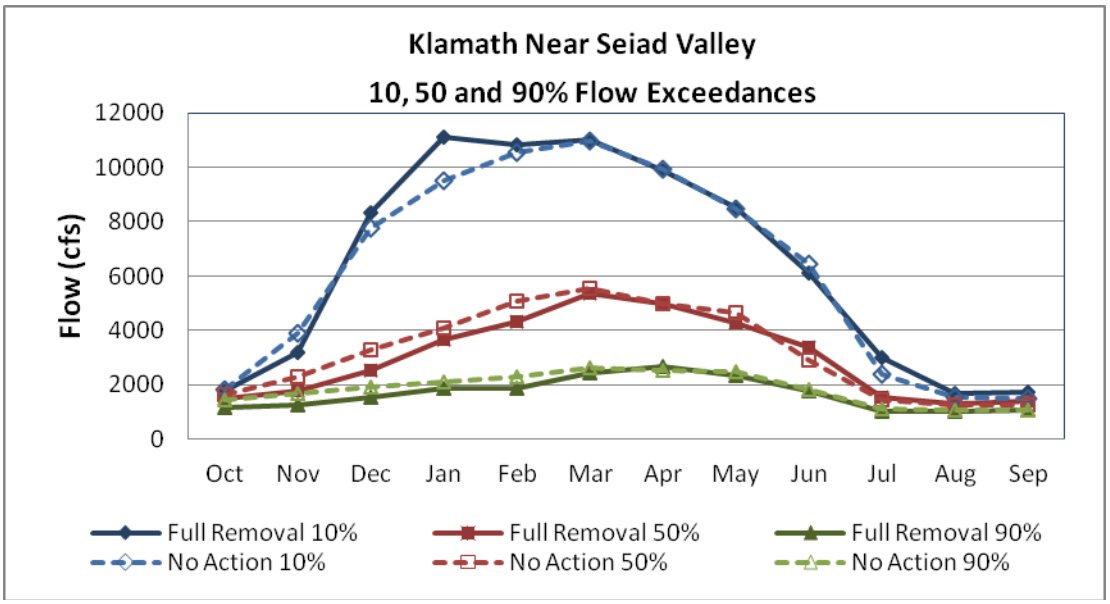


Figure 3.6-10. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Near Seiad Valley.

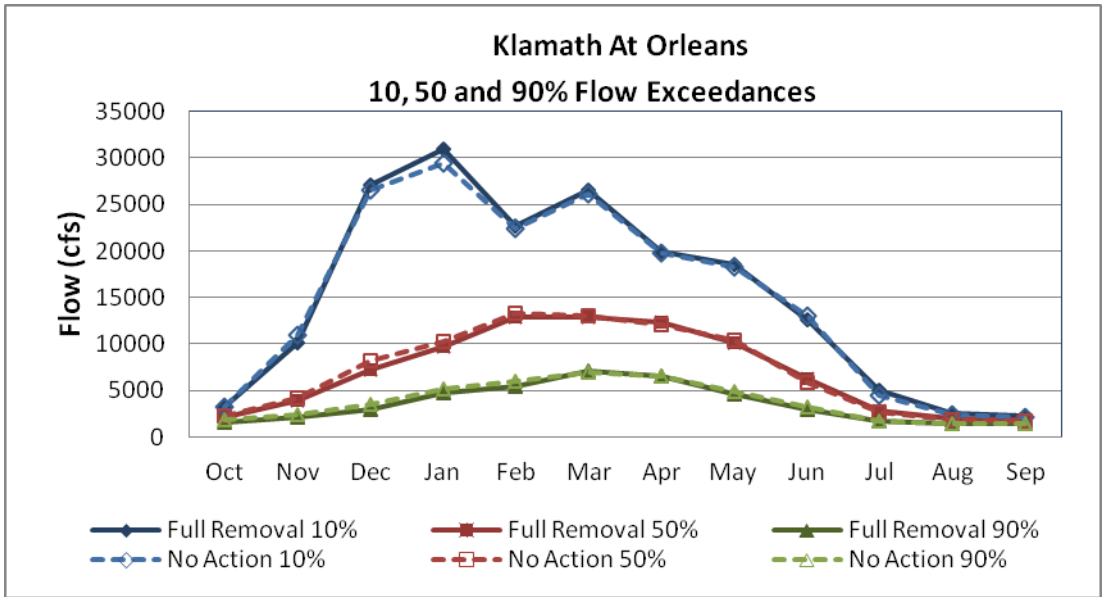


Figure 3.6-11. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action at Orleans.

J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams provide only incidental flood protection during flood events. Table 3.6-9 shows peak flood flows and shows flood attenuation of less than ~~5~~7 percent would have been provided by Iron Gate and Copco 1 Dams under the No Action/No Project Alternative~~.~~ for the 100 year flood. (J.C. Boyle and Copco 2 Dams have negligible capacity for flood attenuation.) Under the Proposed Action, the facilities would not be in place to provide this ~~temporary~~ reduction in peak flow.

Table 3.6-9. Flood Attenuation of Iron Gate and Copco 1 Reservoirs

Flood	Peak Flow No Action	Peak Flow Under the Proposed Action	% Reduction With Dams In
Synthetic 100-yr flood	31,460	33,800	6.9
1989	10,200	10,300	1.2
1993	11,100	11,400	2.7
1996	11,200	11,300	1.1
1997	20,500	21,400	4.0
2005	12,400	12,800	3.0

Source: ~~DOI 2011c~~Reclamation 2012b

Appendix J includes model results that show flood maps for the river reaches below Iron Gate Dam to Happy Camp. The series of figures show the 100-year floodplain under the No Action/No Project Alternative and the Proposed Action; the differences between the two floodplains are very minor. The mapping includes the effects of the increase in the 100 year flood peak flow rate and the small amounts of deposition due to the removal of the four facilities.

As described under No Action/No Project Alternative analysis, there are some differences in the current 100~~-~~ year flood inundation areas between FEMA and the model. These differences are attributable to the use of different base data and the use of enhanced elevation data by the Lead Agencies. FEMA is in the process of updating FIRMs using enhanced elevation data but has not accomplished this near the Klamath River.

DOI determined the existing floodplain by computing the 100 year flood and then mapping the extent of that floodplain on the existing topography. The existing floodplain may be different than that ~~proposed~~designated by FEMA because it is based upon more current information. DOI also ~~determined the 100-yr~~simulated a 100 year floodplain after dam removal. Though FEMA ultimately would determine the 100 year floodplain for the Klamath River after dam removal, for the sake of this NEPA/ CEQA analysis, DOI modeled possible changes to downstream flood risk to evaluate how hydrologic changes associated with dam removal might impact the river and property owners downstream from Iron Gate Dam. Based upon the most current inventory of structures downstream ~~of~~from Iron Gate Dam to Humbug Creek over 24 residences are within the existing 100 year flood plain. Less than 6 residences and other structures such as garages are outside of this flood plain, but may be put into the 100 year floodplain after removal of the dams. ~~However,~~ Klamath Ranch Resort is just downstream from Iron Gate Dam and includes several structures and associated infrastructure (e.g. septic tanks, utilities, and roads). This is the largest enterprise that could be affected by a change in the 100 year floodplain, 100 year flood peak flow, and the release of sediment downstream if dams were removed; the final determination of the future 100~~-yr~~ year floodplain after dam removal will be made by FEMA. The purpose of the analysis was to estimate the costs to mitigate the increase in flood risk.~~ The existing bridges are within the 100-year floodplain; however, these structures would need to be evaluated to determine if they would still maintain enough clearance to not be inundated by flooding.~~ If dam removal was pursued under the Proposed Action, the Dam Removal Entity would work with property owners to get full descriptions of property, buildings, and infrastructure; assess risks in more detail; and discuss feasible mitigation options as needed.

All the bridges over the Klamath River from Iron Gate to Hambug Creek were evaluated to determine the effects of the increase in the 100 year flood (Reclamation, 2012). All the bridges intended for vehicle traffic have more than 3 ft of freeboard for the 100 year flood under the Proposed Action. CalTrans requires that there is 2 ft of clearance below the low cord for the 50 year flood and that the 100 year flood passes under the low cord. The potential for increasing scour at the bridge piers was also evaluated. In all cases except the Rail Bridge (RM 183.3), the scoured bed elevation will not decrease more than 0.2 ft due to the Future Dams Out alternative. This is not considered a significant change in scour elevation considering the uncertainty associated with scour computations and the

conservatism used in scour computations. The largest change to the scour elevation is at the Rail Bridge where it is expected to decrease approximately 1.2 ft. The change in scour elevation is not considered to affect significantly the structural integrity of the piers considering likely presence of bedrock near the riverbed that will limit scour at this location. Further investigations are planned to confirm the geologic conditions at this site. Therefore, no improvements to the existing bridges should be necessary to convey flows under the Proposed Action.

Not all of the structures that could be exposed to increased flooding risks are permanent. However, an increase in risk to one habitable structure or bridge is considered to be significant according to the significance criteria. Mitigation measures H-~~-~~1 and H-2 are described below.

Modeled flows represent average monthly conditions, but peak flows for fisheries and storms could result in greater flows for a short duration. Table 3.6-9 shows the flood attenuation during a 100-year storm, and the dams provide an even smaller percent attenuation during a peak flow event. During high flow periods, the existing flood control capacity with the four dams would do little to reduce flood damage. Therefore, there would be little change to flood control capacity after the four dams are removed.

While high-flow events would experience only minor changes in magnitude under the Proposed Action, the timing of the storm peak could change. Modeling indicates that during a 100-year storm, the peak flows could reach downstream areas approximately 10 hours sooner under the Proposed Action compared to the No Action/No Project Alternative (Reclamation 2012b). This change could reduce the time that residents have to prepare for floods; however, the change would not substantially increase the risk that residents would be unprepared. The National Weather Service uses weather and watershed models to predict how potential storms and precipitation forecasts could affect the Klamath basin and typically provides flood warnings days in advance. The National Weather Service is now using newer methods of predicting storms that allow a prediction two days in advance that is as accurate as a one-day prediction was five years ago (Haynes and Soulliard 2010).

When a large flood event is predicted, the National Weather Service provides river stage forecasts for the Klamath River for the USGS gages at Seiad Valley, Orleans and Klamath. They currently do not publish a forecast for river stage at Iron Gate gage. However, they work with PacifiCorp to issue flood warnings to Siskiyou County. After removal of Copco and Iron Gate Dams, it is likely that National Weather Service will publish a forecast at the Iron Gate gage location (~~DOI 2011c).~~ Reclamation 2012b). Adding flood forecasting information at this site would improve information disseminated to the residents downstream.

Both Klamath County (Klamath County 2010b) and Siskiyou County participate in the NFIP and rely on existing 100-year flood maps prepared by FEMA to plan for future development or management near flood prone areas. Regulations under the NFIP require participating communities to “inform FEMA of any physical changes that affect 100-year flood elevations…within 6 months of the date that such data are available.” This

information is submitted in the form of a LOMA-F or LOMR by the community. FEMA will review the submitted data and determine if a map revision is warranted and proceed accordingly (FEMA 2002). Removal of the four dams would change the 100-year flood inundation zone when compared to the current FEMA map. This would require either a LOMA-F or LOMR to be prepared by Klamath and Siskiyou Counties for areas within their jurisdictions. Both counties might require the DRE or other responsible agency to work with them to prepare the application. In Klamath County, the FEMA 100-year flood inundation area would change due to removal of J.C. Boyle Reservoir.

The change to the 100-year floodplain inundation area downstream from Iron Gate Dam would increase the risks of flooding structures; therefore, the impact on flood hydrology would be significant. Mitigation Measures H-1 and H-2 would reduce the impact to flood hydrology to less than significant.

Removing the Four Facilities could reduce the risks associated with a dam failure. ~~The~~ As discussed in the No Action/No Project Alternative, the Four Facilities~~, collectively,~~ store over 169,~~000~~ 000 acre-feet of water ~~when they are full.~~that could inundate a portion of the watershed if the dams fail (Siskiyou County Web Site 2011). The dams are inspected regularly, and the probability for failure has been found to be low. ~~However, if a dam failed, it could inundate a portion of the downstream watershed (Siskiyou County website 2011).~~ Removing the Four Facilities would eliminate the potential for dam failure and subsequent flood damages. **Therefore, eliminating the dam failure risk associated with the Four Facilities would have a beneficial effect on flood hydrology.**

~~*The relocation of the Yreka water supply pipeline could affect river flows and result in changes to flood risks.* The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the reservoir to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline could either be suspended from a pipe bridge across the river near its current location, or rerouted along the underside of the Lakeview Bridge just downstream of Iron Gate Dam. The pipe bridge would be located above the 100 year flood line as the intention is to prevent the pipeline from being exposed to high velocity flows. Thus, the pipe bridge would not affect flood hydrology. If the pipeline was placed on the Lakeview Bridge, there would be no effect to flood hydrology from the placement of the pipeline that would be directly caused by the pipeline separate from the bridge. **Therefore, there would be no change from existing conditions from flood risk from the relocation of the Yreka water supply pipeline.**~~

Under the Proposed Action, recreational facilities currently located on the banks of the existing reservoirs would be removed following drawdown and could change flood hydrology. The existing recreational facilities provide camping and boating access for recreational users of the reservoirs. Once the reservoirs are drawn down, these facilities would be removed. These facilities would be well above the new river channel, and deconstruction would not place anything in the channel or otherwise impeded low or high

flows in the Klamath River. **Therefore, there would be no change from existing conditions from flood hydrology from the removal of the recreational facilities.**

Keno Transfer

Implementation of the Keno Transfer could cause changes to operations affecting flows downstream ~~of~~ from Keno Dam, which could cause changes to flood risks. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on flood hydrology compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice. **Implementation of the Keno Transfer would have no change from existing conditions from flood risks.**

East and ~~West Side~~Westside Facilities – Programmatic Measures

Decommissioning the East and ~~West Side~~Westside Facilities could cause changes in flood risk downstream ~~of~~from the facilities. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA ~~will redirect water flows currently diverted~~would eliminate the need for diversions at Link River Dam into the two canals~~, back in to Link River.~~. Following decommissioning of the facilities there ~~will~~would be no change in outflow from Upper

Klamath Lake or inflow into Lake Ewauna. Therefore, implementation of the East and ~~West Side~~Westside Facility Decommissioning action would result in no change from existing conditions.

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

The relocation of the Yreka Water Supply Pipeline could affect river flows and result in changes to flood risks. The existing water supply pipeline for Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the reservoir to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would be suspended from a pipe bridge across the river near its current location. The pipe bridge would be located above the 100 year flood line as the intention is to prevent the pipeline from being exposed to high velocity flows. Thus, the pipe bridge would not affect flood hydrology. Therefore, there would be no change from existing conditions from flood risk from the relocation of the Yreka Water Supply Pipeline.

KBRA – Programmatic Measures

The KBRA, which is a ~~component of~~connected action to the Proposed Action, encompasses several programs that could affect flood hydrology, including:

- Phases I and 2 Fisheries Restoration Plan
- Wood River Wetland Restoration
- Future Storage Opportunities
- On-Project Plan
- Water Use Retirement Program
- Emergency Response Plan
- Water Diversion Limitations
- Climate Change Assessment and Adaptive Management
- Interim Flow and Lake Level Program

3.6.4.3.3 Phases 1 and 2 Fisheries Restoration Plans

Implementation of the Fisheries Restoration Plans could change flows downstream ~~of~~ from Upper Klamath Lake, which could result in changes to flood risks. Actions within the floodplain and river channel including: floodplain rehabilitation, large woody debris replacement, fish passage correction, cattle exclusion fencing, riparian vegetation planting, and treatment of fine sediment sources could alter river hydraulics. The restoration actions are designed to improve aquatic and riparian habitat and the potential changes in river hydraulics are intended to improve the habitats' ability to support river fisheries. Changes in river hydraulics could generate minor changes in flood risks in and around the specific restoration locations. The timing of and specific locations where these resource management actions could be undertaken is not certain but it assumed that some of these actions could occur at the same time and in the vicinity of the hydroelectric facility removal actions analyzed above. **However, potential changes in river hydraulics are likely to generate a less than significant impact to flood risks.**

Implementation of specific plans and projects outlined in the Fisheries Restoration Plans will require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.

3.6.4.3.4 Wood River Wetland Restoration

Implementation of Wood River Wetland Restoration may change flows upstream and downstream ~~of~~from Upper Klamath Lake, which could result in changes to flood risks. A study of future Wood River Wetland area management options would be conducted to provide additional water storage for a total of 16,000 acre-feet of storage capacity in or adjacent to Agency Lake. This additional storage upstream of Upper Klamath Lake is likely to decrease potential flood risks downstream ~~of~~from Upper Klamath Lake by potentially storing excess flows. The improvements in flood risk generated by implementation of the Wood River Wetland Restoration Project would not be expected to contribute to the effects of hydroelectric facility removal analyzed above. **Implementation of the Wood River Wetland Restoration Project is anticipated to have a beneficial effect on flood risks. Implementing Wood River Wetland Restoration will require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

3.6.4.3.5 Future Storage Opportunities

Implementation of Future Storage Opportunities by Reclamation may cause changes to flows upstream and down downstream ~~of~~from Upper Klamath Lake, which could result in changes to flood risks. Reclamation plans to identify and study additional off-stream storage opportunities with a 10,000 acre-feet of storage milestone in implementation of KBRA. Offstream storage is likely to decrease potential flood risks by potentially storing excess flows. The improvements in flood risk generated by development of off-stream storage would not be expected to contribute to the effects of hydroelectric facility removal analyzed above. **Implementation of Future Storage Opportunities is anticipated to have a beneficial effect on flood risks. Implementing Future Storage Opportunities will require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

3.6.4.3.6 On-Project Plan

Implementation of the On-Project Plan may change flows downstream ~~of~~from Upper Klamath Lake during dry years, which could result in changes to flood risks. The On-Project Plan supports full implementation of Water Diversion Limitations by taking actions to reduce water use for irrigation. These actions include: land fallowing and shifting to dryland crop alternatives, changes in land use and forage availability/types for terrestrial species, efficiency and conservation measures (i.e. drip irrigation), development of groundwater sources, or creation of additional storage. Reductions in water use under the On-Project Plan would not be expected to contribute to any changes in flood risk generated by the hydroelectric facility removal action. **Implementation of the On-Project Plan is likely to generate no change in flood risk when compared to existing conditions as it would be implemented during dry years during the irrigation season when flood risks are low. Implementing the On-Project Plan will require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

3.6.4.3.7 Water Use Retirement Program (WURP)

Implementation of the WURP would change flows upstream of Upper Klamath Lake, which could result in changes to flood risks. The WURP is a voluntary program for the purpose of supporting fish populations restoration by permanently increasing inflow to Upper Klamath Lake by 30,000 acre-feet per year. A variety of management measures and irrigation water use changes would help to accomplish an inflow increase and are described in Section 2.4.3.9. Upper Klamath Lake storage has already increased after breaching of levees and dikes by the Williamson River Delta project which would be large enough to accommodate the inflow increase. Other KBRA measures described below would manage outflow to the Klamath River. Reductions in water use under the WURP would not be expected to contribute to any changes in flood risk generated by the hydroelectric facility removal action. **Implementation of the WURP is expected to generate no change in flood risks when compared to existing conditions because flow changes would be implemented during the irrigation season and not the flood season. Implementing the WURP will likely require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

3.6.4.3.8 Emergency Response Plan

Implementation of an Emergency Response Plan could result in changes to flood risks in the event of failure to a Klamath Reclamation Project facility or dike on Upper Klamath Lake or Lake Ewauna. The purpose of the plan is to prepare water managers for an emergency affecting the storage and delivery of water needed for KBRA implementation. The components of the Emergency Response Plan are described in Section 2.4.3.9 and include potential emergency response measures and processes to implement emergency responses. While use of an Emergency Response Plan could potentially reduce damage to property or loss of life due to a facility or dike failure, the intent of this plan is to allow for continued storage and delivery of water according to KBRA commitments and would not affect the probability of experiencing a flood. Additionally the Emergency Response Plan would not be expected to contribute to any changes in flood risk generated by the hydroelectric facility removal action. **Therefore, it is anticipated that implementation of the Emergency Response Plan would generate no change in flood risk when compared to existing conditions, although it would likely help to reduce damage to property or loss of life due to a flood event which would be a beneficial effect to flood risks. Implementing the Emergency Response Plan will likely require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

3.6.4.3.9 Climate Change Assessment and Adaptive Management

Implementation of Climate Change Assessment and Adaptive Management may change flows upstream and downstream ~~of~~from Upper Klamath Lake, which could result in changes to flood risks. One of the main purposes of Climate Change Assessment and Adaptive Management is to respond to and protect basin interests from the adverse affects of climate change. Flood risks could be adversely impacted due to climate changes which increase river flows and/or flooding frequency. Klamath Basin Parties including technical experts would be involved in the development of assessment and adaptive management strategies. Assessments and development of adaptive management strategies would be implemented continuously to respond to predicted climate changes.

The improvements in flood risk generated by the Climate Change Assessment and Adaptive Management Program would be expected improve the effects of hydroelectric facility removal analyzed above. **While flood risks could be adversely impacted by climate change in general, implementation of Climate Change Assessment and Adaptive Management would help to reduce flood risks in the event of climate changes and be beneficial to flood risks. Implementing Climate Change Assessment and Adaptive Management will likely require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.**

Interim Flow and Lake Level Program

Implementation of Interim Flow and Lake Program during the interim period would change river flows, which could result in changes to flood risks. The goal of the Interim Flow and Lake Level Program is to "further the goals of the Fisheries Program" during the interim period. This would require changes in flows to accommodate fish needs during the irrigation season. ~~These flow changes would be similar to what is currently recommended under biological opinions.~~ Changes in water flows under the Interim Flow and Lake Level Program would not be expected to contribute to any changes in flood risk generated by the hydroelectric facility removal action. **Therefore, implementation of the Interim Flow and Lake Level Program would cause no change in flood risk from existing conditions because flow changes would not be implemented during the flood season.**

3.6.4.3.10 Alternative 3: Partial Facilities Removal of Four Dams

Under the Partial Facilities of Four Dams Alternative, impacts would be the same as for the Proposed Action. While this alternative would leave some facilities in place, it would remove enough of the facilities to allow a free-flowing river at all times and would not alter flood effects discussed under the Proposed Action. **The increased flood risks would be less than significant. The change in the 100-year floodplain downstream from Iron Gate Dam would increase the risks of flooding structures and would be significant. Mitigation measures H-1 and H-2 would reduce this impact to less than significant. Eliminating the dam failure risk would have a beneficial effect.**

Keno Transfer

The flood hydrology impacts of the Keno Transfer under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

East and ~~West Side~~Westside Facilities – Programmatic Measures

The surface water and hydrology impacts of the decommissioning the East and ~~West Side~~Westside canals under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

The surface water and hydrology impacts of relocating Yreka's Water Supply Pipeline under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

KBRA – Programmatic Measures

Under this alternative, the KBRA would be fully implemented and the potential effects would be the same as described for the Proposed Action. **Implementation of the KBRA would result in a less than significant impact to flood hydrology.**

3.6.4.3.11 Alternative 4: Fish Passage at Four Dams

Under the Fish Passage at Four Dams Alternative, flows downstream ~~of~~ from Iron Gate Dam would remain the same as for the No Action/No Project Alternative. The risk of dam failure and downstream flooding would be the same as under the No Action/No Project Alternative and existing condition. Within the Hydroelectric Reach, however, flows would change to accommodate the new fish ladders and requirements within the bypass reaches. Flows within the J.C. Boyle Bypass Reach would increase to meet fish needs in this area. Although the flows would increase compared to the No Action/No Project Alternative, the existing channel capacity is adequate to accommodate these increases. Flows downstream ~~of~~from Iron Gate Dam would not change. **Therefore, the effects from Fish Passage at Four Dams Alternative on flood hydrology would be less than significant because the river channel capacity can support flow increases and there would be no increased risks of flooding.**

3.6.4.3.12 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Drawdown of reservoirs could result in short-term increases in downstream surface water flows and result in changes to flood risks. Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, short-term drawdown of reservoirs would occur at Copco 1 and Iron Gate dams, with the same effects as for the Proposed Action. No drawdown would occur in Klamath County because J.C. Boyle Reservoir would remain in place. As described in the Proposed Action, **drawdown-related impacts to flood risks for the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less than significant because flow changes would be within the historic range.**

The release of sediment stored behind Copco 1 and Iron Gate dams and resulting downstream sediment deposition could result in changes to flood risks. Approximately 46 to 81 percent of sediment behind Copco 1 Dam, and 25 to 38 percent of sediment behind Iron Gate Dam would be eroded and flushed down the river during removal activities (~~DOI 2011c).~~Reclamation 2012b). As was described and analyzed above for the Proposed Action, the magnitude of sediment deposition is relatively small compared to sediment loading from other existing sources along the Klamath River. Additionally, the sedimentation would be short~~-~~ term following dam removal. Because the sediment deposition would be short~~-~~ term and small in comparison with the No Action/No Project Alternative, it would not affect stream characteristics in a way that would substantively affect flood inundation or flood risks. **Therefore, sediment deposition would have a less than significant effect on flood risks.**

The 100-year floodplain inundation area downstream ~~of~~from Iron Gate Dam could change between River Mile 190 and 105 (study area). Removing Copco 1 and Iron Gate would result in a change in flows downstream ~~of~~ from Iron Gate Dam. These changes

would be less than the Proposed Action, but could result in flooding to some structures in the 100-year floodplain. Additionally, flow requirements in the J.C. Boyle Bypass Reach would increase flows, but similar to the Fish Passage at Four Dams Alternative, these changes would be within the historic range of flows in this reach. **The change to the 100-year floodplain inundation area downstream from Iron Gate Dam would increase the risks of flooding structures; therefore, the impact on flood hydrology would be significant. Mitigation measures H-1 and H-2 would reduce the impact to flood hydrology to less than significant.**

Removing Copco 1 and Iron Gate Dams could reduce the risks associated with a dam failure. Copco 1 and Iron Gate Dams together store over 90,000 acre-feet of water when they are full. The dams are inspected regularly, and the probability for failure has been found to be low. However, if a dam failed, it could inundate a portion of the downstream watershed (Siskiyou County ~~website~~Web Site 2011). Removing the dams would eliminate the potential for dam failure and subsequent flood damages. J.C. Boyle Dam would still be in place, and the potential for dam failure would be the same as in the No Action/No Project. The inundation area, however, could change because removal of the downstream facilities would affect flow patterns. **Overall, eliminating the dam failure risk associated with Copco 1 and Iron Gate Dams would have a beneficial effect on flood hydrology.**

~~*The relocation of the Yreka water supply pipeline could affect river flows and result in changes to flood risks*. Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, relocation of the Yreka water supply pipeline would occur at Iron Gate dam, with the same effects as for the Proposed Action. As described in the Proposed Action, **there would be no change from existing conditions from flood risks from the relocation of the Yreka water supply pipeline.**~~

Recreational facilities currently located on the banks of Iron Gate and Copco reservoirs would be removed following drawdown and could change flood hydrology. Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, recreation facilities would be removed at Iron Gate and Copco reservoirs, with the same effects as for the Proposed Action. **Therefore, there would be no change from existing conditions flood hydrology from the removal of the recreational facilities.**

Construction of a new gage within the 100-year floodplain at Copco 2 Dam or J.C. Boyle Dam to measure flows could affect flood hydrology. Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative a new gage would need to be developed at Copco 2 Dam or J.C. Boyle Dam to measure flows required to protect fish habitat downstream. Incorporation of environmental measures in the project would avoid construction-related impacts from construction in the floodplain. **The construction of a new gage would be a less than significant impact.**

Changes in flows in the Hydroelectric Reach including the J.C. Boyle and Copco 2 ~~bypass~~Bypass Reaches could affect flood hydrology. Similar to the analysis stated under the Fish Passage at Four Dams Alternative, flows would change to accommodate the new fish ladders and requirements within the bypass reaches. As stated under the Fish

Passage at Four Dams Alternative, **the effects on flood hydrology would be less than significant because the river channel capacity can support flow increases and there would be no increased risks of flooding.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures
The surface water and hydrology impacts of relocating Yreka's Water Supply Pipeline under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as for the Proposed Action.

3.6.4.4 Mitigation Measures

3.6.4.4.1 Mitigation Measure by Consequence Summary

Mitigation Measure H-1: ~~Prior to dam removal~~Once there is a positive determination, the DRE will inform the National Weather Service (NWS), River Forecast Center, of a planned major hydraulic change (removal of four dams) to the Klamath River that could potentially affect the timing and magnitude of flooding below Iron Gate.~~–~~ The River Forecast Center is the ~~federal~~Federal agency that provides official public warning of floods.~~ As needed, the River Forecast Center would update their hydrologic model of the Klamath River to incorporate these hydraulic changes so that changes to the timing and magnitude of flood peaks would be included in their forecasts.~~ The NWS currently forecasts flood elevations at the Seiad Valley gage on the Klamath River and at several points downstream, which are all downstream from the Four Facilities. After the removal of the Four Facilities, the Lead Agencies will work with NWS to allow it to forecast floods at Iron Gate gage as well, located just downstream from Iron Gate Dam. Shifting the analysis point upstream will help increase the warning time available to respond to flood conditions.

If there is a positive determination, NWS will begin evaluating the natural stream response of the Klamath River between Upper Klamath Lake and the location of Iron Gate Dam, which includes characterizing the hydrologic response of tributaries entering this river reach and routing water (from upstream sources and tributary inputs) through this reach without dams and reservoirs (the natural channel). In addition, at least two new stream gaging stations will be installed and operated to assist in the calibration of the model. Key locations would likely include a larger tributary that enters the PacifiCorp Hydroelectric Reach (e.g. Jenny Creek) and another gage on the main-stem river (e.g. near the current location of Copco 1 Dam). The gage on the tributary will be installed several years prior to dam removal to ensure that there is adequate time to develop a flood warning at the Iron Gate stream gage. The updates needed are similar to those that are regularly performed by the NWS when operating the models. Because the dams are not operated for flood control and have limited influence on the peak discharges at Iron Gate Dam, the historical stream gaging information can still provide valuable information in the development of a flood warning model at Iron Gate Gage and therefore, NWS will not be only reliant upon the new stream gaging.

As currently occurs, flood forecasts and flood warnings would be publicly posted by the River Forecast Center for use by ~~federal, state~~Federal, State, county, tribal, and local agencies, as well as the public, so timely decisions regarding evacuation or emergency response could be made.~~–~~

Prior to dam removal, the DRE will inform FEMA of a planned major hydraulic change to the Klamath River that could affect the 100-year flood plain. The DRE will ensure recent hydrologic/hydraulic modeling, and updates to the land elevation mapping, will be

provided to FEMA so they can update their 100-year flood plain maps downstream ~~of~~ from Iron Gate Dam (as needed), so flood risks (real-time and long~~-~~ term) can be evaluated and responded to by agencies, the private sector, and the public.

Mitigation Measure H-2: The DRE will work with willing landowners to ~~move or relocate~~develop and implement a plan to address any increased flood threat generated by changes to the
100-year flood inundation area as a result of the removal of the Four Facilities for permanent, legally established, permitted, habitable structures in place before dam removal. ~~The DRE will move~~Such plan could include measures to move, modify, or elevate structures where feasible~~ that could be affected by changes to the 100-year flood inundation area as a result of the removal of the Four Facilities.~~ .

3.6.4.4.2 Effectiveness of Mitigation in Reducing Consequence

These mitigation measures will be effective as they will identify the extent of the increased flood risks and take measures which will reduce the risks for loss, injury or death from flooding.

3.6.4.4.3 Agency Responsible for Mitigation Implementation

The DRE would be responsible for implementing mitigation measures H-1 and H-2.

Mitigation Measures Associated with Other Resource Areas

Implementation of Mitigation REC-1 would create a plan to develop recreational facilities and access points along the newly formed river channel between J.C. Boyle Reservoir and Iron Gate Dam. Recreation facilities, such as campgrounds and boat ramps, currently located on the edge of the reservoir would need to be replaced in appropriate areas near the new river channel once the reservoir is removed. These facilities will not contribute to channelization of the river and thus increase flood risks, or create infrastructure in the flood plain that would be at risk of damage during inundation. **Therefore, there would be no change from existing conditions to Flood Hydrology from the implementation of REC-1.**

3.6.5 References

Abney, R.M. 1964. A Comparative Study of the Past and Present Condition of Tule Lake. October 30, 1964. p. 3.

Akins, G.J. 1970. The Effects of Land Use and Land Management on the Wetlands of the Upper Klamath Basin. March 1970. pp. 34-36; pp. 43-50; and Figures 7-10.

Association of State Dam Safety Officials (ASDSO). 2000. California's Dam Safety Laws and Regulations Summary. July 2000.~~ Accessed on: 7-11-2011. Available at: http://www.damsafety.org/media/Documents/PDF/CA.pdf~~ Available at: http://www.damsafety.org/media/Documents/PDF/CA.pdf. Accessed on: July 11, 2011.

ASDSO. 2011. Top Issues Facing the Dam Community. ~~Accessed on: 7-11-2011. Available at: http://www.damsafety.org/news/?p=c0fdade4-ab98-4679-be22-e3d7f14e124f.~~ Available at: http://www.damsafety.org/news/?p=c0fdade4-ab98-4679-be22-e3d7f14e124f. Accessed on: July 11, 2011.

Bureau of Reclamation (Reclamation). 2005. Natural Flow of the Upper Klamath River – Phase I. November 2005.

~~Reclamation.~~ _____. 2010. Klamath Project 2010 Operations Plan. p. 1. ~~Accessed on: 11-08-2010.~~ Available at: http://www.usbr.gov/mp/kbao/operations/2010/2010_OPS_PLAN.pdf. Accessed on: November 8, 2010.

~~Department of the Interior (DOI), Reclamation. 2011a. Website – Klamath Project Information. Accessed on: 2-8-2011. Available at: http://www.usbr.gov/projects/Project.jsp?proj_Name=Klamath+Project~~

~~DOI, Reclamation. 2011b. Klamath Project 1010 Operations Plan. April 6. 2011.~~

~~DOI, Reclamation. 2011c. Technical Report No. SRH-2011-02, DRAFT~~ _____. 2012a. "Detailed Plan for Dam Removal – Klamath River Dams." Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO.

_____. 2012b. "Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration~~. March~~," Technical Report No. SRH-2011~~. p. 2-1; pp. 2-20 to 2-41; Section 6; Section 8; and Appendix A.~~-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO.

Department of the Interior (DOI~~.~~), Reclamation. 2011a. Web site – Klamath Project Information. Available at: http://www.usbr.gov/projects/Project.jsp?proj_Name=Klamath+Project. Accessed on: February 8, 2011.

_____, Reclamation. 2011b. Klamath Project 1010 Operations Plan. April 6. 2011.

_____. Undated. Secretary's Determination on Klamath River Dam Removal and Basin Restoration 100-year Flood Draft Inundation Mapping Map. Undated.

Desert Research Institute ~~Website.~~Web Site. 2011. Western U.S. Climate Historical Summaries.~~ Accessed on: 5-6-2011. Available at: http://www.wrcc.dri.edu/Climsum.html.~~ Available at: http://www.wrcc.dri.edu/Climsum.html. Accessed on: May 6, 2011.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project FERC Project No. 2082-027. November 2007. pp. 2-14; 3-62 thru 3-94; and 3-539 thru 3-543.

Federal Emergency Management Act Federal Insurance and Mitigation Administration. 2002. National Flood Insurance Program, Program Description. August 1, 2002. pp. 3-13.

~~Greimann, Blair P. 16 March 2011. (Hydraulic Engineer, Bureau of Reclamation, Denver Federal Center). Email correspondence with Chris Park of CDM, Sacramento, California.~~

Haynes, Alan and Soulliard, Letitia. 2010. Trends in Precipitation Forecasting Skill at the California Nevada River Forecast Center. In Western Regional Technical Attachment Lite 10-05. Available at: http://www.cnrfc.noaa.gov/publications/talite1005.pdf. Accessed on: February 20, 2012.

Klamath Hydroelectric Settlement Agreement (KHSA) 2010. February 18. 2010.

Klamath County. 2010a. Land Development Code, Article 59 Flood Hazard Zones.

Klamath County. 2010b. Comprehensive Plan for Klamath County, Oregon. January 2010 Audit. Goal 7 pp. Goal 7-1 thru Goal 7-4.

National Oceanic and Atmospheric Administration ~~Fisheries Service~~ (NOAA) Fisheries Service~~).~~. 2005. NOAA Technical Memorandum NMFS-NWFSC-66, Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead, June 2005. ~~Pp.~~ pp. 311-312.

NOAA Fisheries Service, Southwest Region. 2010. Biological Opinion, Operation of the Klamath Project Between 2010 and 2018. March 15, 2010. pp. 167 and 177.

U.S. Geological Survey (USGS) 2009a. Klamath River Water Quality Data from Link river Dam to Keno Dam, Oregon, 2008. ~~Accessed on May 9, 2011.~~ p. 2. Available at: http://pubs.usgs.gov/of/2009/1105/pdf/ofr20091105.pdf. ~~P. 2.~~ Accessed on: May 9, 2011.

~~U.S. Geological Survey.~~_____. 2009b. Water-Data Report 2009, 11516530 Klamath River below Iron Gate Dam, CA, Klamath River Basin.

~~U.S. Geological Survey Website.~~_____. 2011. Water Quality Data. Available at: http://waterdata.usgs.gov/ca/nwis/dv/?referred_module=sw. Accessed on: February 14, 2011. ~~Available at: http://waterdata.usgs.gov/ca/nwis/dv/?referred_module=sw~~

Siskiyou County. 1986. Siskiyou County, California Code, Title 10 Planning and Zoning, Chapter 6 Zoning, Article 54 Floodplain Combining Districts (F). February 27, 1986.

Siskiyou County, 1990. Siskiyou County, California Code, Title 10 Planning and Zoning, Chapter 10 Flood Damage Prevention. December 13, 1990. Section 10-10.07.6.

Siskiyou County. 1997. Siskiyou County General Plan Land Use Policies. October 9, 1997. Policies 21 thru 27.

Siskiyou County ~~Website.~~Web Site. 2011. Siskiyou County Multi-Jurisdictional Hazard Mitigation Plan. 2011. Available at: http://www.co.siskiyou.ca.us/PHS/

emerg/hazard_mitigation.aspx. Accessed on: June 29, 2011. ~~Available at: http://www.co.siskiyou.ca.us/PHS/emerg/hazard_mitigation.aspx.~~

Wallace, M. 1998. Seasonal Water Quality Monitoring in the Klamath River Estuary, 1991-1994 for the California Department of Fish and Game. Inland Fisheries Administrative Report No. 98-9.

Weddell, B.J., K.L. Gray, and J.D. Foster. Undated. History and Ecology of Lower Klamath, Tule Lake, Upper Klamath, and Klamath Forest National Wildlife Refuges, Oregon and California. Undated. p. 3.

3.7 Groundwater

This section of the Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) describes the changes in groundwater levels and availability that would be caused by the Proposed Action and alternatives.

3.7.1 Area of Analysis

This EIS/EIR's area of analysis, or "project area," for groundwater as related to the Klamath Hydroelectric Settlement Agreement (KHSA) includes the area within 2.5 miles upstream of J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs. The project area lies within Klamath County, Oregon, and Siskiyou County, California. The project area for the Klamath Basin Restoration Agreement (KBRA) with respect to groundwater is the Klamath basin upstream of Copco 1 Dam. This is the area covered by a United States Geological Survey (USGS)-Oregon Water Resources Department (WRD) groundwater model designed to determine effects on groundwater from pumping water for irrigation purposes. No model exists for areas below Copco 1 Dam. Groundwater issues, such as changes in groundwater levels or recharge, are described in this section~~, 3.7 Groundwater~~. Issues related to geology are described in Section 3.11, Geology, Soils, and Geologic Hazards.

3.7.2 Regulatory Framework

Groundwater resources within the area of analysis are regulated by the ~~state~~ State and local laws listed below.

3.7.2.1~~–~~ State Authorities and Regulations

- California Water Code (CWC §10750, §10753.7, §1702, §1706, §1727, §1736, and §1810) (California, State of)
- California Assembly Bill 3030 (CWC §10750 et seq.)
- California Senate Bill 1938 (Sections 10753.4 and 10795.4 of, to amend and renumber Sections 10753.7, 10753.8, and 10753.9 of, and to add Sections 10753.1 and 10753.7)
- Oregon Revised Statutes (Chapters 536 through 541) (Oregon, State of)
- California Department of Water Resources (DWR) Bulletin 118 (DWR 2003)

3.7.2.2~~–~~ Local Authorities and Regulations

- Siskiyou County Code (Title 3, Chapter 19) (Siskiyou County)

3.7.3 Existing Conditions/Affected Environment~~———~~

3.7.3.1 Groundwater Basin Hydrology Description

3.7.3.1.1 Regional Groundwater Conditions

The project area has few wells that completely characterize groundwater conditions. Gannett et al. ~~2010~~2007 completed the most recent and comprehensive attempt to estimate the water level gradients and flow patterns within the project area upstream and downstream ~~of~~from the four dam sites. Figures 3.7-1 and 3.7-2 show a generalized groundwater flow map for the Upper Klamath Basin and portions of the Lower Klamath

Basin. Figure 3.7-2 suggests that the regional groundwater flow patterns along the Klamath River downstream ~~of~~from Keno Dam are generally from the higher elevations (upland areas, mountain ranges, hills, etc.) toward the Klamath River, and from Keno Dam toward Iron Gate Dam (~~United States Department of the Interior [DOI]~~Bureau of Reclamation (Reclamation) 2011a). Figure 3.7-2 ~~suggests a~~shows a very steep groundwater ~~divide exists under~~ head gradient between Keno Dam~~. The~~ and the J.C. Boyle Reservoir. That steep head gradient suggests the presence of a groundwater ~~level contours suggest~~barrier and is also roughly correlative with the mapped trace of the Sky Lakes fault zone (Personius, 2003). A groundwater barrier at this location implies that the groundwater system above Keno Dam is ~~isolated~~separate from the groundwater system below Keno Dam.

The Lead Agencies reviewed the area around the reservoirs on USGS topographic 7½-minute quadrangle maps (Iron Gate and Copco Quadrangles in California; Spencer Creek and Chicken Hills Quadrangles in Oregon) (~~DOI 2011a~~Reclamation 2012a). Numerous springs, where groundwater discharges to the surface, are shown surrounding Iron Gate Reservoir. These springs occur at elevations from less than 50 to more than 300 feet (ft) above the reservoir level (~~DOI 2011a~~Reclamation 2012a). The maps also show springs around Copco Reservoir. These springs are similarly less than 50 to more than 800 ~~feet~~ft above the reservoir level (~~DOI 2011a).~~ Reclamation 2012a).

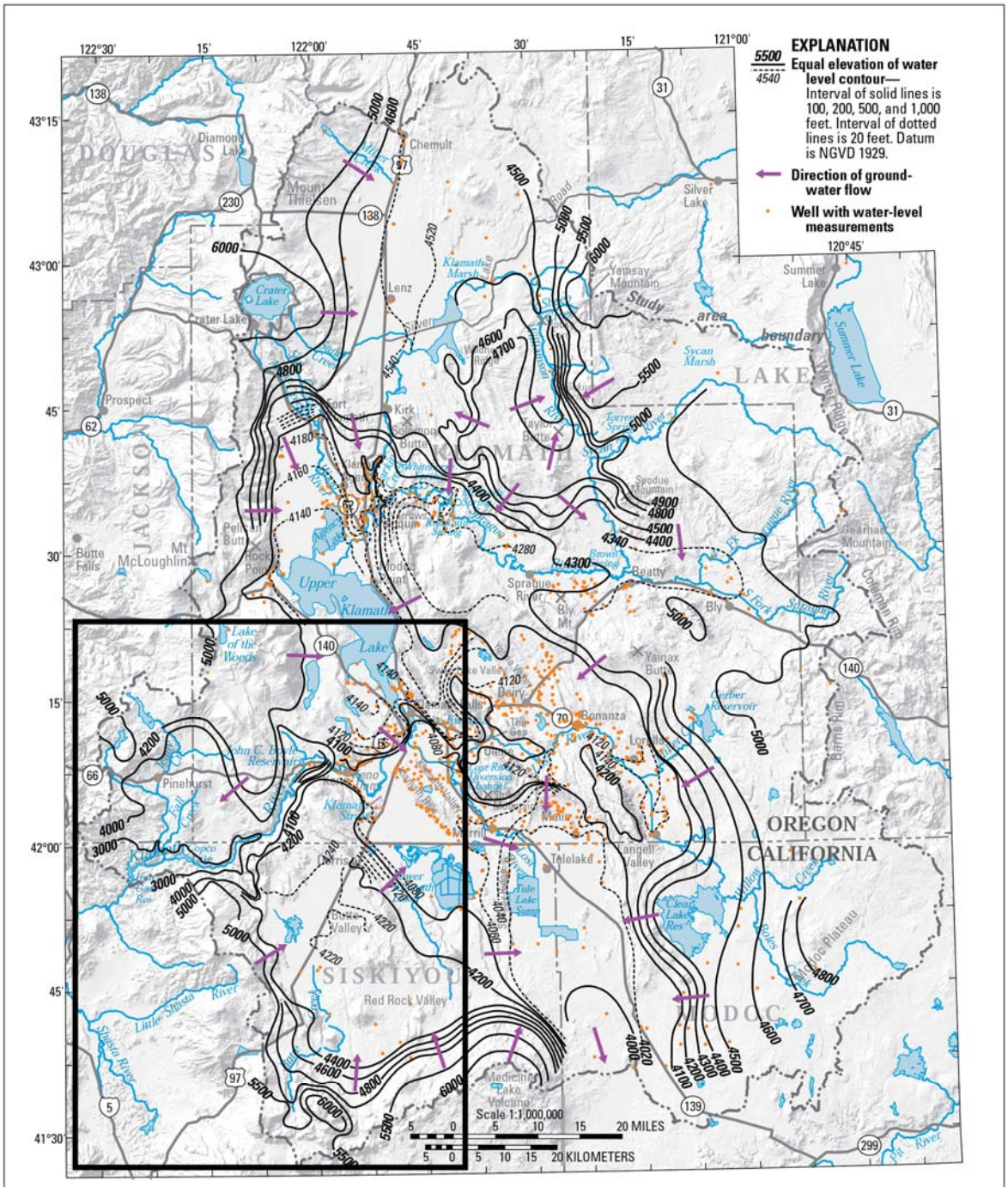
The USGS mapping shows a number of the small drainages that empty into Copco Reservoir have a spring at the headwater of the drainage. The maps show very few springs in the vicinity of J.C. Boyle Reservoir, and those that are shown are only a few tens of feet above the reservoir level (~~DOI 2011a~~Reclamation 2012a). However, many of the small drainages that empty into J.C. Boyle Reservoir have a spring at the headwater of the drainage (e.g., Spencer Creek (Gannett et al. ~~2010~~2007)). The presence of springs in the area suggests local groundwater systems, and possibly a regional groundwater system, that are not receiving water directly from the reservoirs (~~DOI 2011a~~Reclamation 2012a). That is, the water discharging from the springs is not thought to be reservoir water (~~DOI 2011a).~~

Reclamation 2012a).

The flows from the springs and the location of the springs could be influenced indirectly by the presence of a reservoir because the reservoir could create higher groundwater levels adjacent to the reservoir. These higher groundwater levels could cause groundwater levels to be increased as compared to the condition where the reservoir was not in place. These increased groundwater levels could rise to the ground surface and affect the location of a spring and the volume of water discharging from the spring. The level of hydraulic connection between the reservoirs and the spring systems is not known (~~DOI 2011a~~Reclamation 2012a).

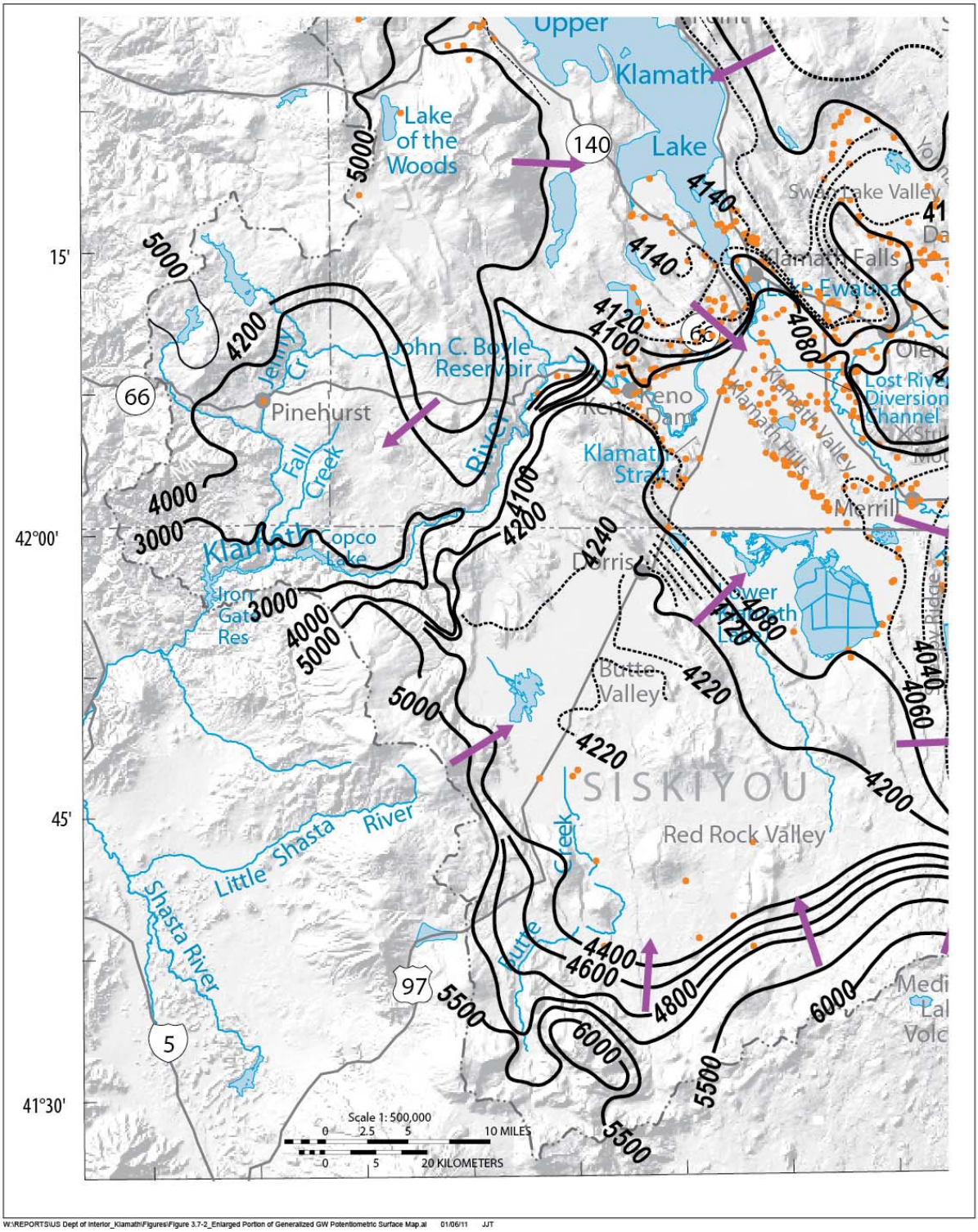
A spring complex about one mile below J.C. Boyle Dam contributes substantial flow to the river (Gannett et al. ~~2010).~~2007). The water discharging at this site may be originating from the local groundwater system. The flows could also be influenced by

seepage from the reservoir that is flowing around or under the dam and coming to the surface at the spring site. It is likely that the flows from this spring complex are influenced by both the local groundwater system as well as leakage from the reservoir (~~DOI 2011a~~Reclamation 2012a).



W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure 3.7-1_Generalized GW Potentiometric Surface Map.ai 01/06/11 JJT

Figure 3.7-1. Generalized Groundwater Potentiometric Surface Contour Map and Groundwater Flow Directions in the Upper Klamath Basin [after Gannett et al. ~~2010~~]2007].



W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure 3.7-2_Enlarged Portion of Generalized GW Potentiometric Surface Map.ai 01/06/11 JJT

Figure 3.7-2. Enlarged Portion of the Generalized Groundwater Potentiometric Surface Contour Map and Flow Directions for the Areas ~~Around~~around J.C. Boyle, Copco, and Iron Gate Reservoirs [after Gannett et al. ~~2010]~~2007].

Sources of Groundwater in Project Area

Groundwater in the project area is likely fed by the infiltration of precipitation and subsequent percolation ~~of precipitation~~ through the surface materials to the bedrock units. As Figures 3.7-1 and 3.7-2 show, at a regional scale, groundwater ~~appears to flow~~flows into the project area near the four dams from upland areas toward the Klamath River and the reservoirs. The figures show an apparent groundwater divide in the area just upstream of J.C. Boyle/Keno Impoundment. These figures also show the regional trends in groundwater elevations and flow paths. Where groundwater levels are above the river and reservoir elevations, it is generally assumed that groundwater levels in the vicinity of the reservoirs are supported by the regional groundwater system more so than by reservoir leakage. However wells immediately adjacent (potentially extending up to a mile from the reservoirs under certain conditions) to the reservoirs are more likely influenced by reservoir leakage where such leakage exists.

~~Local groundwater~~Groundwater in the project area is also ~~fed~~maintained by groundwater ~~underflow~~flows from ~~these~~ upgradient areas. In the absence of barriers to vertical flow, surface water infiltration is a common source of recharge to groundwater systems. Rivers, lakes and other surface water bodies are common sources of site specific infiltration recharge. Aerial precipitation is more of a dispersed, wide extent source of infiltration recharge. Given a regional groundwater flow direction toward the river and reservoirs in the project area, reaches are more likely receiving water from the groundwater systems than they are losing water to the groundwater systems, while reservoirs are more likely to lose water to the groundwater (~~DOI 2011a~~Reclamation 2012a). However, there are conditions where the reservoirs could be gaining water from the groundwater system(s) (~~DOI 2011a).~~Reclamation 2012a). The lack of data from groundwater wells in the area makes a more specific characterization of groundwater sources in the project area difficult.

Groundwater Sinks in Project Area

In areas where surface water levels are lower than the adjacent groundwater level, groundwater can discharge to the surface water (e.g., rivers, streams, and reservoirs). This would be called a groundwater "sink" because groundwater flows towards it and is lost from the groundwater system. Gannett et al. (~~2010~~2007) estimates that groundwater adjacent to the Klamath River discharges to the river in the project area. An average discharge of 190 cfs of groundwater for the reach from Keno Dam to downstream ~~of~~ from the J.C. Boyle Powerhouse and 92 cfs for the reach from there downstream to Iron Gate Dam is estimated (Gannett et al. ~~2010~~2007). These estimates are calculated for the length of each of these reaches based on gage data and changes in reservoir storage. These estimates may include some ungaged tributary inflows.

Groundwater pumping is also a typical process in the project area where water is removed from the groundwater system. In the project area, groundwater is pumped to the surface for domestic use and irrigation. Most domestic wells around the reservoirs are likely seasonal residences (i.e., owner's official address is different than the well location address) and are not expected to be a major groundwater sink in the project area (~~DOI 2011a~~Reclamation 2012a). Average well yields in Siskiyou County, California are just

over 19 gpm while in Klamath County, Oregon the average yield is just over 22 gpm (~~DOI 2011a~~Reclamation 2012a). Based on completion dates on well logs for Siskiyou County, an average of five new wells per year have been installed in the project area since 1963. In Klamath County the average is about three new wells per year since 1976, including the area around Keno and Keno Dam, Oregon (~~DOI 2011a~~Reclamation 2012a).

A large groundwater flow system exists in the Upper Klamath Basin (Gannett et al. ~~2010).~~2007). Groundwater is recharged in areas in the Cascade Range and upland areas surrounding the basin. Groundwater flows from these areas toward the interior of the basin and subbasins (Figure 3.7-1). Many of the streams in the interior of the basin are at least partially fed by groundwater discharge (Gannett et al. ~~2010).~~2007). Some streams are fed predominately by groundwater (i.e., baseflow) at a consistent rate throughout the year.

Groundwater is used in the Upper Basin to irrigate agricultural land as well as for domestic, industrial, and municipal purposes. Groundwater is used as a primary source of irrigation water where surface water is not available and also as a supplemental source when surface supplies are limited (Gannett et al. ~~2010~~2007).

Groundwater levels in the Upper Basin vary in response to ~~both~~ climatic ~~and pumping conditions. Climatic variations can vary the~~cycles, groundwater ~~level by five feet within the basin. The typical~~ pumping, lake levels, and canal operations. Typical annual drawdown and recovery cycles caused by groundwater pumping ~~can be~~are from one to ten ~~feet.~~ft. Groundwater use in the Upper Basin ~~has~~ increased by approximately 50 percent ~~since~~ in response to the 2001 biological opinion, primarily in the area surrounding Reclamation's Klamath Project. ~~The~~ This pumping increase resulted from changes in surface water management practices . Reclamation's groundwater acquisition program in 2001 and National Oceanic and Atmospheric Administration Fisheries Service's (NOAA Fisheries Service) requirement for a 100,000 acre-ft pilot water bank are the primary factors in this increase. The pilot water bank, which operated during the 2003, 2004, and 2005 water years, was required by the 2002 NOAA Fisheries Biological Opinion. The estimated groundwater pumping ~~has~~in the area was approximately 28,600 acre-ft in 2001. In 2004, pumping increased to approximately 69,300 acre-ft for water bank operations (Gannett 2012b).

Prior to 2001, groundwater levels were affected by typical climate-based fluctuations of approximately five ft resulting from cycles of dry and wet periods. Near centers of groundwater pumping for irrigation, water levels also typically varied between one and ten ft from year to year as a result of seasonal pumping. Following the increased pumping that started in 2002, groundwater levels have declined more than ten ft in portions of the deep water-bearing zones in the Klamath Valley. Overall, the increase in pumping resulted in groundwater levels dropping 10 to 15 ~~feet~~ft in portions of this area between 2001 and 2004 (Gannett et al. ~~2010~~2007).

Local Groundwater Conditions

The California DWR *Bulletin 118 – Update 2003, California's Groundwater*, delineates 515 groundwater basins and subbasins throughout the ~~state~~State. The area of analysis for the Proposed Action and alternatives does not fall within one of these delineated basins. The area is defined as a "groundwater source area" by the California DWR. A "groundwater source area" is "rocks that are significant in terms of being a local groundwater sources, but do not fit the [typical] category of basin or subbasin" (DWR 2003). The Klamath River from the Oregon-California Stateline to downstream from Iron Gate Dam is a predominantly non-alluvial river flowing through mountainous terrain. Downstream from the Iron Gate Dam, and for most of the river's length to the Pacific Ocean, the river maintains a relatively steep, high-energy, coarse-grained channel frequently confined by bedrock. Section 3.11, Geology, Soils, and Geologic Hazards, of this document describes project area geology in more detail.

Well information was obtained and reviewed from the databases of both the Oregon WRD and the California DWR to identify well logs for known domestic and irrigation wells within several miles upstream and downstream ~~of~~from the Four Facilities. Roughly 83 percent of the logs (300 out of 360 logs) ~~had~~included sufficient ~~information~~detail to ~~be able to identify with a reasonable amount of certainty~~locate the ~~locations of these~~ wells ~~in relation~~ relative to the reservoirs. Of the 300 logs for which reasonable coordinate data could be determined, only 63 wells were within 2.5 miles of one or more of the three reservoirs, 25 near Iron Gate, 22 near Copco 1 and 2, and 16 near J.C. Boyle (~~DOI 2011a).~~

Reclamation 2012a).

Using the local topography, reservoir bathymetry, and lithologic descriptions on the well logs, representative cross-sections ~~across various spans of~~ through the reservoirs and adjacent lands were ~~generated~~drawn such that each cross-section intersected at least one known well location. The cross-section for J.C. Boyle is presented below, and cross sections for Copco 1 and 2 and Iron Gate are presented in Appendix K. Each cross-section displays the topography, water surface elevation of the reservoir, well log ID, abbreviated well log lithology, and the static water level in the well. The water-bearing units in each well are presented in summary tables for each reservoir.

The following discussions of potential or possible impacts to the local wells from the Proposed Action are predicated on the ~~concept~~conceptual model that in order to be impacted, the water-bearing unit that each well is tapping must be hydraulically connected to the reservoir – either by having the water-bearing unit exposed to the surface (i.e., daylight) within the reservoir walls or being hydraulically connected to the reservoir through a series of permeable layers between the reservoir and the water-bearing unit.

The potential for impacts to the wells is further predicated on the relative elevation differences between the static water level in the well(s) and the water surface elevation of the reservoir. Specifically, if the water-bearing unit being tapped by any given well is in hydraulic connection with a reservoir, then the static water level in the well should be

similar or close to the water surface elevation in the reservoir. If the static water level is higher or lower than the reservoir level, and the water-bearing unit is not exposed along the reservoir walls, then it is likely that the water-bearing unit is reflecting a regional or local aquifer system influence in addition to, or in place of, the reservoir. If the water-bearing unit itself is entirely above the reservoir water levels, or is substantially deeper (more than three or four intervening impermeable units) than the lowest portion of the reservoir, then it would be unlikely that the water-bearing unit would be in hydraulic connection with the reservoir. It should be noted that the static water level in a well can vary from year to year based on preceding hydrologic conditions (i.e., climatic cycles, wet years vs. dry years).

J.C. Boyle Reservoir

The bedrock surrounding and underlying the J.C. Boyle Reservoir is principally composed of moderately well bedded to massive, moderately well-consolidated volcanic rocks of the High Cascade Geomorphic Province. Lava flows dominate the landscape and geologic strata and form many of the ridges above the reservoir. In the downstream portion of the reservoir (downstream from the Highway 66 bridge) young lava flows line the sides of the reservoir (~~DOI 2011a~~Reclamation 2012a). Section 3.11, Geology, Soils, and Geologic Hazards, provides additional geologic information.

The Oregon WRD well database identifies 50 wells within 2.5 miles of the J.C. Boyle Reservoir (Oregon WRD 2011). Sixteen of these 50 wells were able to be located geographically based on well addresses recorded on the drill logs or by comparing the well log information to ownership parcel data supplied by Klamath County. Ten of those 16 wells were shallow Oregon Department of Transportation borings near bridge footings. Figure 3.7-3 shows the locations of the wells that could be located. The construction details for these wells are outlined in Appendix K.

Three cross-sections that intersected at least one of the six wells were developed. ~~Figure~~ Figure 3.7-3 shows the locations of these cross-sections. Figures 3.7-4 and 3.7-5 show the cross-sections. The well parameters used to develop the cross-sections are summarized in Table 3.7-1.

The data in Table 3.7-1 suggests that the water-bearing volcanic units ~~of the High Cascade~~ are deeper than the bottom elevation of the reservoir (i.e., the pre-reservoir river bed) in wells 10059 and 51633. The static water level for each well is 50 to 100 ft below the bottom of the reservoir. The top of the water bearing layer and the static water level in well 14002 are similar to the elevation of the river bed (~~DOI 2011a~~Reclamation 2012a). Therefore, the reservoir level is unlikely to affect these wells.

The lateral extent, homogeneity/inhomogeneity, and degree of fracturing, of the volcanic deposits in the region are variable. Some degree of hydraulic connectivity exists between the reservoir and water bearing strata near the reservoir which allows downward migration of reservoir water. There may also be a zone of similar horizontal hydraulic connectivity around the reservoir. The extent and degree of connectivity is uncertain based on the limited well data. Both wells 10059 and 14002 have significant amounts of

clay recorded on the logs at depths between the top of their water bearing units and the equivalent depth of the old river bed that probably inhibits or significantly reduces the vertical migration of infiltration water from the reservoir. The extents of these clay units are uncertain (~~DOI 2011a~~Reclamation 2012a).

~~Comparison of the elevations of the static water levels in the six wells near J.C. Boyle reservoir shows that two wells downstream of the dam (13628, 14002) have static water levels 20 to 40 feet below the pre-dam river bed elevation (at the dam site); the two wells (10514, 10059) furthest away from the reservoir (4,721 feet and 5,518 feet from the reservoir) have static water level elevations nearly 100 feet below the pre-dam upstream river bed elevation; and the two wells near the shore of the reservoir have static water level elevations 20 to 30 feet below the pre-dam river bed elevation at the dam site. The static water level elevations in the wells furthest from the reservoir are near or below the static water level elevations for the wells closer to the reservoir. No clear determination of any trends in vertical head gradients can be drawn from the data of these six wells (DOI 2011a).~~

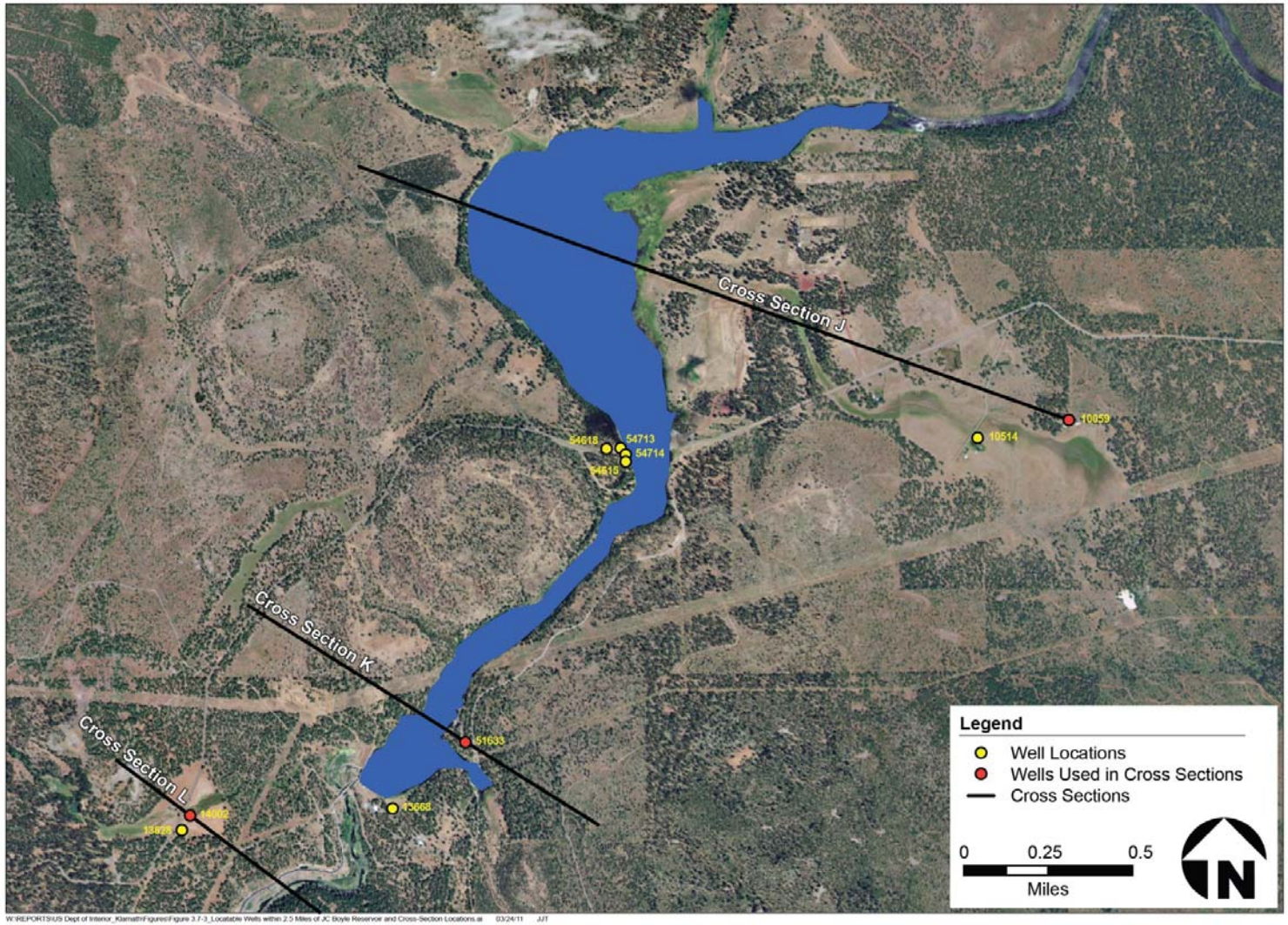


Figure 3.7-3. Locatable Wells within 2.5 Miles of J.C. Boyle Reservoir and Cross-Section Locations.

Table 3.7-1. Well Construction Information for Wells[1] within 2.5 Miles of J.C. Boyle Reservoir[2]

Well ID[3]	Drill Date	Well Diameter (in)	Depth to top of perforated zone or bottom of surface casing in an open well (ft)	Depth to bottom of perforated zone (ft)	Depth of Well (ft)	Depth to 1st Water (ft)	Pumping Rate (gpm)	Depth to Static Water (ft)	Located on Cross-Section	Static Water Elevation (ft)	Water-Bearing Unit and Top Elevation (ft)
10059	6/29/1990	6	159 [4]	Open	281	77	12	222	J	3,686	Brown lava and clay from 203 to 223 ft bgs interspersed with black rock from 212 to 215 ft bgs, and gray rock and clay, and gray rock from 223 to 281 ft bgs with bubbly brown lava from 257 to 280 ft bgs; Elevation 3,705 ft
14002	8/10/1988	6	99 [4]	Open	238	181	25	178	L	3,698	Hard gray volcanic rock from 181 to 238 ft bgs; Elevation 3,695 ft
51633	10/19/2006	6	280 [4]	Open	315	126	55	126	K	3,701	Gray and brown basalt from 126 to 315 ft bgs interspersed with hard gray baslalt, broken and fractured zones, and two ash layers; Elevation 3,700 ft

Source: ~~DOI 2011a~~Reclamation 2012a, DOI 2010.

Notes:

[1]Well list does not include Oregon Department of Transportation boreholes used for bridge footings.

[2]Reservoir stage is 3,787 ft AMSL; river bed elevation at the dam is 3,720 ft AMSL.

[3]All wells listed as domestic supply wells.

[4]Depth to the bottom of the surface casing or sanitary seal in holes/wells that are open~~Key:~~

Key:

AMSL: above mean sea level

bgs: below ground surface

in: inches

ft: feet

gpm: gallons per minute

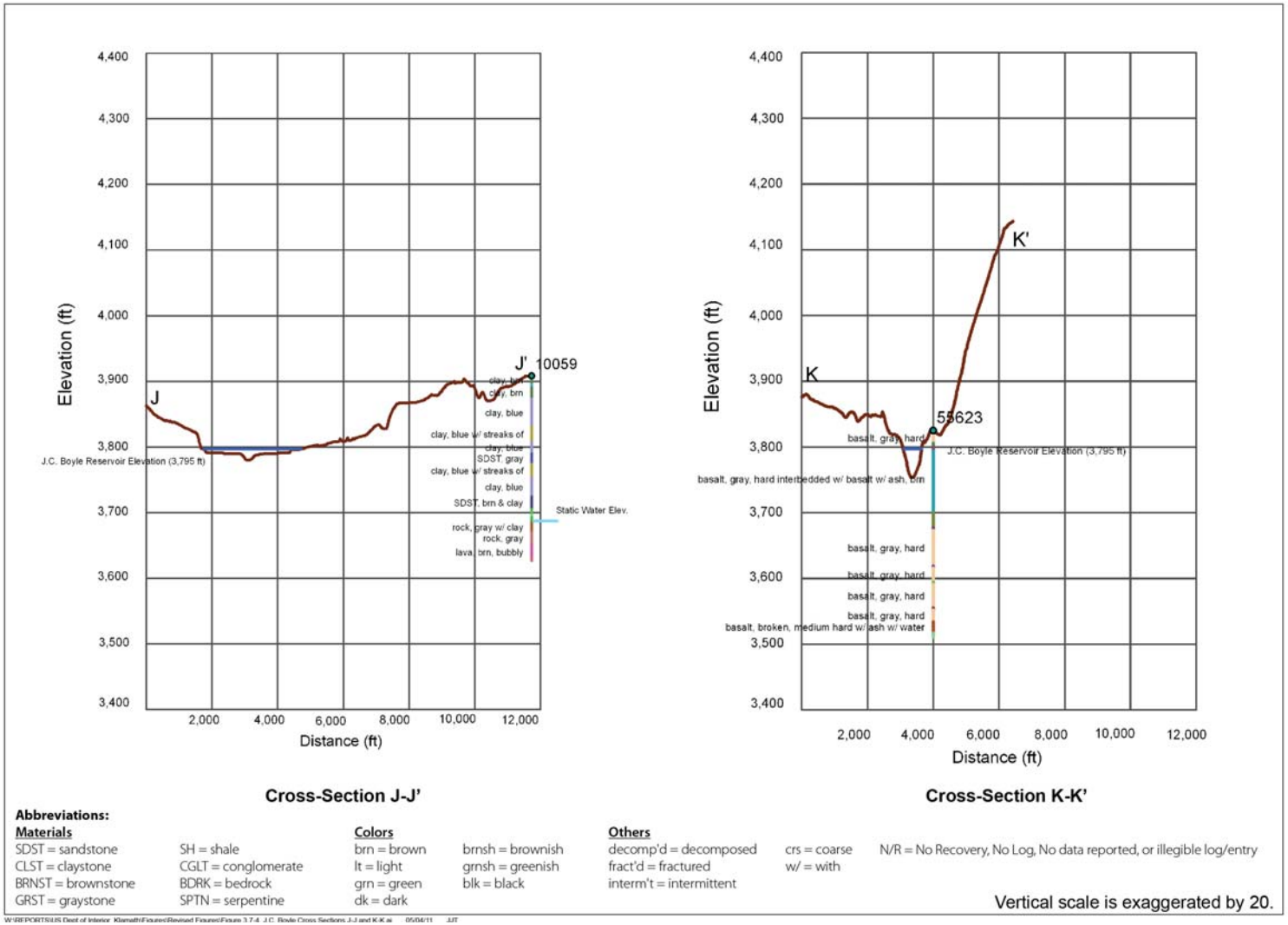
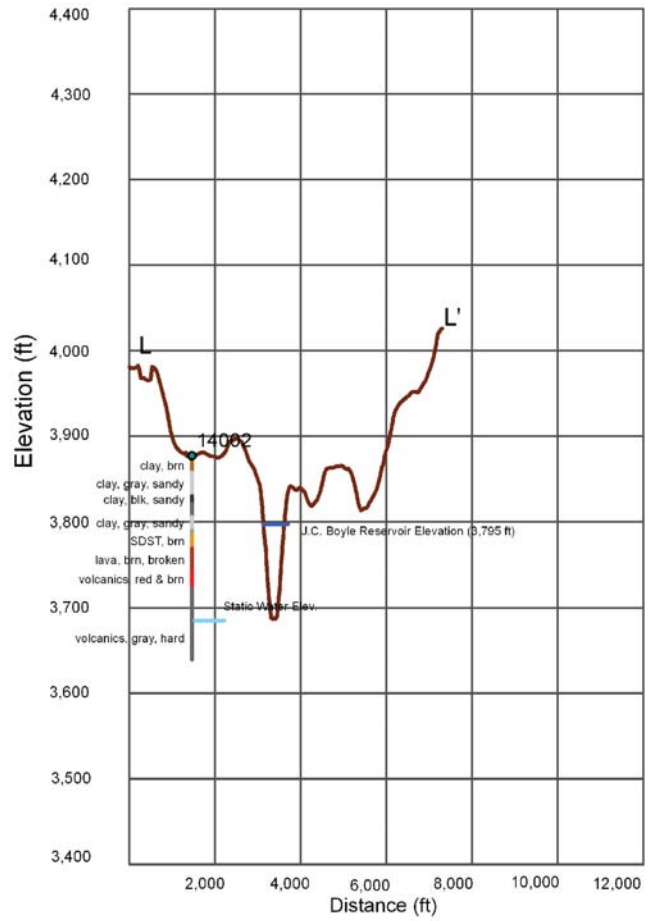


Figure 3.7-4. J.C. Boyle Reservoir Cross-Sections J and K.



Cross-Section L-L'

Abbreviations:

Materials		Colors		Others		
SDST = sandstone	SH = shale	brn = brown	brnsh = brownish	decomp'd = decomposed	crs = coarse	N/R = No Recovery, No Log, No data reported, or illegible log/entry
CLST = claystone	CGLT = conglomerate	lt = light	grnsh = greenish	fract'd = fractured	w/ = with	
BRNST = brownstone	BDRK = bedrock	grn = green	blk = black	interm't = intermittent		
GRST = graystone	SPTN = serpentine	dk = dark				

Vertical scale is exaggerated by 20.

W:\REPORTS\US Dept of Interior_Klamath\Figures\Revised Figures\Figure 3.7-5_J.C. Boyle Cross Sections L-L.ai 05/04/11 JJT

Figure 3.7-5. J.C. Boyle Reservoir Cross-Section L

Comparison of the elevations of the static water levels in the six wells near J.C. Boyle reservoir shows that two wells downstream from the dam (13628, 14002) have static water levels 20 to 40 ft below the pre-dam river bed elevation (at the dam site); the two wells (10514, 10059) furthest away from the reservoir (4,721 ft and 5,518 ft from the reservoir) have static water level elevations nearly 100 ft below the pre-dam upstream river bed elevation; and the two wells near the shore of the reservoir have static water level elevations 20 to 30 ft below the pre-dam river bed elevation at the dam site. The static water level elevations in the wells furthest from the reservoir are near or below the static water level elevations for the wells closer to the reservoir. No clear determination of any trends in vertical head gradients can be drawn from the data of these six wells (Reclamation 2012a).

Copco 1 and Copco 2 Reservoirs

As described in Section 3.11, Geology, Soils, and Geologic Hazards, Copco Lake including the smaller impoundment at Copco 2 Dam, sits at the divide between the Western Cascade and the High Cascade geomorphic provinces. The Western Cascade is faulted and intruded by basaltic dikes and its composition of lower and higher permeable stratified rocks results in discrete aquifer units. The relationship between groundwater flow in and between the High Cascade and Western Cascade is complicated and not well understood but the groundwater utilized in the vicinity of Copco Lake is likely contained in the permeable units of the High Cascade or upper water bearing units of the eastern dipping Western Cascade based upon the generally shallow depth of known groundwater wells. The Western Cascade strata have the potential to contain geothermal reservoirs where capped by the High Cascade lava flows (Hammond 1983).

The identification of wells in the vicinity of the Copco Reservoirs followed the same method as for the J.C. Boyle Reservoir. The California DWR well database identifies ~~22~~ 22 wells within 2.5 miles of the Copco Reservoirs. Figures and tables showing the locations and construction details of the 22 identified wells and the five cross-sections that were developed are provided in Appendix K.

The data for the wells in the cross-sections indicate that the water-bearing units and static water levels are above the bottom of the reservoir. All the wells near the Copco Reservoirs, with the exception of one well, have static water levels that are below the reservoir stage but above the river bed elevation at the dam site. Similarly, all the wells except one have elevations for the top of the water bearing unit below the reservoir stage and above the river bed elevation at the dam site. The two exceptions are two different wells. The top of the water bearing formation was not identified on the log for some wells. In this case, the elevation at which water was first encountered in the drilling is used as a substitute for the top of the water bearing unit.

The average static water level for all wells less than 300 ~~feet~~ft from the reservoir is 2,591 ~~feet~~ft while the average static water level for all wells greater than 400 ~~feet~~ft from the reservoir is 2,680 ~~feet (DOI 2011a).~~ft (Reclamation 2012a). These levels suggest that there is downward groundwater flow near the reservoir (i.e., groundwater is flowing down toward the reservoir). Because

groundwater is flowing toward the reservoir, this information suggests that the water level in the reservoir does not have a significant lateral influence on groundwater levels in the area around J.C. Boyle reservoir (~~DOI 2011a~~Reclamation 2012a).

Iron Gate Reservoir

Iron Gate Reservoir overlies the volcanic units of the Western Cascade which like Copco 1 Reservoir have been faulted and intruded by basaltic dikes (Hammond 1983). The relationship between groundwater flow in the units of the Western Cascade is complicated and not well understood. Specific groundwater well data provides the best understanding of the occurrence of groundwater in the vicinity of Iron Gate Reservoir.

The identification of wells in the vicinity of Iron Gate Reservoir followed the same method as for the J.C. Boyle, Copco 1, and Copco 2 Reservoirs. The California DWR well database identifies 25 wells within 2.5 miles of the Iron Gate Reservoir. Figures and tables showing the locations and construction details of the 25 identified wells and the five cross-sections that were developed are provided in Appendix K.

The well data shows that the static water level (when recorded) is above the reservoir stage with only two exceptions (wells 781723, 99834). The static water level for all the wells is also above the elevation of the river bed at the dam site with only one exception (781723). The data in Appendix K shows that the estimated elevation of the top of the water bearing unit (recorded on 13 of the 25 logs) is above the reservoir stage in 10 of the 13 wells. The top of the water bearing unit is between the reservoir stage and the reservoir bottom in two wells. The top of the water bearing unit is below the reservoir bottom in only one well (781723).

Wells further away from Iron Gate Reservoir have higher static water levels and generally higher top of water bearing unit elevations than wells closer to the reservoir. These elevations indicate groundwater flow direction is towards the reservoir in agreement with the regional groundwater gradients (Gannett et al, ~~2010~~2007). Wells within 2,000 ~~feet~~ft of the reservoir have static water levels very close or above to the reservoir stage (one exception, well 334387) indicating a potential flow direction toward the reservoir. The current well dataset cannot determine conclusively whether Iron Gate Reservoir has any vertically downward or horizontal seepage (~~DOI 2011a).~~ Reclamation 2012a).

3.7.4 Environmental Consequences

The section analyzes the environmental consequences on groundwater from implementation of the Proposed Action or its alternatives. Effects to groundwater quality are not expected because groundwater discharges to surface water in the majority of the area. Impacts to water quality are discussed in detail in Section 3.2, Water Quality.

3.7.4.1 Environmental Effects Determination ~~Methodology~~Methods

The method for this analysis was to compare the effects of the Proposed Action and alternatives to the existing conditions. This analysis used the groundwater information presented in Section 3.7.3 to evaluate potential effects on existing wells and on groundwater's influence on surface water resources in the project area.

3.7.4.2 Significance Criteria

For the purposes of this EIS/EIR, impacts would be significant if they would result in the following:

- Lowering of the local groundwater table level so the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted.

- Substantially interfering with groundwater levels or groundwater recharge so there would be changes to the groundwater/surface water interaction that would adversely affect surface water conditions or related resources.

Land subsidence caused by aquifer collapse can be caused by many processes such as the dewatering of fine grained materials (i.e., clays) or collapse of the structure of an aquifer (i.e., through overpumping, dissolution, or piping). Although land subsidence as a result of changes in groundwater levels is a common significance criterion, it is not considered in this EIS/EIR given that land subsidence would not be an effect of the Proposed Action or alternatives because water levels would not be lowered in areas of substantial clay deposits and the rock types of the aquifer are not susceptible to collapse in the area of analysis.

3.7.4.3. Effects Determinations

3.7.4.3.1 Alternative 1: No Action/No Project

Under the No Action/No Project Alternative, there would be no change in project dam and associated facility operations and no impacts on groundwater resources~~.~~ in the vicinity of the reservoirs. Under the No Action/No Project Alternative, J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams and their associated facilities would remain in place and be operated similarly as they have been during historical operations. Therefore, the No Action/No Project Alternative would not change the elevation of surface water in the reservoirs outside of historical ranges. Groundwater levels in the vicinity of the reservoirs would be expected to remain consistent with historic values. **Therefore, no changes from existing conditions relative to the elevation of the groundwater table in the vicinity of the reservoirs would be expected.**

Under the No Action/No Project Alternative, there could be increased groundwater storage. Activities associated with the No Action/No Project Alternative include certain resource management actions that are currently approved and ongoing, and which would continue to be implemented. Actions that could affect groundwater resources include Agency Lake and Barnes Ranches. These actions would provide ~~new~~ storage to store additional surface water supplies. In some years, when water is available, groundwater use could decrease. However, as with historic conditions, groundwater use may fluctuate depending on climatic conditions (i.e., there would likely be more groundwater pumping during dry years when surface water diversions are less available). Stored surface water ~~would~~ may also increase seepage into underlying groundwater basins. **This would be a beneficial effect to groundwater resources.**

3.7.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (the Proposed Action)

Under the Proposed Action, groundwater levels in existing wells adjacent to the reservoirs could decline in response to the drop in surface water elevation when the reservoirs are removed. The water-bearing units from which most of the existing domestic or irrigation wells pumps are ~~either~~: a) below the elevation of the original river channel, ~~are~~b) exposed along reservoir walls, or ~~are~~ c) above the reservoir stage. ~~There is limited~~ The paucity of data ~~to fully characterize~~regarding the ~~degree of~~ hydraulic connection between these water bearing units and the reservoirs precludes the articulation of definitive statements so reasonable inferences are offered below.

Some of the water-bearing units ~~that are~~ tapped by existing domestic or irrigation wells ~~are~~ lie above the reservoir water surface elevation and are at elevations similar to those of mapped springs. These springs are likely fed by the same water-bearing units supplying the wells and neither ~~would likely~~ are expected to be significantly impacted by the removal of the reservoirs. ~~The primary impact that would be expected could be a drop in the groundwater levels in these higher elevation water bearing units as the reservoirs drain and new local groundwater levels are established relative to the river elevation.~~

~~A number of existing domestic or irrigation wells lie close to the reservoir shorelines (well within the 2.5 miles.) These wells may be influenced by the dropping reservoir water levels when directly or indirectly connected to the reservoir. However, all but three of the shoreline wells tap water-bearing units with elevations below the bottom of the reservoir. The degree of impact will be controlled by the degree of hydraulic connectivity between the reservoirs and the water bearing units below and adjacent to the reservoirs. The degree of connectivity between the reservoirs and water bearing units below and adjacent to the reservoirs is uncertain.~~

~~As noted previously, there are existing (and locatable) domestic or irrigation wells that pump from water-bearing units that may be directly connected to the reservoirs. Therefore, changes in reservoirs water levels might directly affect the groundwater level in the wells. Other wells in the vicinity of these three wells access deeper water-bearing units.~~

~~In general, domestic or irrigation wells with static water levels that are close to the elevation of the pre-dam river channel will, most likely, not be impacted by the removal of the reservoirs as the river already is a base line for these wells. Similarly, wells with static groundwater levels above the pre-dam river bed elevation, but below current reservoir stages, could experience groundwater level declines down to pre-dam river bed elevations as the river is re-established. The~~ Wells that pump from water-bearing units that are directly connected to the reservoirs will likely be affected by reservoir removal and the impacts could be significant. Wells which tap water-bearing units below the bottom of the reservoir are assumed to be maintained by regional groundwater flow patterns that will continue to “sink” toward the restored Klamath River and its alluvial floodplain. Consequently, those wells are unlikely to be affected by the removal of the reservoirs. Ultimately however, the potential impacts at specific wells will depend upon

local hydrogeologic conditions at the well site as well as the well construction characteristics. ~~Hydrogeology between well locations conditions can vary widely between sites.~~

Fish hatchery operations will continue at the Iron Gate Hatchery for eight years following removal of the Iron Gate Dam. After eight years, hatchery production will continue, but may be at an alternate site. Under the KHSA, PacifiCorp is responsible for evaluating hatchery production options that do not rely on the current Iron Gate Hatchery water supply. Such options could include use of groundwater, surface water, or water reuse technologies. PacifiCorp is also responsible for proposing and implementing a post-Iron Gate Dam Hatchery Mitigation Plan (Hatchery Plan) to provide continued hatchery production for eight years after the removal of Iron Gate Dam; and this Hatchery Plan would be developed with information from PacifiCorp's evaluation. However, PacifiCorp is not required to propose a Hatchery Plan until six months following an affirmative Secretarial Determination. The Lead Agencies do not currently know what PacifiCorp will propose in the Hatchery Plan and are unlikely to know unless there is an affirmative Secretarial Determination. An impact analysis of a hatchery production option that does not rely on the current Iron Gate water supply would be purely speculative at this point. Therefore, the potential environmental effects of implementing a hatchery production option that does not rely on the current Iron Gate water supply are not analyzed in this EIS/EIR.

There are existing domestic and irrigation groundwater wells that could not be located reliably based on the information in the Oregon WRD or California DWR databases. In addition to the non-locatable wells in the databases, there are likely other existing wells in the vicinity of the reservoirs. The real estate information presented in the Dam Removal Real Estate Evaluation Report prepared by the United States Department of the Interior (DOI) in 2011 lists 1,467 potentially impacted parcels near the Copco and Iron Gate reservoirs. Of those 1,467 parcels, 12% (176 parcels) are listed as improved and 88% (1,291 parcels) are shown as vacant (~~DOI 2011b).~~Bender Rosenthal, Inc. 2011). The extent of improvements on the 12% of parcels is not known. However, it is possible that improvements may have included installation of a groundwater well for domestic supplies. The number of improved parcels near the J.C~~.~~. Boyle reservoir is not known. Therefore, there could be additional domestic or irrigation wells in water-bearing units that intercept the reservoirs. **A decline in groundwater levels ~~at nearby wells~~in existing wells adjacent to the reservoirs in response to the drop in surface water elevation when the reservoirs are removed would be a significant impact, but implementation of mitigation measure GW-1 would reduce this impact to less than significant.**

The Proposed Action could cause a reduction in groundwater discharge to the Klamath River. Removing the dam and eliminating the reservoir could result in less percolation of surface water to the underlying groundwater aquifer due to removal of the water body. However, as discussed in Section 3.7.3 Affected Environment, the reservoirs generally lie within rock valleys where this recharge is expected to be low. Gannett et. al. ~~2010~~ 2007

concluded that the Klamath River reaches in the project area are gaining reaches (i.e., groundwater discharges to the stream). This assessment, and characteristics of the rock surrounding the reservoirs, suggest that any surface water that may have infiltrated to groundwater systems under the reservoir would likely discharge back to the river just downstream ~~of~~from the impoundment.

The Proposed Action would result in the same relative volume of water flowing through the project area in the Klamath River. The timing of river's hydrograph would be modified to improve fish habitat. Under current conditions, water is retained in the reservoirs to maximize hydropower production by filling and keeping the reservoirs as full as possible; however, the stored volume in the reservoirs does not vary substantially from one time period to another to act as a buffer to flows going down the river. Under the Proposed Action, the water in the river would remain in the river through the project area. **The Proposed Action's impacts on groundwater recharge and the resulting groundwater/surface water interaction would be less than significant.**

~~*The Proposed Action will require the relocation of the City of Yreka water supply pipeline*. The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and will have to be relocated prior to the decommissioning of the dam to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline wouldbe suspended from a pipe bridge across the river near its current location. The water supply utilized by the City will not change, and none of the construction activities are anticipated to interact with or impact existing groundwater supplies or require groundwater supplies to complete the construction. **The relocation of the Yreka water supply pipeline would result in no change in existing conditions of groundwater supplies.**~~

Under the Proposed Action, recreational facilities currently located on the banks of the existing reservoirs will be removed following drawdown. The existing recreational facilities provide camping and boating access for recreational users of the reservoirs. Once the reservoirs are drawn down, these facilities will be removed. The removal of the recreational facilities would not impact groundwater or groundwater recharge. **The removal of the recreational facilities would result in no change ~~in~~from existing conditions ~~of~~on groundwater resources.**

Keno Transfer

Implementation of the Keno Transfer could cause adverse effects to local groundwater. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. ~~The~~ There will be no changes in facility operations. This transfer would not result in the generation of impacts to groundwater compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section 7.5.4). **Therefore, the implementation of the Keno Transfer would result in no change from existing conditions.**

East and ~~*West Side*~~Westside Facilities – Programmatic Measures

Decommissioning the East and ~~West Side~~Westside Facilities could have adverse effects to groundwater resources. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA ~~will redirect water flows currently diverted~~would eliminate the need for diversions at Link River Dam into the two canals~~, back in to Link River.~~. Following decommissioning of the facilities there will be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. Groundwater recharge in the area is not expected to change. **The decommissioning of the East and ~~West Side~~Westside facilities would result in no change ~~in~~from existing conditions ~~of~~ on groundwater resources.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

The Proposed Action would require the relocation of the Yreka Water Supply Pipeline. The existing water supply pipeline for Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the dam to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would be suspended from a pipe bridge across the river near its current location. The water supply utilized by Yreka would not change, and none of the construction activities are anticipated to interact with or impact existing groundwater supplies or require groundwater supplies to complete the construction. **The relocation of the Yreka Water Supply Pipeline would result in no change from existing conditions on groundwater supplies.**

KBRA – Programmatic Measures

The KBRA, which is ~~a component of the~~ an action connected to the Proposed Action, encompasses several programs that could affect groundwater, including:

- Water Diversion Limitations
- On-Project Plan
- Water Use Retirement Program
- Interim Flow and Lake Level Program
- Emergency Response Plan

Water Diversion Limitations and the On-Project Plan

The Water Diversion Limitations program could reduce irrigation water in the driest years. The KBRA provides for limitations on specific diversions to Reclamation's Klamath Project through the Water Diversion Limitations program, and a means to address these limitations on the diversion through the On-Project Plan. The Water Diversion Limitations program (KBRA Section 15.1) ~~would~~ could reduce the availability of surface water for irrigation on Reclamation's Klamath Project~~ to 100,000 acre feet less than the demand in the driest years to protect mainstem flows~~. These limitations are intended to increase water availability for fisheries purposes~~. Reducing surface~~ at critical times and increase the certainty of water ~~diversions~~deliveries to Reclamation's Klamath Project~~ irrigators could result in increased reliance on groundwater substitution during the driest years. Groundwater pumping could occur with emergency wells located on Reclamation's Klamath Project~~. ~~These wells can only be pumped under a drought declaration. Irrigators typically utilize gravity delivered surface water when available. An~~ If the Water Diversion Limitations program diversion quantities were compared to historic diversion data, the maximum reduction in surface water diversion to Reclamation's Klamath Project would have been about 100,000 AF in the driest years (Klamath Settlement Parties 2010). For example, if KBRA's Water Diversion Limitations program were in place during 2010, instead of receiving approximately 185,000 AF of water, Klamath Reclamation Project irrigators would have received 330,000 AF, an increase of approximately 145,000 AF (Hicks, J. 2012). KBRA makes this possible through more real-time water management.

Recognizing that Klamath Reclamation Project irrigators are likely to require supplemental water or other actions during dry and other years, the KBRA provides for creation of the On-Project Plan by the Klamath Water and Power Agency (KWAPA). The On-Project Plan is being prepared and is intended to align water supply and demand within Reclamation's Klamath Project (KBRA Section 15.2). Implementation of the On-Project Plan could include water conservation and improved efficiency, increased water storage, groundwater management, and demand reduction (e.g. forbearance agreements, change in crop type, and land idling) (KBRA, § 15.2.3., KWAPA, Technical Memorandum 2, § 10.3. [KWAPA 2011a, KWAPA 2011b and KWAPA 2011c]). In the event there is an increased reliance on groundwater, as compared to historic levels, because of the Water Diversion Limitations program, such increased use could affect groundwater levels in the pumped aquifer and reduce groundwater inflow into the Klamath River and its tributaries.~~ Groundwater substitution could also affect wells that tap into the same water-bearing units (Gannett et. al. 2010). Therefore~~

Recognizing the potential for increased reliance on groundwater, the KBRA includes provisions that would require monitoring of pumping at existing wells, the monitoring of groundwater levels in the pumped aquifer, and the monitoring of springs affected by drops in groundwater levels. Additionally, the KBRA ~~prohibits~~specifies the development of an On-Project Plan objective prohibiting adverse effects on groundwater ~~use~~levels within Reclamation's Klamath Project boundaries~~ that results in a reduction in flow of a spring by more than six percent to avoid impacts on groundwater discharge into the~~

~~Klamath River and its tributaries that would reduce the availability of thermal refugia for fish in these water bodies.~~. The KBRA defines adverse effects as the flow of certain springs being reduced by more than six percent from year 2000 flows when the groundwater system was in a state of equilibrium (KBRA Section 15.2.4). The KBRA identifies springs to be monitored and protected as those along Upper Klamath Lake, the Wood River subbasin, Spring Creek on the Williamson River, the Klamath River downstream to Copco 1 Dam, Shovel Creek, and Spencer Creek. The KBRA also prohibits the On-Project Plan from using new irrigation wells when an irrigator has a surface water forbearance agreement or similar agreement (KBRA, p. 75, § 15.2.4.D.). Additionally, the KBRA would also provide funding to remedy adverse impacts due to groundwater use (KBRA Appendix C-2). As part of this effort to mitigate any effects on groundwater, the KBRA requires implementation of the work plan in Appendix E-2 of the KBRA ~~includes a work plan~~ which provides for investigation and monitoring of the groundwater resources of the Upper Klamath Basin.

~~With implementation of the KBRA, groundwater investigation and monitoring would occur and the results would be incorporated into the On-Project Plan (KBRA Section 15.2). In~~ The USGS, in support of this groundwater investigation and monitoring effort, ~~the USGS is developing~~ developed a groundwater model ~~planned for completion in 2011~~ that will be utilized to assess the effects of groundwater use in the basin and identify any adverse changes in groundwater levels (Gannett ~~2011). The On-Project Plan would include a plan for the use of groundwater, actions by managers to remedy any adverse impacts identified by groundwater investigations or monitoring, and includes a prohibition on adverse impacts on groundwater sources. A fund for remedying adverse impacts due to groundwater use is identified in KBRA Appendix C-2.~~ et al., 2012). The work plan would be implemented in three phases. The first phase would be to evaluate all existing and historic stream gaging station and groundwater level monitoring sites and data and to also identify the additional sites where streamflow, spring discharge, or groundwater level data are required. The second phase would be to establish the additional sites identified in phase one. The third phase would be the collection of data over time, analysis of data, and reporting of findings.

Implementation of the On-Project Plan and Water Diversion Limitations program has the potential to generate localized short-term adverse effects on groundwater through the increased use of groundwater to replace surface water deliveries. These effects would be reduced through: the implementation of groundwater monitoring and pumping restrictions ~~triggered by any observed~~as described in KBRA 15.2.4.A.i, the reduction of groundwater pumping in the driest years, increased data collection, new modeling of the maximum potential groundwater withdrawals, and increased funding related to mitigating adverse effects on groundwater. As a result, implementation of the Water Diversion Limitations program and the On-Project Plan will not exceed the thresholds of significance. Although implementation of the Water Diversion Limitations program would reduce the need for supplemental groundwater in the driest years, details of the On-Project Plan are not yet available. So although the Lead Agencies expect

implementation of the On-Project Plan to benefit groundwater levels~~.~~, the plan's overall success is too speculative to assess given its current status of development.

The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above reduce any potential for groundwater improvements generated by this program to contribute to groundwater effects generated by facility removal. **In the long~~-~~ term, implementation of the On-Project Plan (KBRA Section 15.2) and the Water Diversion Plan (KBRA Section 15.2.4) would be expected to benefit groundwater resources by protecting them from overuse (through provisions prohibiting adverse impacts to groundwater, where none currently exist~~).~~), but because such benefits cannot be accurately assessed at this time, the effect on groundwater is determined to be less than significant. Implementation of the On-Project Plan and Water Diversion Plan will require future environmental compliance as appropriate.**

Water Use Retirement Program (WURP)

Upland vegetation management under the WURP would increase inflow to Upper Klamath Lake. The WURP is intended to permanently increase the flow of water into Upper Klamath Lake by 30,000 acre-~~feet~~ft per year to support restoration of fish populations (KBRA Section 16.2.2). Actions to increase inflow would include upland vegetation management of high water-use plants (i.e., juniper removal) to increase groundwater recharge. The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above reduce any potential for groundwater improvements generated by this program to contribute to groundwater effects generated by facility removal. **Implementation of the WURP would benefit**

groundwater resources by increasing groundwater recharge through upland vegetation management. Implementation of the WURP will require future environmental compliance as appropriate.

Interim Flow and Lake Level Program

The purchase and lease of water under the Interim Flow and Lake Level Program would increase water for fisheries. The Interim Flow and Lake Level Program (KBRA Section 20.4) would be an interim program of water purchase and lease to reduce surface water diversions and further the goals of the fisheries programs during the interim period prior to full implementation of the On-Project Allocation and WURP. Water purchase and lease agreements with a term greater than the interim period defined in KBRA Section 20.4.2 would be subject to a consistency requirement with the On-Project Plan~~.~~ (KBRA Section 20.4.3). Reduced surface water diversions would not be expected to directly result in increased groundwater use given provisions developed to prevent adverse impacts to groundwater in the KBRA (Section 15.2.4). The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above eliminate any potential for negative groundwater effects generated by this program contributing to groundwater effects generated by facility removal. **Implementation of the Interim Flow and Lake Level Program would result in less than significant impacts on groundwater resources in the short term, and would be expected to benefit groundwater resources in the long- term. Implementation of the Interim Flow and Lake Level program will require future environmental compliance as appropriate.**

Emergency Response Plan

Implementation of an Emergency Response Plan could result in changes to groundwater following the failure of a Klamath Reclamation Project facility or dike on Upper Klamath Lake or Lake Ewauna. The purpose of the plan is to prepare water managers for an emergency affecting the storage and delivery of water needed for KBRA implementation~~.~~ (KBRA Section 19.3). The components of the Emergency Response Plan are described in the EIS/EIR Section 2.4.3.~~9~~10 and include potential emergency response measures and processes to implement emergency responses. Implementation of an Emergency Response Plan could potentially reduce emergency groundwater use following a facility or dike failure that limited surface water deliveries by shortening the duration of any surface water delivery interruption. The intent of this plan is to allow for continued storage and delivery of water according to KBRA commitments, and would not affect the probability of facility or dike failure. Additionally, given the geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above, the Emergency Response Plan would not be expected to contribute to any changes in groundwater generated by the hydroelectric facility removal action. **Therefore, it is anticipated that implementation of the Emergency Response Plan would result in no change ~~to~~from existing conditions ~~in~~on groundwater resources. However, implementation of the Emergency Response Plan would likely help to reduce groundwater use due to a facility or dike failure which would be a beneficial**

effect to groundwater resources. Implementing the Emergency Response Plan will likely require the analysis of changes to flood risks in future environmental compliance investigations as appropriate.

3.7.4.3.3 Alternative 3: Partial Facilities Removal of Four Dams Alternative

The groundwater impacts of the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

Keno Transfer

The groundwater impacts of the Keno Facility ~~Transfer~~transfer under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

East and ~~*West Side*~~Westside Facility Decommissioning – Programmatic Measure

The groundwater impacts of the East and ~~West Side~~Westside Facility Decommissioning under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The groundwater impacts of the Yreka Water Supply Pipeline relocation would be the same as the Proposed Action.

KBRA – Programmatic Measures

The groundwater impacts of the KBRA under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

3.7.4.3.4 Alternative 4: Fish Passage at Four Dams

Under the Fish Passage at Four Dams Alternative, surface water elevations in the reservoirs would not change and there would be no changes to the relative elevation of the groundwater table. Under the Fish Passage at Four Dams Alternative, the J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams and Reservoirs would remain in place and water levels in the reservoirs would be similar to historical levels. Therefore, the Fish Passage at Four Dams Alternative would not change the elevation of surface water in the reservoirs outside of historical ranges. Therefore, no changes to the relative elevation of the groundwater table in the vicinity of the reservoirs would be expected. **There would be no groundwater impacts under the Fish Passage at Four Dams Alternative.**

3.7.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Groundwater impacts associated with the removal of Copco 1 and Iron Gate would be the same as under the Proposed Action. Groundwater impacts at Copco 2 and J.C. Boyle would be the same as those described for the No Action/No Project Alternative.

3.7.4.4 Mitigation Measures

3.7.4.4.1 Mitigation Measure by Consequences Summary

Mitigation Measure GW-1 – This mitigation measure provides for the deepening (or replacement) of an existing affected domestic or irrigation groundwater well so the

groundwater production rate from the well is returned to conditions prior to implementation of the Proposed Action or its alternatives. This mitigation measure is intended to mitigate for potential impacts from the Proposed Project or its alternatives. Therefore, a preconstruction well survey will be conducted prior to implementation of the Proposed Project or its alternatives. This survey will measure water levels and pumping rates in existing domestic and irrigation wells. This information will form the basis of review for potential claimed damages following construction activities. Well owners not participating in this preconstruction survey will be required to provide adequate documentation showing a decrease in production from the well before and after construction conditions. The review of pre-construction data will be considered with respect to preceding hydrologic conditions (i.e., climatic cycles, wet year vs. dry year). This mitigation measure would also provide an interim supply of potable water for health and safety prior to the completion of the modifications to the affected well.

Effectiveness of Mitigation in Reducing Consequences

Implementation of mitigation measure GW-1 would ensure that affected groundwater wells are able to provide water supply benefits similar to those prior to implementation of the Proposed Action or its alternatives.

Agency Responsible for Mitigation Implementation

The Dam Removal Entity would be responsible for implementing mitigation measure GW-1.

Remaining Significant Impacts

Following implementation of mitigation measure GW-1, no significant adverse impacts associated with groundwater would be anticipated. If the amount of groundwater discharging to the Klamath River was reduced so adverse impacts on fish habitat or habitat for other aquatic species resulted, such impacts would be considered significant. The potential for such impacts and mitigation for them have been addressed in other relevant chapters of this EIS/EIR.

Mitigation Measures Associated with Other Resource Areas

Mitigation measure REC-1 would develop new recreational facilities and access point along the newly formed river channel between J.C. Boyle Reservoir and Iron Gate Dam. Recreation facilities, such as campgrounds and boat ramps, currently located on the edge of the reservoir would need to be replaced in appropriate areas near the new river channel once the reservoir is removed. Water supplies for these facilities would most likely be supplied through wells located on the new recreational sites. These wells would be replacing existing wells and water consumption is unlikely to increase as a result of replacing recreational facilities. **Therefore, impacts to groundwater as a result of implementing mitigation measure REC-1 would be less than significant.**

No other mitigation measures associated with other resource areas as described in this EIS/EIR would affect groundwater resources.

~~3.7.5~~

3.7.5 References

California Department of Water Resources. 2003. California's Groundwater: Bulletin ~~118~~ 118 – Update 2003. Available at: http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm~~–~~.

California, State of. California Water Code. Available at: http://www.leginfo.ca.gov/~~cgi-bin/calawquery?codesection=~~.html/wat~~&codebody=&hits=20~~_table_of_contents.html.

Bender Rosenthal, Inc. 2011. (a). Dam Removal Real Estate Evaluation Report. for U.S. Department of the Interior ~~(DOI)~~, Bureau of Land Management and Bureau of Reclamation ~~(~~, March 22, 2011. Available at: http://klamathrestoration.gov/sites/klamathrestoration.gov/ files/Real%20Estate%20Evaluation%20Report_final.pdf.

Bureau of Reclamation~~). 2010. E-mail communication with California Department of Water Resources re: well log information for Siskiyou County. April-May 2010.~~

~~DOI,~~ (Reclamation~~. 2011a.~~). 2012a. "Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration~~"~~," Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, ~~U.S. DOI,~~ Bureau of Reclamation, Technical Service Center, Denver, CO.

~~DOI,~~ _____. 2012b. Irrigated Agriculture Economics Technical Report. Bureau of Reclamation~~. 2011b. Dam Removal Real Estate Evaluation Report.~~, Technical Service Center, Resource Management and Economics Group. Denver, CO. Available at: http://klamathrestoration.gov/sites/klamathrestoration.gov/ files/EIS-EIR-Draft/Econ-Reports/Irrigated%20Ag_9-9(accessible).pdf.

Department of the Interior (DOI), Reclamation. 2010. E-mail communication with California Department of Water Resources re: well log information for Siskiyou County. April-May 2010.

Gannett, M.W., K.E. Lite, Jr., J.L. La Marche, B.J. Fisher, and D.J. Polette. ~~2010.~~ 2007. Ground-Water Hydrology of the Upper Klamath Basin, Oregon and California. U.S~~.~~. Geological Survey Scientific Investigations Report 2007-5050. Version 1.1. Available at: http://pubs.usgs.gov/sir/2007/5050/. April 2010 revision.

Gannett, Marshall. 2011. ~~Personal~~ Written communication between Marshall Gannett, USGS and Elizabeth Vasquez, USBR. September 2, 2011.

Gannett, M.W., Wagner, B.J., and Lite, K.E., Jr., 2012, Groundwater simulation and management models for the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2012–5062, 92 p.

Gannett, Marshall. 2012b. Written communication between Marshall Gannett, USGS and Elizabeth Vasquez, Reclamation. January 19, 2012.

Hammond, P. 1983. Volcanic Formations along the Klamath River near Copco Lake. California Geology Publication, California Division of Mines and Geology. ISSN 0026 4555.

~~Oregon Department of Human Services, Drinking Water Program. 2010. Review of groundwater wells database.~~Hicks, John. 2012. Written communication between John Hicks, USBR and Christine Karas, USBR. June 28, 2012.

Klamath Water and Power Agency (KWAPA). 2011a. Technical Memorandum 1 – Project Goals/Objectives and Approach for Development of the On-Project Plan. Available at: ~~http://170.104.63.9/countyinventory.php~~http://www.kwapa.org/assets/TM1BODapprovedSCAN_2.pdf

~~Oregon, State of. Oregon Revised Statues 2009 Edition.~~. Accessed on: July 18, 2012.

KWAPA. 2011b. Technical Memorandum 2 – Water Supply and Operations for the On-Project Plan Area. Available at: ~~http://www.leg.state.or.us/ors/home.html~~http://www.kwapa.org/assets/FINAL-TM-2-April-2012.pdf. Accessed on: July 18, 2012.

KWAPA. 2011c. Technical Memorandum 3 – Irrigation and Water Requirements/Demands for the On-Project Plan Area. Available at: http://www.kwapa.org/assets/TM3OPPA.pdf. Accessed on: July 18, 2012.

Klamath Settlement Parties. 2010. Summary of the Klamath Basin Settlement Agreements. May 2010. Available at: http://www.edsheets.com/Klamath/Summary%20of%20Klamath%20Settlement%20Agreements%201-7-10.pdf. Accessed on December 22, 2011.

Oregon Water Resources Department~~.~~ (OWRD). 2011. Oregon Water Resources Department Tools and Data ~~website.~~Web site. Available at: http://www.wrd.state.or.us/OWRD/PUBS/ToolsData.shtml#Ground_Water~~—~~.

Siskiyou County, California. Code of Ordinances. Available at: http://library.municode.com/index.aspx?clientId=16630&stateId=5&stateName=California.

3.8 Water Supply/Water Rights

This section describes the impacts on surface water supply availability and water rights compliance that would be associated with implementation of the Proposed Action and alternatives.

3.8.1 Area of Analysis

The area of analysis includes the Klamath Basin in south central Oregon and northwestern California. This discussion divides the Klamath Basin into Upper and Lower Klamath Basins based upon hydrologic sub-basins. The Upper Klamath Basin covers 5.6 million acres, and contains the reaches of the Klamath River upstream of Iron Gate Dam. Along this portion of the Klamath River, six dams exist, of which four are being considered for removal under the Klamath Hydroelectric Settlement Agreement (KHSA). The Upper Klamath Basin also contains Reclamation's Klamath Project, which diverts irrigation water from the Klamath River for two National Wildlife Refuges (NWRs) and agricultural use. The Upper Klamath Basin is the area that would be most directly affected by implementation of the Proposed Action. The Lower Klamath Basin covers approximately 4.5 million acres and includes seven hydrologic sub-basins. The lower reaches of the Klamath River are included from downstream of Iron Gate Dam to the river's mouth on the California coastline. Downstream of Iron Gate Dam, the Klamath River has no dams on its mainstem. The sections below are generally organized from upstream to downstream.

3.8.2 Regulatory Framework

This section describes the regulatory framework regarding water rights and supply at the ~~federal~~ Federal and ~~state~~ State levels. Section 3.2, Water Quality, discusses the regulations protecting water quality.

3.8.2.1 Federal Water Law

3.8.2.1.1 The Reserved Rights Doctrine

The Reserved Rights Doctrine was first articulated in the 1908 Supreme Court decision in *Winters* v. *United States*. The doctrine provides that when lands are set aside as Indian or other ~~federal~~ Federal reservations, sufficient water to fulfill the purposes of the reservation is reserved as well. Federal reserved water rights arise expressly or by implication from ~~federal~~Federal treaties, statutes, and ~~executive~~Executive orders, and vest no later than the date the reservation was established. Unlike ~~state~~ State appropriative rights, ~~federal~~Federal reserved water rights are for present and future uses and may be exercised at any time and are not lost through non-use. 43 U.S.C. 666, commonly known as the McCarran Amendment (66 Stat. 560; adopted July 10, 1952) waives the sovereign immunity of the United States in suits to determine rights to use the water of a river system or other source. The waiver authorizes States to quantify Federal Indian reserved water rights, and water rights associated with other Federal reservations, in the context of

comprehensive State general stream adjudications. While ~~federal~~Federal reserved water rights may be quantified ~~and administered~~ by ~~states in the context of comprehensive state water adjudication~~a State under the McCarran Amendment's narrow waiver of sovereign immunity, they are ~~otherwise~~ governed by ~~federal~~Federal, not ~~state~~State, law.

3.8.~~2.~~2~~.~~.2 State Water Law

Two basic water law doctrines exist in the United States, and States administer water resources within their boundaries in accordance with one ~~of two state water law doctrines,~~ or ~~a~~ some combination of the ~~two~~doctrines. Under the doctrine of prior appropriation, water rights are based on beneficial use, with the first person putting water to use accruing the ~~best~~ highest priority appropriative right to receive water in times of shortage, regardless of the proximity of the place of use to the source of water. Appropriative rights must be used to be retained. Under the riparian doctrine, rights are based on location rather than use, with landowners bordering waterways possessing corresponding rights to use the flow, and with any water shortages shared accordingly among riparian landowners. Riparian rights may be used at any time, and are not lost through non-use.

A number of ~~states~~States, including Oregon, recognize certain riparian rights, but require all water users, including riparian landowners, to obtain water use permits from the ~~state.~~State. In California, riparian landowners may use natural flows for beneficial purposes on riparian lands without a permit, but appropriative rights acquired after 1914 may only be acquired by permit.

3.8.2.2.1 Oregon

Oregon enacted a comprehensive water use code in 1909, establishing a process by which all new water uses must be applied for and permitted. If an appropriation of water was initiated prior to enactment of the 1909 water code and not forfeited or abandoned since then, the current property owner may have a vested water right. Such vested ~~and Federal Reserved~~ water right claims are determined in Oregon in a two-step administrative and judicial process known as a general stream adjudication. The Oregon Water Resources Department (OWRD) initiated an adjudication of all pre-1909 and ~~federal~~Federal reserved water right claims for the use of surface water in the Klamath Basin in 1975. The Klamath Basin Adjudication, which is ongoing, is the first adjudication in the State to include ~~federal~~Federal water right claims, including claims for and by the Klamath Tribes, for ~~National Wildlife Refuges~~four NWRs, for Reclamation's Klamath Project, for a National Park, for public water reserves, for the wild and scenic portion of the Klamath River in Oregon, for three other wild and scenic river segments in the Upper Klamath Basin, and for a National Forest. Water right claims have also been filed by numerous private water users, individual Klamath Indian allottees, and successors to allottees.

Oregon's water laws are codified in Oregon Revised Statutes, Chapters 536 through 541.

3.8.2.2.2 California

California enacted a water use law in 1914, establishing a system of permitting and licensing of all new appropriative uses of water. ~~Riparian~~ In general, riparian rights continue to have higher priority in California, with riparian landowners retaining a right to use natural flows for beneficial purposes on riparian lands at any time without obtaining a permit from the State Water Resources Control Board (SWRCB). An

adjudication may be initiated to determine relative rights to use water from a specific source, but ~~California has not initiated a comprehensive~~ no such proceeding to determine all rights in the Klamath Basin ~~Adjudication which includes all federal reserved water rights. New permits are not accepted if~~ , including Federal reserved rights, has been initiated to date in California. If the SWRCB determines ~~the~~ a stream is ~~already~~ fully appropriated~~.~~, no new permits are issued. The SWRCB has determined the mainstem of the Klamath River, from 100 yards downstream of Iron Gate Dam to the Pacific Ocean, is ~~declared~~ fully appropriated during the entire calendar year ~~by the~~ (SWRCB ~~(~~2010).

California's water rights law is contained in case law, the California Water Code, and the California Code of Regulations, Title 23.

3.8.2.2.3 Upper Klamath Basin Adjudication

If an appropriation of water was initiated prior to the enactment of the 1909 water code and has not been forfeited or abandoned since then, a water user may have a "vested" water right. Federal reserved water rights vest no later than the date of the reservation, and as early as "time immemorial," regardless of whether they have been used. A "time immemorial" water right is one that originated under aboriginal title and was subsequently recognized by Federal law. A claim to a vested water right is determined and made a matter of record through an adjudication proceeding. The OWRD is responsible for gathering information about the use of water and presenting to the circuit court OWRD's findings of fact and order of determination, which states who has the right to use water, the amount and location of water use, period of use, and priority date. If nobody files an exception to OWRD's findings, then they are final. If any exceptions are filed, the circuit court hears the matter de novo (again) or delegates it for rehearing. A water right certificate is issued for each decreed right (State of Oregon 2009).

The Klamath Basin Adjudication is the adjudication process for pre-1909, ~~federal~~Federal reserved, and *"Walton"* (non-Indian successor to Indian allottees) water right claims for the use of surface water within the Upper Klamath Basin in Oregon. The Klamath Basin proceeding began in 1975. Claims of water use have been gathered and contests to the claims have been filed on all of those claims. Administrative law judges have been holding hearings and issuing proposed orders determining the claims and contests. The OWRD will review those proposed orders, and any proposed settlements of contests, and submit its Findings and Order of Determination to the Circuit Court in ~~likely~~ 2012 or 2013 (the last proposed orders are due to be issued in April 2012). Water right claims have been filed by private water users the Klamath Tribes, Klamath allottees, and the United States (for Indian and other ~~federal~~Federal reservations of land and the Reclamation's Klamath Project). Once OWRD's findings are submitted to court there will be an opportunity for parties to file exceptions to those findings. The Klamath Circuit Court will resolve the exceptions and issue a decree. As of July 2010, 97 percent of contests and 92 percent of the claims in the Upper Klamath Basin have reached a proposed resolution, either by issuance of an administrative law judge's proposed order or by a proposed settlement of contests (State of Oregon 2010a).

3.8.2.3 Interstate Water Allocation

3.8.2.3.1 Klamath Basin Compact

Allocations of water among ~~states~~ States are generally made by compact – a negotiated interstate agreement made with the consent of Congress – or by ~~federal~~Federal judicial proceeding. No ~~federal~~Federal court proceeding has allocated the waters of the Klamath River between Oregon and California. However, in 1957, the two States ratified and Congress consented to the Klamath Basin Compact, to "facilitate and promote the orderly, integrated and comprehensive development, use, conservation and control" of water resources in the Klamath Basin. Subject to all vested rights, the Compact provides for equitable distribution of water among the two ~~states and the federal government~~States and the Federal Government, and for preferential rights to the use of water after the effective date of the compact for domestic and irrigation purposes in the Upper Klamath Basin. The Compact recognizes, and protects from any adverse impact, the rights, privileges, and immunities of tribes, as well as the rights, powers and jurisdiction of the United States.

3.8.3 Existing Conditions/Affected Environment

The following section describes the environment and environmental setting for water supply availability and water rights compliance that could be affected by implementing the KHSA (including the Keno Transfer and decommissioning of PacifiCorp's East Side/~~West Side~~Westside Facilities) and ~~Klamath Basin Restoration Agreement (~~KBRA~~)~~. The Klamath Basin water supply is described, including ~~the~~its relationship to Reclamation's Klamath Project and PacifiCorp's Klamath Hydroelectric Project.

The Klamath Basin is divided into two areas, the Upper and Lower Klamath Basins, as described in Section 3.8.1. The Upper Klamath Basin includes six hydrologic sub-basins: Sprague, Williamson, Upper Klamath Lake, Lost, Butte, and Upper Klamath East. The Lower Klamath Basin includes seven hydrologic sub-basins: Upper Klamath West, Shasta, Scott, Salmon, Lower Klamath, Trinity, and South Fork Trinity. Figure 3.8-1 shows the subset of Klamath River hydrologic sub-basins within the affected environment.

Average annual precipitation in Klamath Falls, Oregon is 13.3 inches, occurring primarily as rain during the fall and winter seasons. Precipitation amounts in the (Lower) Klamath Basin in northwest California can be more than seven times that amount. Surface water runoff is closely related to annual precipitation patterns and has historically defined distinct dry and wet cycles. Recent trends include dry periods from 1915 to 1940 and 1975 to 1994 and wet periods from 1885 to 1915 and 1940 to 1975 (Department of the Interior [DOI] 2011). Klamath River runoff patterns have been measured by United States Geological Survey gages dating back as far as 1905 and reflect these climatic cycles. ~~These gages display a decreasing trend in runoff that follows a general decreasing trend in precipitation amounts.~~

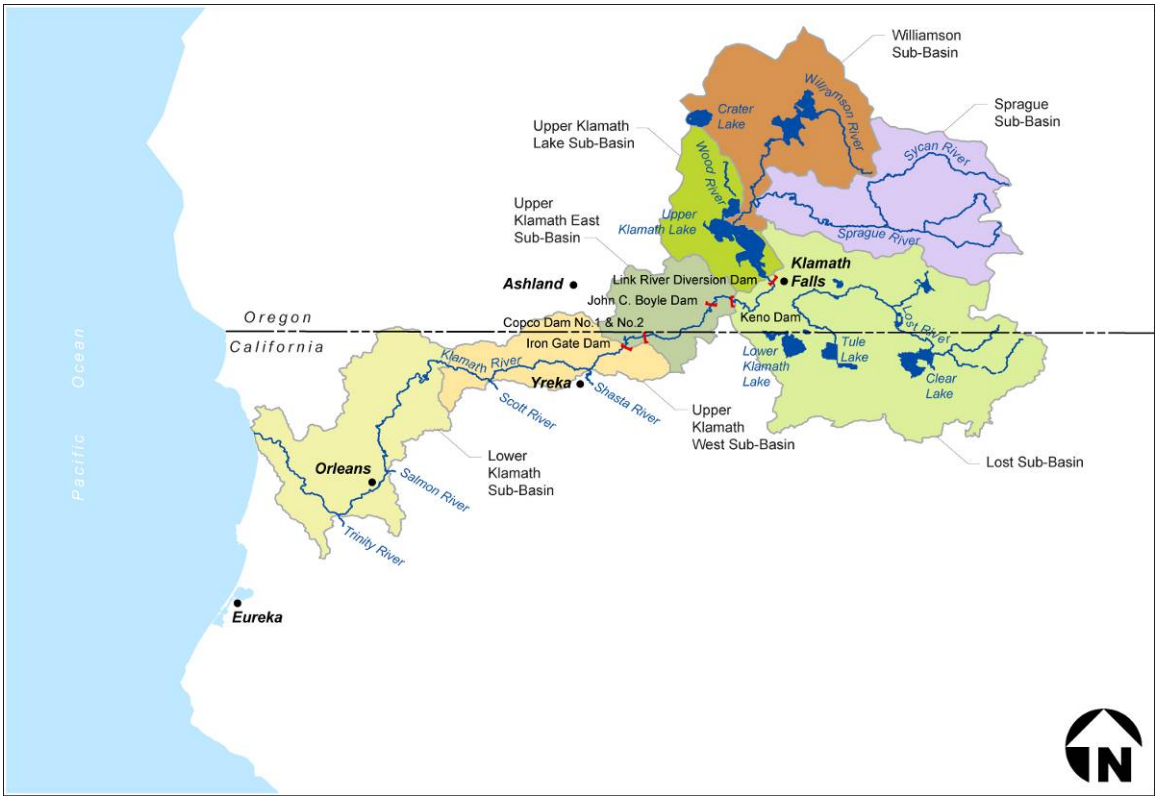


Figure 3.8-1. Area of Analysis

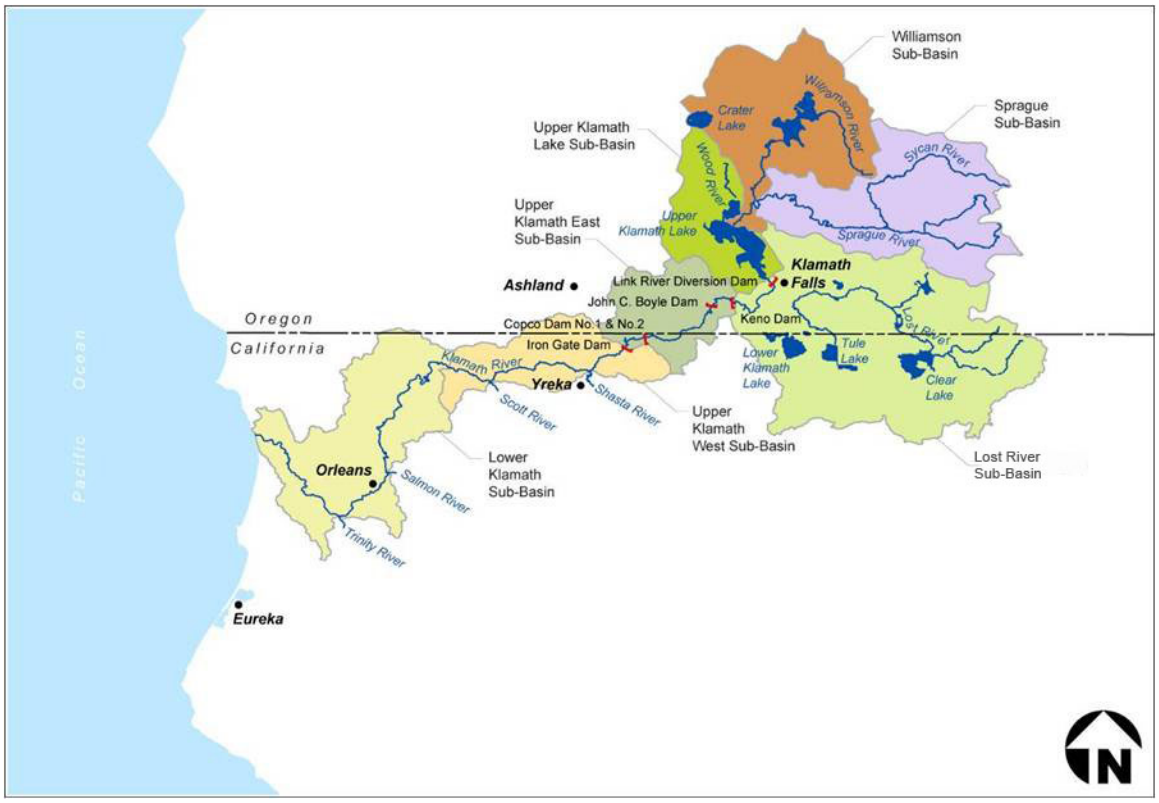


Figure 3.8-1. Area of Analysis.

3.8.3.1 Upper Klamath Basin

Of the Upper Klamath Basin's six hydrologic sub-basins, the Sprague, Williamson, and Wood Rivers provide the majority of the flow volume to the Klamath River via Upper Klamath Lake. Upper Klamath Lake is a controlled, natural lake that serves water users as a large, shallow storage basin and also provides the necessary habitat for several fish species that the Klamath Tribes have relied upon for centuries. Several measures have increased storage in the lake during recent years. In 2007, two miles of levees were breached, restoring approximately 3,500 acres of wetlands in the Williamson River Delta area. Another 1,400 acres were flooded in 2008, which provided 28,800 acre-feet of additional storage in Upper Klamath Lake. Table 3.8-1 shows data for the six hydrologic sub-basins in the Upper Klamath Basin.

~~The Upper Klamath Basin has multiple~~Multiple entities ~~that~~ rely ~~heavily~~ on the availability of the Upper Klamath Basin's water supply. The Klamath Tribes, upper Klamath irrigators, Reclamation's Klamath Project, Klamath Hydroelectric Project, and six NWRs are all included in the Upper Klamath Basin.

Table 3.8-1. Upper Klamath Basin Hydrologic Sub-Basins

Sub-Basin	Size (acres)	Irrigated Acres	Water Supply Source
Williamson River	928,000	65,100	90% diverted from streams, 10% groundwater
Sprague River	1,020,000	61,600	65% diverted from streams, 35% groundwater
Upper Klamath Lake	465,300	52,300	Diverted from streams or from Upper Klamath Lake
Lost River (Three sub-basins)			
Upper Lost River Sub-basin	*1,200,000*	*84,500*	50% of water coming from Reclamation's Klamath Project
Middle Lost River Sub-basin	*454,500*	*117,000*	70% of agricultural land is irrigated with Reclamation-supplied water; the rest is obtained from groundwater, individual surface water rights, or special Reclamation contracts.
Tule Lake Sub-basin	*296,600*	*64,800*	Groundwater provides 40–50% of water for irrigated pastures; most tailwater is reused from Reclamation
Butte Valley	388,100	52,300	Butte Valley sub-basin is an internal drainage basin with an artificial outlet. Groundwater flows from west to east out of the sub-basin toward Lower Klamath Lake. Irrigation water is from groundwater sources and diverted from surface water.
Upper Klamath River East	419,400	4,000	All irrigation water is diverted from the river or tributary streams; water withdrawals are insignificant along this stretch of the river.

Source: Natural Resource Conservation Service (United States Department of Agriculture 2004)

3.8.3.1.1 The Klamath Tribes

The Klamath Tribes consist of the Klamath and Modoc Tribes and the Yahooskin Band of the Snake Indians. In an 1864 Treaty with the United States, the Tribes ceded over 20 million acres of land in southern Oregon and Northern California to the United States, reserving for themselves an area extending northeast from Upper Klamath Lake, and containing over 2 million acres. Within the boundaries of the Klamath Reservation, the Treaty provided that the Tribes would retain exclusive fishing and gathering rights. Pursuant to the General Allotment Act of 1887, tribal lands within the Reservation were allotted to individual tribal members, and over the next decade, many of the allotted lands passed into non-Indian ownership. By the early 20th century, the Reservation had been reduced to approximately half its original size. In 1954, Congress terminated ~~federal~~ Federal recognition of the Klamath Tribes and condemned the Tribes' remaining lands. However, the Tribes' fishing and gathering rights, as recognized in the 1864 Treaty, survived termination. The Klamath Termination Act expressly preserved the Tribes' water rights, fishing rights, and other treaty privileges, and the ~~federal~~Federal courts have

since confirmed the existence, scope and priority of the Klamath Tribes' water rights in the Upper Klamath Basin. In a series of decisions in *United States v. Adair (Adair)*, the courts held that the Tribes have a water right sufficient to support their treaty fishing, hunting and gathering rights, with a priority date of "time immemorial" - thus senior to all other users in the basin. The courts also recognized a tribal water right for agrarian purposes, with a reservation date (1864) priority. Individual tribal members who received allotments pursuant to the General Allotment Act have a right to use a proportionate share of the tribal water for agrarian purposes, as do their non-Indian successors in interest under certain circumstances. The Klamath Tribes, the United States on behalf of the Tribes, individual Klamath Indian allottees, and non-Indian successors to Indian allottees have numerous claims in Oregon's Klamath Basin Adjudication.

3.8.3.1.2 Upper Klamath Landowners

Individual landowners within the Upper Klamath Basin have water rights for a variety of purposes, including but not limited to irrigation, domestic, livestock, instream use and wildlife purposes. All water right users in the Klamath Basin are subject to the senior ~~federal~~Federal reserved ~~Tribal~~ instream flow rights of the Klamath Tribes that may reduce the available water to junior water rights users. Private irrigators in the ~~upper~~Upper Klamath Basin have filed claims in the adjudication ~~proceedings~~ and some have organized themselves into an association to help support its members through the legal process of protecting their water rights. The Upper Klamath Water Users Association was created by a group of off-Project water users and is a non-profit organization protecting the ~~interest~~ interests of its members within the Klamath and Lost River Drainages. They are considered off-Project water users because they are outside of the Reclamation's Klamath Project. In addition, there are other irrigators above Klamath Lake who are seeking to protect their water rights.

3.8.3.1.3 Klamath Basin National Wildlife Refuge System

Between 1908 and 1958, six NWRs were established in the Upper Klamath Basin: Klamath Marsh (formerly Klamath Forest) (1958), Upper Klamath (1928), Bear Valley (1978), Lower Klamath (1908), Tule Lake (1928), and Clear Lake (1911). Klamath Marsh NWR is along the Williamson River, and the Upper Klamath NWR is on the northwest and southeast sides of Upper Klamath Lake. The other four are south of Klamath Falls in Oregon and California ~~and~~ ; two are adjacent to, ~~or~~ and two are within, the boundaries of Reclamation's Klamath Project.

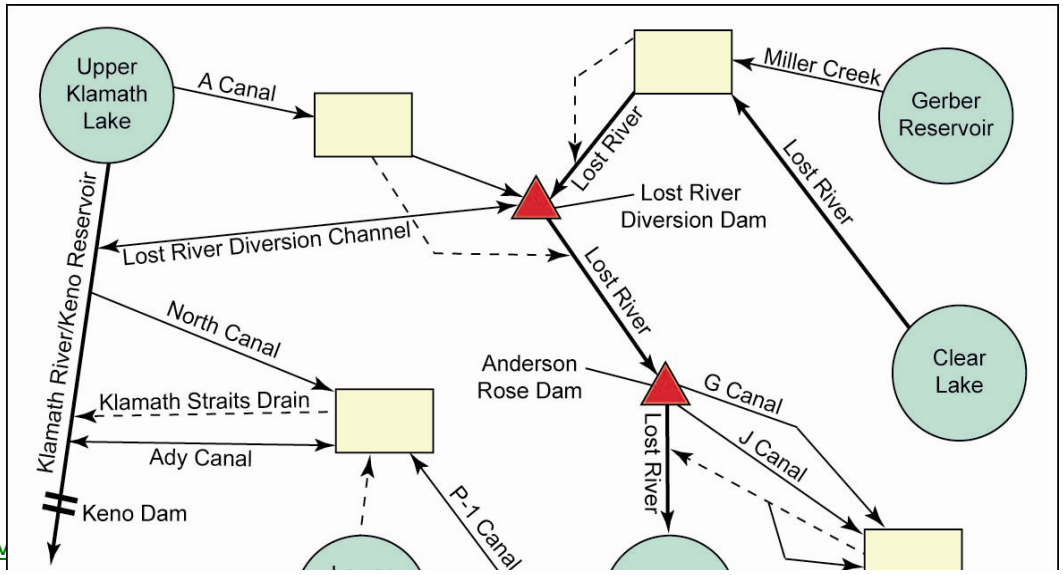
The United States Fish and Wildlife Service (USFWS) manages the NWRs. These areas provide suitable habitat and resources for migratory birds and other fish and wildlife species. The USFWS has claimed vested water rights under the Reclamation's Klamath Project for two of the refuges, the Lower Klamath and Tule Lake NWRs~~, as well as federal~~. USFWS has also claimed Federal reserved water rights for ~~the two refuges.~~Klamath Marsh and Upper Klamath NWR. Water rights for these four refuges are being quantified in the Klamath Basin Adjudication.

3.8.3.1.4 Reclamation's Klamath Project

Reclamation's Klamath Project facilities provide irrigation water to approximately 1,~~400~~ 400 farms covering about 235,000 acres (Congressional Research Service 2005) and to the Lower Klamath and Tule Lake NWRs. In 1905, Reclamation filed an application with the State of Oregon to secure a water supply for the lands within the Project area (Reclamation 2000). There are more than 250 contracts associated with Reclamation's Klamath Project; these contracts are with various irrigation districts and other water users (Reclamation 2000). In most cases, the contracts have no end date, and they specify acres to be covered rather than an amount of water to be provided (Reclamation 2000). Water users formed the Klamath Water Users Association in ~~1905~~1953 to help protect the "on-Project" water interests inside the Reclamation's Klamath Project.

Water is delivered to Reclamation's Klamath Project water users under contractual obligations between the United States and the water districts subject to the availability of water and in accordance with the Project water rights. Reclamation's Klamath Project also provides water to the refuges when available, which is usually after meeting contractual deliveries. Additionally, Reclamation has an obligation to ensure that the refuges receive adequate water to fulfill their Federal reserved water rights, when in priority and when water is available. Beginning in 1995, in compliance with the ESA and tribal trust responsibilities, water was first made available to meet the needs of the ESA listed fishes in Upper Klamath Lake and the Klamath River, then to meet contractual irrigation deliveries and then to the refuges.

The Upper Klamath Lake is one of the main sources of water for Reclamation's Klamath Project. The project's infrastructure and operation turned the Lost River hydrologic basin, once largely a closed basin, into a tributary to the Klamath River by returning flows through the Lost River Diversion Channel and Tule Lake to Lower Klamath Lake. The Lost River is another main source of water for Reclamation's Klamath Project, as is the Klamath River from Keno Impoundment/Lake Ewauna. Upper Klamath Lake represents most of its storage, but the lake is shallow, with an average depth of approximately 9 feet when full (Wood et al. 2006). Upper Klamath Lake can only provide small opportunities for carryover storage between years; therefore, Reclamation's Klamath Project operations are dependent on the amount of annual precipitation. Figure 3.8-2 shows a schematic of Reclamation's Klamath Project.



~~3.8-~~V

Figure 3.8-2. Schematic of Reclamation's Klamath Project

Beginning in ~~January~~April, Reclamation forecasts the available water ~~supplies~~ supply and establishes a general management plan for ~~its Klamath Project for~~ the coming year. ~~Reclamation forecasts the condition of its Klamath Project systems supply~~ Reclamation's forecast is based upon Natural Resource Conservation Service forecasts, watershed conditions, and projected water use for both irrigation and wildlife use. The annual operations plan ~~delineates~~estimates water availability and has been provided to the water users' community since 1995 (Reclamation 2000).

~~In 1905, Reclamation filed a formal application with the State of Oregon to secure a water supply for the lands within the Project area (Reclamation 2000).~~

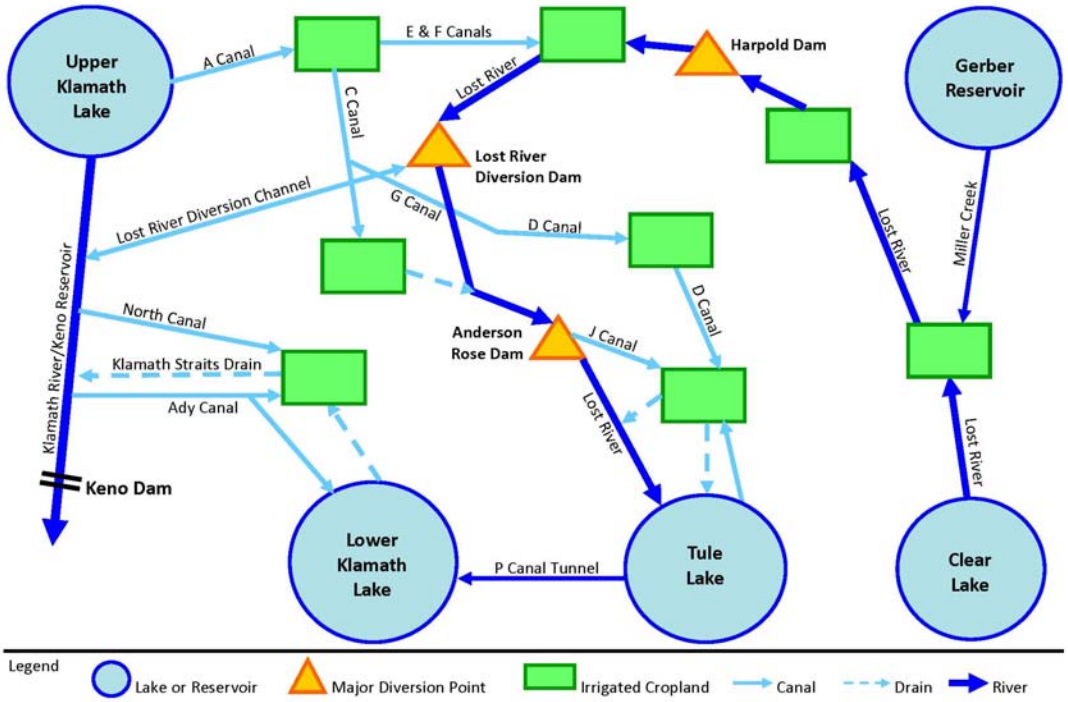


Figure 3.8-2. Schematic of Reclamation's Klamath Project.

3.8.3.1.5 Klamath River Dams

Multiple dams are associated with the Klamath Hydroelectric Project, which is in both Klamath County, Oregon and Siskiyou County, California, and is owned and operated by PacifiCorp. ~~Eight developments are part of the~~ The Klamath Hydroelectric Project includes eight developments, of which seven are on the mainstem of the Klamath River. Reclamation owns the Link River Dam, which ~~forms~~controls Upper Klamath Lake. The East and ~~West Side~~Westside powerhouses, downstream of Link River Dam, ~~indicate~~represent the upstream boundary of the Klamath Hydroelectric Project ~~and~~; the Iron Gate Development is the downstream boundary.

Flows through the Hydroelectric Reach (from Keno Dam downstream to Iron Gate Dam) are related to flow releases from Upper Klamath Lake ~~elevations~~, flows diverted to and

returned from Reclamation's Klamath Project, relatively small storage capacities of the Klamath Hydroelectric Project developments, and the releases out of Iron Gate Dam (Federal Energy Regulatory Commission [FERC] 2007). Upper Klamath Lake holds 83 percent of the total storage capacity of the reservoirs on the Klamath River (FERC 2007) and approximately 98 percent of active storage (Greimann 2011). Associated reservoirs for J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams contain 14 percent of the total storage capacity and 2 percent of the active storage on the river. However, these dams were not designed for water supply storage purposes and are most often operated as run-of-the-river facilities.

A query on California's Electronic Water Rights Information Management System provided three water right listings upstream of Iron Gate Development~~ (and within the State of California) that listed the Klamath River~~, with the Klamath River identified as the water source. These rights are held by PacifiCorp for irrigation and stock watering, for a total of 5,475 acre-feet during April 1 through October 31. Their locations are approximately four miles upstream of the Copco 1 Reservoir. Three additional PacifiCorp water rights list Copco 1 Reservoir as the water source. Each is for 3,200 cfs and they are associated with power generation and impoundment of water for Copco 1 and 2 Powerhouses. PacifiCorp filed Statements of Diversion and Use for pre-1914 claims with the California SWRCB to use water at Iron Gate Dam for hydropower activities as part of their licensing application. The pre-1914 claims are for 1,800 cfs for power generation, 50 cfs for fish propagation facilities, 3,300 cfs to refill regulatory storage space in Iron Gate Reservoir, and 48 cfs for fish culture.

PacifiCorp ~~has~~ holds two Oregon water right permits, one associated with the J.C. Boyle Dam hydroelectric generation and the other for irrigation purposes on less than an acre. The irrigation water is drawn from the Link River. (Source: State of Oregon Water Resource Department Water Rights Information System (State of Oregon 2010b)).

3.8.3.1.6 Municipal Water Rights

City of Yreka

The City of Yreka receives its water supply from Fall Creek, a tributary to the Klamath River in the Upper Klamath Basin that is approximately 23 miles northeast of the city. ~~A~~ California State Water Rights Permit 15379 allocates the City of Yreka up to 15 cfs or 9.7 million gallons per day (mgd) from this source, although the current demand is less than the permitted ~~allotted~~ amount (City of Yreka 2010). The City of Yreka's diversion was completed in 1969 and the public water systems facilities at Fall Creek include ~~three~~two impoundments; an intake structure with fish screens, a pump, and pre-treatment facility; a cathodic protection field at the Fall Creek Campground and Day Use Boat Ramp; and a 24-inch pipeline that crosses on the eastern upstream end of Iron Gate Reservoir. Water diverted from Fall Creek for the City of Yreka is mainly returned through subsurface drains, infiltration, and irrigation runoff to a tributary of the Shasta River (City of Yreka 2010). ~~It should also be noted that the~~ The California Department of Fish and Game (CDFG) possesses a 10 cfs non-consumptive water right (SWRCB License 11681) for fish propagation at Fall Creek Hatchery between March 15 and December 15 each year, not to exceed 5,465 acre-feet per year. ~~Shasta River flows into the Klamath River downstream of Iron Gate Dam.~~

3.8.3.2 Lower Klamath Basin

As described above, the Lower Klamath Basin includes seven sub-watersheds downstream of Iron Gate Dam. The area of analysis does not include the Shasta, Scott, Salmon, and Trinity Rivers (see Figure 3.8-1). Generally, the flow rate in the Klamath River increases substantially further downstream within the Lower Klamath Basin, as described in Section 3.6.3.3. The months of July through October generally have much lower flow volumes than the spring runoff months. The long-term average annual flow rate at Iron Gate Dam is just more than 2,000 cfs and approximately 17,600 cfs at the mouth of the Klamath River. Historic stream flows for the Klamath River are discussed in Section 3.6.3.3.

3.8.3.2.1 Klamath River Water Rights

Downstream of ~~Iron Gate Dam~~the California State line, the mainstem of the Klamath River flows ~~freely 190 miles~~ through Siskiyou, Del Norte, and Humboldt Counties to the Pacific Ocean. A query on California's Electronic Water Rights Information Management System provided ~~32~~ 38 water right listings with the Klamath River as the water source (Table 3.8-2). Six of these water rights listings are upstream of Iron Gate Dam and 32 of these listings are on the mainstream of the Klamath River downstream of Iron Gate Dam. Appendix L contains the query results and has a map that displays the documented locations.

~~**Sixteen Statement of Diversion and Use water rights types were filed between 1967 and 2010; 6 of the 16 are currently inactive. Ten appropriative water rights are a state filing; these were all filed in 1956 by the SWRCB.**~~

Table 3.8-2. Summary of Water Rights Listings From California's Electronic Water Rights Information Management System

Type of Water Rights Listings[1]	Number of Claims
Statement of Diversion and Use	
Claimed	16
Inactive	6
Appropriative Water Rights	
State Filing	10
Licensed	4
Permitted	1
Small Domestic Registration	1

Source: California Electronic Water rights information Management System (SWRCB 2010)
Notes:
[1]Status Definitions:
Claimed: Riparian and pre-1914 appropriative rights predate the Water Commission act. Entities that hold these rights are not required to obtain a permit from the SWRCB. These types of rights can only be confirmed by the courts.
Inactive: Unexercised water right.
State filing: To preserve water for future use and development consistent with a coordinated plan such as the State's Water Plan or a County General Plan. The SWRCB holds them in trust for the people of California. Parties who desire to develop water supply projects consistent with the coordinated plan may petition the SWRCB to assign all or part of the State-filed application to them. If approved, this action gives the petitioner a water right priority based on the date that the State-filed the water right application.
Licensed: If a project is determined to be using the allotted water beneficially under the conditions of a permit, a vested water right license is issued.
Permitted: A permit is an authorization that allows for the development of a project to proceed with considerations for the beneficial uses of water, the public interest, reasonableness, and the public trust.
Registered: In lieu of a water right, entities can register to divert and use a small amount of water from a stream for domestic purposes or the use of a small amount of water for livestock. In such cases, the use is registered with the SWRCB and must follow conditions set by the CDFG to protect fish and wildlife.

A total of 22 Statement of Diversion and Use water rights were filed with the SWRCB; 6 of the 22 are currently inactive. Statement of diversion and use water rights include reported riparian water rights as well as pre-1914 appropriative rights.

A total of 15 appropriative water rights have been filed after 1914. Of these 15 appropriative water rights, 10 are State filings only, meaning that those rights have not yet been assigned or developed. State filings are to preserve water for future use and development consistent with a coordinated plan such as the State's Water Plan or a County General Plan. State filings hold water in trust for the people of the State of California based on the date of filing. The State filings on the Klamath River all have priority dates of 1956. A State filing in Siskiyou County that maybe intended for the use of the Shasta Valley Irrigators was submitted in 1956 by the SWRCB to use 60,000 acre-feet from the point of diversion at the current location of Iron Gate Dam. As of December 2010, no diversion infrastructure exists or is planned for construction involving this water right application. None of the alternatives considered in this EIS/EIR would affect these State filings.

There are four appropriative water rights with a licensed status: one with PacifiCorp in 1957, one with Klamath River Country Estates Owners Association Inc~~.~~., in 1960, and two with individuals in 1964 and 1966. The Klamath Community Services District holds one appropriative permitted water right from 1968, and there is one Small Domestic Registration water right from 2006. There are also multiple claims on a number of the creeks, unnamed springs, and groundwater sources scattered within the Lower Klamath Basin.

It is expected that each of these water rights listings will have associated intake facilities to draw water from the Klamath River however; the specific type, location, and layout of each of these intake facilities is unknown at this time.

~~**Shasta Valley Irrigators**~~

~~Shasta Valley Irrigators (Siskiyou County) claim that an application was submitted in 1956 on their behalf to the State of California to use 60,000 acre-feet from the Klamath River with a point of diversion at Iron Gate Dam. Application A016958 was submitted in 1956 on behalf of the SWRCB, but does not specifically name the Shasta Valley Irrigators as recipients of the water. As of December 2010, no diversion infrastructure exists or is planned for construction involving this water right application.~~

Indian Tribes

Quartz Valley Indian Reservation

The members of the Quartz Valley ~~Indian~~ Community are of upper Klamath (Karuk) and Shasta Indian ancestry. The 174-acre Quartz Valley Indian Reservation is in Siskiyou County near the community of Fort Jones within the Klamath watershed and area of study. Any fishing and concomitant water rights to which the Quartz Valley ~~Community~~ Indian Reservation may be entitled have not yet been determined.

Karuk Tribe

Congress never formally ratified the treaty negotiated between the United States and the Karuk Tribe in 1851, and no statute or executive order otherwise set aside reservation lands for the Tribe. However, the United States has more recently taken lands into trust for the benefit of the Karuk Tribe, including ~~over 810~~652 acres in Siskiyou County and ~~approximately 40 acres in~~ Humboldt County. Most of the Tribe's aboriginal lands along the Klamath River, above the Klamath Trinity Confluence, now form part of the Klamath National Forest. Any fishing and concomitant water rights to which the Karuk Tribe may be entitled have not yet been determined.

Hoopa Valley and Yurok Tribes

The Klamath River Reservation, consisting of a strip of land beginning at the Pacific Ocean and extending one mile in width on each side of the Klamath River for a distance of approximately 20 miles, was established by Executive Order in 1855. The Reservation was established on Yurok ancestral lands. In 1876, a second executive order established the Hoopa Valley Indian Reservation, a 12 mile square area southeast of the Klamath River Reservation, beginning at the confluence of the Klamath and Trinity Rivers, and bisected by the Trinity River. A third executive order in 1891 created an extended Hoopa Valley Reservation, which encompassed the original Hoopa Reservation, the Klamath River Reservation, and a strip down the Klamath River from the Klamath-Trinity confluence connecting the two original reservations. In 1988, Congress passed the Hoopa-Yurok Settlement Act, 25 U.S.C. 1300i et seq, which partitioned the extended reservation between the Hoopa Valley and Yurok Tribes, with the Yurok Reservation comprising the original Klamath River Reservation and the connecting strip, and the Hoopa Reservation comprising the original 12 mile square area. The ~~federal~~Federal courts have confirmed that the United States reserved fishing rights for the Hoopa Valley and Yurok Tribes when it set aside reservations along the Klamath and Trinity Rivers. DOI has found that the original orders setting aside the Hoopa Valley and Yurok Reservations also reserved rights for instream flows sufficient to sustain fish within the reservation. Although the State of California has not commenced an adjudication to determine the quantity of water to which the Tribes have a right to support their reserved fishing rights, the recognition of such rights is consistent with the ~~federal~~Federal precedent set in United States v. Adair.

Resighini Rancheria

The 239-acre Resighini Rancheria is located near the mouth and on the south bank of the Klamath River, and is surrounded by the Yurok Reservation. The Rancheria Reservation was purchased by the Bureau of Indian Affairs in 1938 under the authority of the Indian Reorganization Act, and proclaimed an Indian reservation by Secretarial Order in 1939. Any fishing and concomitant water rights associated with the Resighini Rancheria have not yet been determined.

3.8.4 Environmental Consequences

The analysis of water rights focuses on changes to water supply and compliance with existing water rights laws. This analysis discusses the changes to river flows and water diversions throughout the affected environment in the Klamath Basin and whether the changes could affect existing water rights or water supplies.

3.8.4.1 Environmental Effects Determination Methods

The impact assessment is based on flow rates and water supply delivery data from the hydrologic modeling completed by the Lead Agencies, along with the methods and assumptions that were utilized in the model. The Lead Agencies applied a one-dimensional HEC-RAS model using historic flow data as input to the model. The modeling provided results for the No Action/No Project Alternative and the Proposed Action. The model's average daily instream flow data helps to describe how the flows would change under different alternatives. The hydrologic modeling addressed flow-related changes associated with the Klamath Basin Restoration Agreement (KBRA); flow changes downstream of the Four Facilities from KBRA actions are incorporated into the modeling analysis of removal of the Four Facilities. The Lead Agencies used this data to assess whether changes to instream flows as a result of the project would be adequate to meet water right requirements. The Lead Agencies also compared water supply diversions to baseline conditions and water rights to determine impact significance. The Hydrology, Hydraulics, and Sediment Transport Studies include more information on the modeling methods and assumptions (DOI 2011Reclamation 2012).

Specific analysis of changes in river flows and the resulting effect on fisheries are described in Section 3.3, Aquatic Resources. The assessment of the alternatives' effects on Safe Drinking Water Act requirements is presented in Section 3.2, Water Quality. The assessment of the alternatives' effects on Fire Suppression is presented in Section 3.18, Public Health and Safety, Utilities and public servicesPublic Services, Solid wasteWaste, Power.

3.8.4.2 Significance Criteria

For the purposes of this Environmental Impact Statement/Environmental Impact Report (EIS/EIR), impacts would be significant if they would result in the following:

- Causing injury to existing water rights or adjudication claims.[1]
- Decreasing water supplies beyond what is needed for public health and safety (i.e., needs for drinking water and fire suppression) for the current population.

3.8.4.3 Effects Determinations

3.8.4.3.1 Alternative 1: No Action/No Project

The J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams would not be removed under the No Action/No Project Alternative (with a Negative Determination) and operations similar to current operations would be in effect. The Klamath Hydroelectric Project and

[1] An existing water right or adjudication claim is one that was either being used or was part of an existing claim at the time of the Notice of Preparation (NOP).

Reclamation's Klamath Project would be operated as they were before the Secretarial Determination process began, including operation requirements under the 2010 National Oceanic and Atmospheric Administration (NOAA) Fisheries Service Biological Opinion and 2008 USFWS Biological Opinion on Reclamation's Klamath Project. PacifiCorp would resume the FERC relicensing process and operational measures could change.

Under the No Action/No Project Alternative, continued operation of the Four Facilities could affect water supply operations. Under the No Action/No Project Alternative, water supplies would be similar to existing conditions depending on the water year type. However, the current demand for water exceeds the supply. As a result, low water years can be devastating to the Indian Tribes and other communities dependent on water to support fish for subsistence, religious, sport and commercial harvest, and to agriculture communities dependent on irrigation water for their livelihood. The No Action/No Project Alternative does not include any action to change water supplies from existing conditions. **Therefore, the No Action/No Project Alternative would have no effect on water rights or water supplies because the risk of decreasing water supplies beyond what is needed for the current population's public health and safety would not change from the existing conditions.**

Under the No Action/No Project Alternative, ongoing restoration actions would continue to be implemented and could affect water supply availability. These actions include the Agency Lake and Barnes Ranches Project, and ongoing fisheries restoration actions.

Reclamation purchased the Agency Lake and Barnes Ranches adjacent to Agency Lake in 1998 and ~~is currently using~~has used portions of the ranches as pumped storage in some years. These ranches have been transferred to the USFWS and are now part of the Upper Klamath NWR. USFWS is studying the possibility of breaching the dikes which would convert the maximum of 24,000 acre-feet of pumped storage to 63,770 acre-feet of ~~storage from pumped storage to passive storage in~~ dead pool and useable storage in Agency Lake and Upper Klamath Lake. The Agency Lake/Barnes Ranches Project would go through separate National Environmental Policy Act evaluations as plans are developed for future restoration activities. **Future changes would not substantively change the quantity of storage or water supply yield associated with that storage and therefore, there would be no change from existing conditions.**

3.8.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (the Proposed Action)

~~*Relocation of the Yreka water supply pipeline after drawdown of the Iron Gate Reservoir and could affect water supply.* The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the reservoir to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would either be suspended from a pipe bridge across the river near its current location, or rerouted along the underside of the Lakeview Bridge just downstream of Iron Gate Dam.~~

~~The water supply for Yreka, on Fall Creek, would be unaffected by the relocation work. The pipeline would be disconnected for a short amount of time, as dictated by the available storage supply for the city, to prevent interruption of service to the residents of Yreka. **The relocation of the Yreka Pipeline would result in no change from existing conditions.**~~

Removal of recreational facilities currently located on the banks of the existing reservoirs could affect water supply or water rights. The existing recreational facilities provide camping and boating access for recreational users of the reservoirs~~.~~ and currently do not use surface water supplies. Once the reservoirs are drawn down, these facilities would be removed. **The removal of the recreational facilities would result in no change from existing conditions.**

Dam removal could change surface water flows available for diversion downstream of Iron Gate Dam. Modeling efforts rely on historical flow data to create a set of flows under future operational prescriptions. The Lead Agencies compared the modeled flow rate at Iron Gate Dam under the Proposed Action to that of the No Action/No Project Alternative. Figure 3.8-3 shows the exceedance flow results for the No Action/No Project Alternative and the Proposed Action. The results showed either a slightly higher or slightly lower flow rate on the Klamath River downstream of Iron Gate Dam when compared to the No Action/No Project Alternative. Flows under the Proposed Action could change both because of the dam removal activities and the KBRA diversion and instream flow requirements, and these effects are combined in these figures. Figure 3.8-4 shows that these differences would diminish farther downstream from Iron Gate Dam. The modeling results show that at Seiad Valley, approximately 62 miles downstream from the Iron Gate Dam, the flow rates would be nearly identical.

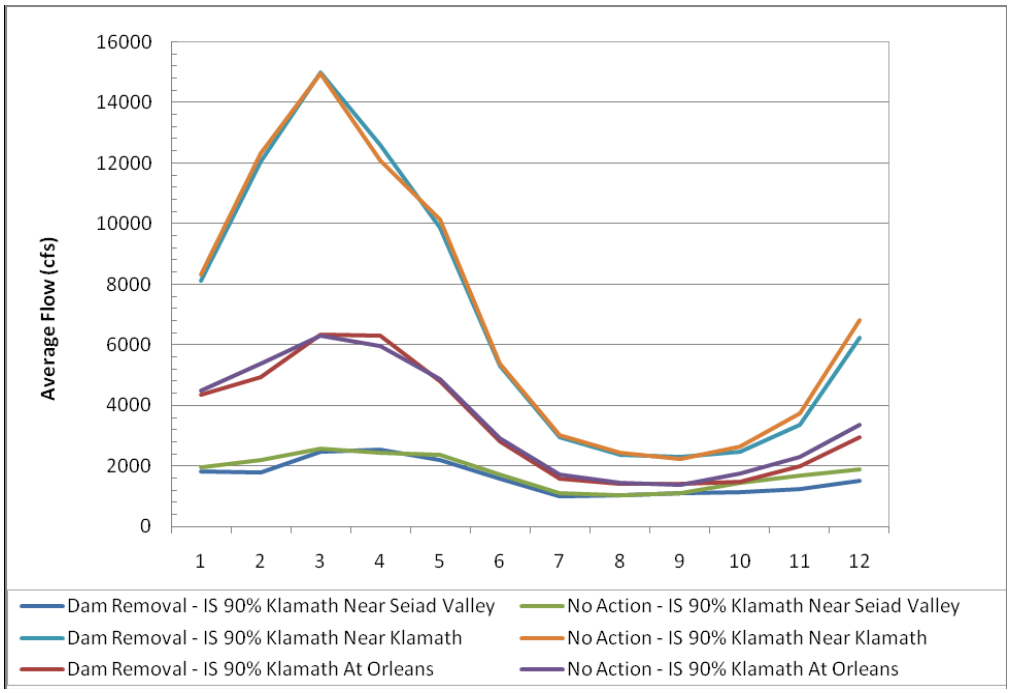


Figure 3.8-4. 90% Exceedance Flows Near Seiad Valley, Orleans, and Klamath for Dam Removal and No Action Alternatives (DOI 2011)

Because the flow rates at Seiad Valley would be nearly identical between the Proposed Action and the No Action/No Project Alternative, the Proposed Action is not likely to affect water supply downstream of Seiad Valley. As shown in Appendix L, approximately 8 of the 32 California water rights are downstream of Seaid Valley. **Under the Proposed Action, impacts on water supply downstream of Seiad Valley would be less than significant.**

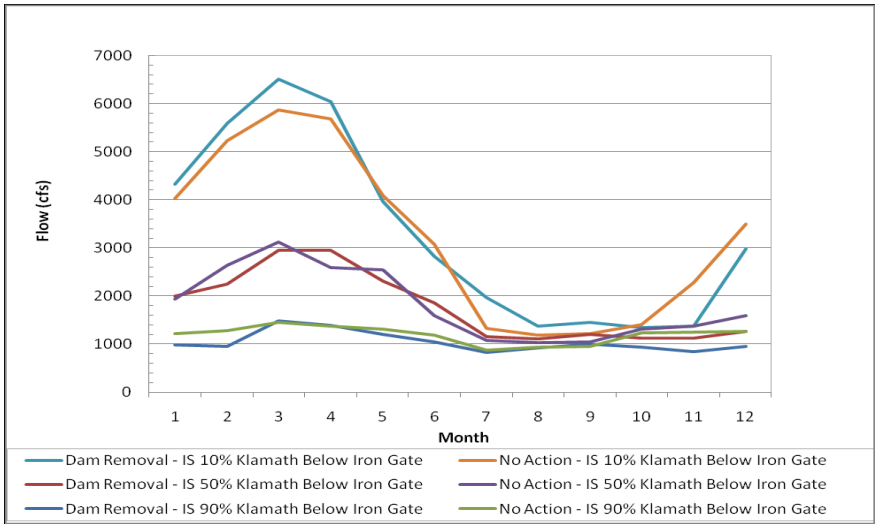


Figure 3.8-3. Flows for different year types under the Proposed Action and No Action Alternatives just downstream from Iron Gate Dam (Reclamation 2012).

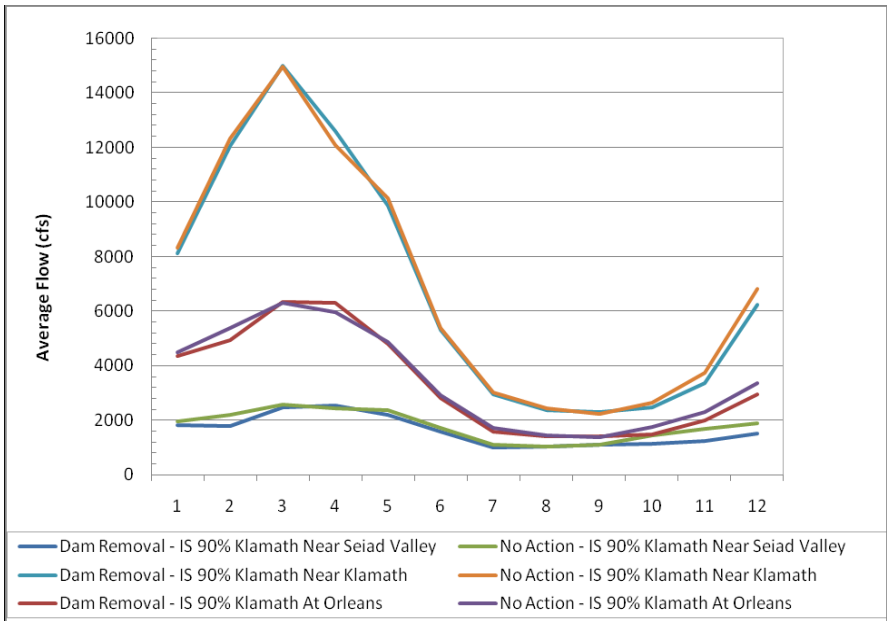


Figure 3.8-4. 90% Exceedance Flows Near Seiad Valley, Orleans, and Klamath for Dam Removal and No Action Alternatives.

Dam removal could ~~be affected by the~~cause changes in water supply compared to the No Action/No Project Alternative. Flow rates just downstream of Iron Gate Dam are the lowest within this reach and provide a conservative estimate on available water supply when comparing to the downstream diversion amounts. ~~There are 24 water right holders along this reach including one small domestic registration and 7 appropriative water rights; 4 are state filings with the SWRCB (reserve water for future use and development), 2 are listed with PacifiCorp and~~ A query of California's Electronic Water Rights Information Management System provided 38 water right listings with the Klamath River as the water source and identified 24 water right holders. Of these listings, sixteen water rights are for riparian uses (Statement of Diversion and Use permits), of which 6 are inactive. Also there are four appropriative water rights with a licensed status: one with PacifiCorp in 1957, one with Klamath River Country Estates Owners Association Inc., in 1960, and two with individuals in 1964 and 1966. The Klamath Community Services District holds one appropriative permitted water right from 1968, and there is one Small Domestic Registration water right from 2006 (Table 3.8-2 and Appendix L). The listing for PacifiCorp is associated with facilities at Iron Gate Dam including operation of the fish hatchery~~, and 2 are for irrigation and fire protection purposes~~. As stated in Section 2.4.3.1, an alternate water source would need to be found for operation of the fish hatchery until the restoration and return of native fish at self sustaining population levels is achieved.~~ The remaining 16 water rights are associated with riparian water rights (Statement of Diversion and Use permits) of which 6 are inactive.~~

The monthly diversion flow rate associated with all of the active and inactive water rights, aside from the four reserved ~~state~~State filings and the PacifiCorp power diversion water right,[2] is approximately 64 cfs (based on water right information in Appendix L). During peak summer months, usage typically doubles. Since usage generally doubles between Iron Gate Dam and Seiad Valley during July and August, the peak short term diversion flow rate that would be diverted is 128 cfs if all users doubled their water diversion rate during the same period. This flow rate represents the peak flow diverted, and would likely be lower during wetter water years. The Proposed Action would change the flows in the river, but the flows would still be substantially greater than the peak diversion. The most conservative comparison is just downstream of Iron Gate Dam, where the flows would be the lowest in the potentially affected reach. Comparing the peak potential diversion with low flow conditions, the diversions would be approximately 16 percent of the Klamath River flows during a dry year[3]. A 90 percent exceedance flow of 824 cfs was used to represent a dry year. The flow rate of 824 cfs was once the

~~2~~ [2] The four state filings with the SWRCB were not included because the water right is associated with a storage amount to preserve water for future use with no indication of the period of time during which the flow volume will be drawn. The PacifiCorp water right is associated with power generation at Iron Gate Dam and does not result in reduction of flows. For the diversion amount given in cubic feet per year (ID: WR-6), a diversion period of six months was assumed.

~~3~~ [3] The increase during July and August is an average based on reported values on Statement Diversion and Use forms available on California Electronic Water Rights Information Management System for the Klamath River.

seasonal low during the month of July, when irrigation and livestock demands are the greatest. (These low flows were used to develop a conservative impact evaluation, but they are less than what is currently acceptable under the NOAA Fisheries Service biological opinion.)

Because the amount of flow diverted for water right users between Iron Gate Dam and Seiad Valley would be less than 20 percent of the flow in the Klamath River in the upstream portions of this reach during dry year, low flow conditions, water right users are not likely to experience decreased supplies because of the changes in flows. **Under the Proposed Action, impacts on downstream Klamath River water right users would be less than significant.**

Release of stored sediment during drawdown of reservoirs could change Klamath River geomorphology and affect water intake pumps downstream of Iron Gate Dam. Reservoir drawdown would release the sediment behind PacifiCorp dams downstream. Reservoir drawdown activities would begin on November 1, 2019 at Copco 1, on January 1, 2020 at J.C. Boyle and Iron Gate Dams, and on June 1, 2020 at Copco 2 Dam. During this period, individual downstream intake facilities could be inundated with sediment deposits, causing operational problems. Reclamation conducted modeling of the reservoir drawdown and erosion of reservoir sediment. The released sediment would likely exceed the carrying capacity of the river during some water year types, and would result in sedimentation and particle settling in slow-moving downstream areas. The fine fraction of the released sediment (silts, clays, and organics) would not be expected to deposit in substantial amounts in the river channel. The majority of this material would be transported to the ocean and would not interact substantially with the river bed. The amount of fine deposition would also decrease with distance from the dam. If drawdown occurred in a dry year, a substantial deposition of sands would be expected in the reach from Iron Gate Dam to as much as eight miles downstream of the dam, around Cottonwood Creek. There are 14 water rights registered on this reach; five are listed as inactive, two are ~~a state filing~~State filings with the SWRCB, and two are associated with PacifiCorp's Iron Gate Dam facility and fish hatchery. The remaining water rights are associated with domestic, irrigation, and/or fire protection use.

The specific layout of these intake facilities is unknown, and they have potential to be affected by sediment deposits. The Lead Agencies have incomplete information on the exact configuration of water diversions in the eight-mile reach of the river that could be affected because this information would be prohibitively expensive to obtain and would not change the significance finding of this impact. These diversions are on private property. The property owners would need to grant access to the Lead Agencies to investigate the diversions, and obtaining permission is time consuming and expensive to implement. Information collection would include extensive data collection efforts regarding the type of diversion facility, elevation, location, screening, and canal or pipeline to the place of use. Some of this information collection would occur in the river, which would increase its expense.

The incomplete information would not change the finding of significance for the water supply impact. The analysis of this impact considered the results of detailed hydraulic, hydrologic, and sediment transport modeling; however, all models have a margin of error. Even small deviations in localized sediment deposition at a site could affect the ability to use diversion facilities. Because of this uncertainty, the Lead Agencies would declare these impacts to be significant and in need of mitigation even if this information was available and indicated that the impact could be minor.

Sediment deposition in the eight miles downstream from Iron Gate Dam could affect diversion facilities that deliver water to users. **Under the Proposed Action, impacts to water intake pumps downstream of Iron Gate Dam would be significant. Implementation of mitigation measure WRWS-1 would reduce this impact to a less than significant level.**

Activities associated with Interim Measures (IMs) could result in changes to PacifiCorp's water rights. Prior to ~~construction~~dam removal, "Interim Measures" as described in the KHSA (KHSA Section 1.2.4) would be implemented and would control operations of the hydroelectric facilities. IM 16 would eliminate three screened diversions from Shovel and Negro Creeks (the Lower Shovel Creek Diversion [7.5 cfs], Upper Shovel Creek Diversion [2.5 cfs], and Negro Creek Diversion [5 cfs]) and would seek to modify PacifiCorp's water rights to move the points of diversion to the mainstem Klamath River. The intent of this measure is to provide additional water for suitable habitat for aquatic species in Shovel and Negro creeks, while not diminishing PacifiCorp's water rights. While this measure would require a change to PacifiCorp's water rights, it would not affect the exercise of the water right (i.e., the quantity of water diversions) or flow in the Klamath River. **Therefore, the impact on water supply from implementation of the Interim Measures would be less than significant.**

3.8.4.3.3 Keno Transfer

Implementation of the Keno Transfer could cause changes to operations affecting water levels upstream of Keno Dam, which could cause changes to water supply or water rights. The Keno Transfer would be a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on water supply/water rights compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section 7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

3.8.4.3.4 East and ~~*West Side*~~Westside Facilities – Programmatic Measures

Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse impacts to water supply and water rights. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA will ~~redirect~~stop diversions of water flows ~~currently diverted~~ at Link River Dam into the two canals, back in to Link River. Following decommissioning of the

facilities there ~~will~~would be no change in outflow from Upper Klamath Lake or inflow into Keno Impoundment/Lake Ewauna. Water users currently reliant on a diversion from the West Canal would have their water supply connection extended to either Link River or Upper Klamath Lake. Therefore, implementation of the East and ~~West Side~~Westside Facility Decommissioning action would result in no change from existing conditions.

3.8.4.3.5 City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

Relocation of the Yreka Water Supply Pipeline after drawdown of the Iron Gate Reservoir could affect water supply. The existing water supply pipeline for Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the reservoir to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would be suspended from a pipe bridge across the river near its current location. The water intake for Yreka, on Fall Creek, would be unaffected by the relocation work. The water quantity and quality diverted from Fall Creek would not change. During connection of the new pipeline, the existing pipeline would be disconnected for less than 12 hours during the winter season. The available water in storage would be able to supply the city for up to 72 hours during the winter (Taylor 2010); therefore, the pipeline connection would not interrupt service to the residents of Yreka. **The relocation of the Yreka Water Supply Pipeline would result in no change from existing conditions.**

KBRA – Programmatic Measures

The KBRA, which is ~~a component of~~action connected to the Proposed Action, encompasses several programs that could affect water rights and water supply, including:

- Fisheries Reintroduction and Management Plan
- Wood River Wetland Restoration
- Water Diversion Limitations
- On-Project Plan
- Future Storage Opportunities
- Water Use Retirement Program
- Off-Project Water Settlement
- Off-Project Water Reliance Program
- Emergency Response Plan
- Climate Change Assessment and Adaptive Management
- Interim Flow and Lake Level Program
- Drought Plan

One of the goals of the KBRA includes improving water supply reliability by increasing storage capabilities and management plans, improving availability. There is not a specific KBRA flow regime in the Klamath River or a specific Upper Klamath Lake level regime. KBRA allows for more flexible management based on water availability and real-time consideration of fisheries issues. Figure 3.8-5 presents Reclamation's Klamath Project Simulation Model results predicting the annual flow at Keno Dam and annual agricultural supply. Appendix E-5 of the KBRA presents a range of simulated conditions developed by some parties; however, these conditions would not necessarily be the flows or lake levels that would occur in a given hydrologic condition or year-type. The agricultural supply represents supply to Reclamation's Klamath Project and includes Tule Lake NWR and Lower Klamath NWRs (two NWRs in the area that are the most directly affected by the KBRA). The flows for the No Action/No Project Alternative are governed by operating requirements under the 2010 NOAA Fisheries Service Biological

Opinion and 2008 USFWS Biological Opinion on Reclamation's Klamath Project, while flows for the Proposed Action would change because of the dam removal activities and would be governed by KBRA diversion and instream flow requirements (as well as future biological opinions). Annual flows downstream of Keno Dam would be generally similar between the No Action/No Project Alternative and Proposed Action except for a few dry years when flow would continue to be supplied to Reclamation's Klamath Project[4].

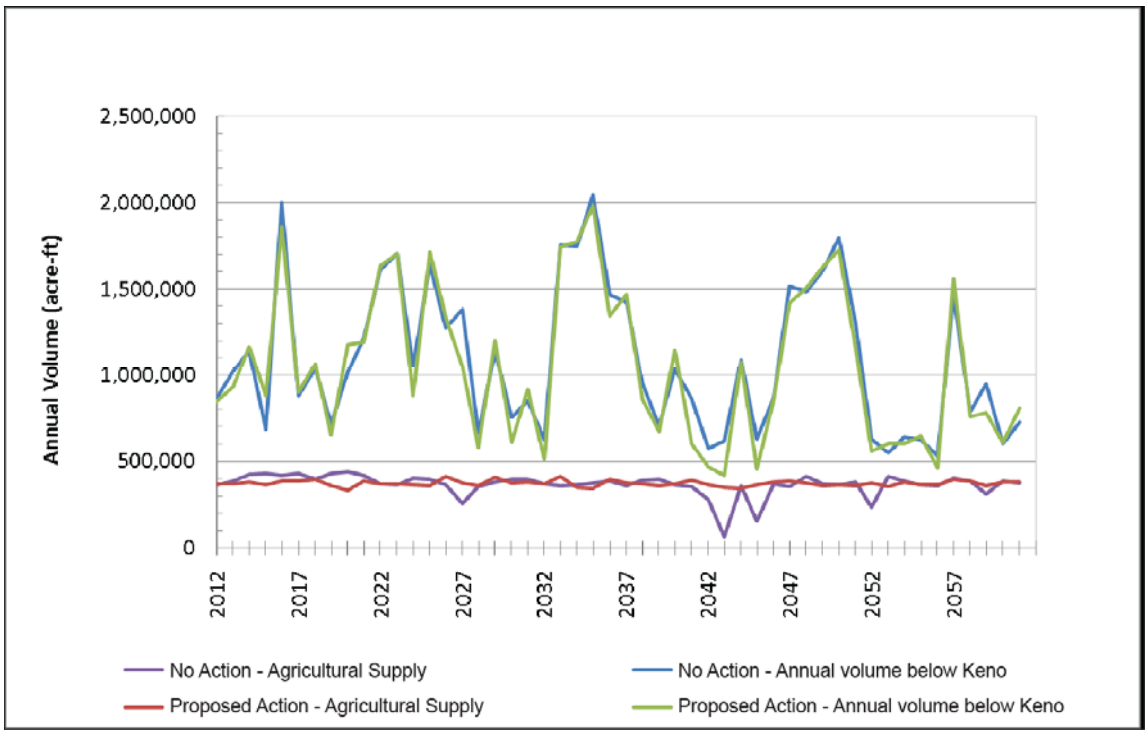


Figure 3.8-5. Annual flows under the No Action/No Project Alternative and Proposed Action (~~DOI 2011)~~Reclamation 2012).

[4] Minimum flows may change in the future. Hydrologic modeling assumed that the Drought Plan would include a minimum flow of 800 cfs (~~DOI 2011).~~Reclamation 2012). The final Drought Plan or future ESA actions could change the minimum flows; however, these assumptions reflect the best available information at the time of the modeling.

Fisheries Reintroduction and Management Plan

Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan would require water rights to divert water for the fish handling facilities. Fish handling facilities to collect fish downstream of Keno Dam and at Link River Dam would require water sources. The facilities would not consumptively use the water; the water would pass through the facilities for release back into the system. ~~The geographic separation between this project and the hydroelectric facility removal actions analyzed above eliminate any potential for negative water supply effects generated by this program from contributing to water supply effects generated by facility removal~~ Changes in water diversions near Keno and Link River Dams would not contribute to any changes in water supply or water rights associated with removal of the Four Facilities because the actions are in different parts of the watershed. **Because the fish handling facility would not increase consumptive use on the Klamath River system, the impacts of the trap and haul operations on water supply/water rights would be less than significant.**

Wood River Wetland Restoration

Implementation of the Wood River Wetland Restoration Project would result in changes to storage opportunities at Agency Lake, which could affect water supply. A study of Wood River Wetland area management options would investigate providing additional storage for a total of 16,000 acre-feet of storage capacity at or adjacent to Agency Lake. This additional storage would improve water supply reliability and assist with alleviating short-term impacts related to water supply delivery during Water Diversion Limitations (another KBRA program) helping to offset a portion of the deficiencies. ~~The geographic separation between this project and the hydroelectric facility removal actions analyzed above eliminate any potential for negative water supply effects generated by this program from contributing to water supply effects generated by facility removal.~~ Changes in water storage in Upper Klamath Lake would not contribute to any changes in water supply or water rights associated with removal of the Four Facilities because the actions are in different parts of the watershed. **Implementation of the Wood River Wetland Restoration Project would be a less than significant impact to water supply. Implementation of the Wood River Wetland Restoration will require future environmental compliance as appropriate.**

Water Diversion Limitations

Implementation of Water Diversion Limitations to Reclamation's Klamath Project could result in changes to water diversions, which may affect water rights and water supply. Water Diversion Limitations provide specific allocation of water for refuges and limitations on specific diversions for the Reclamation's Klamath Project intended to increase water availability for fisheries purposes. Water Diversion Limitations would be implemented during dry years to increase flows for fisheries by reducing Reclamation's Klamath Project diversion upstream ~~of~~ by approximately 100,000 acre-feet. Water diversions could increase by 10,000 acre-feet for irrigation in some years if: 1) dam removal is implemented, 2) 10,000 acre-feet of new storage is created, or 3) Klamath Basin Coordinating Council concurs. Implementation of the diversion limitations would

include assurances of increased reliability of diversions. The On-Project Plan, described in more detail below, provides the framework for management of Water Diversion Limitations implementation. While reducing diversions during the driest years would affect water supply for irrigation, it would not affect what is needed for public health and safety. Water may not be available to fulfill some water rights or adjudication claims during dry years; however the On-Project Plan, Drought Plan, and Future Storage Opportunities to be implemented as part of the KBRA would help to offset a portion of these deficiencies. These plans would provide mechanisms for irrigators to plan for water deliveries based on the type of water year. ~~It is likely that health and safety issues related to water supply would be a priority whereas, water for irrigation would likely be less of a priority. The geographic separation between the Water Diversion Limitations and the hydroelectric facility removal actions analyzed above reduce the potential for negative water supply effects generated by this program from contributing to water supply effects generated by facility removal.~~ Changes in water diversions to Reclamation's Klamath Project would not contribute to any changes in water supply or water rights associated with removal of the Four Facilities because the actions are in different parts of the watershed. **Implementation of Water Diversion Limitations is anticipated to have less than significant impact on water supply to Reclamation's Klamath Project. Implementation of the Water Diversion Limitations will require future environmental compliance as appropriate.**

On-Project Plan

Implementation of the On-Project Plan to allow for full implementation of Water Diversion Limitations to Reclamation's Klamath Project would result in changes to water diversions for irrigation in dry years, which could affect water rights or adjudicated rights~~.~~ and water supply to the NWRs. The purpose of the On-Project Plan is to provide additional water supply or reduce the demand for Reclamation's Klamath Project to make up the differences between anticipated ~~use~~demand and actual diversion. These actions include: land fallowing and shifting to dryland crop alternatives, efficiency and conservation measures ~~(i.e. drip irrigation)~~, development of groundwater sources, or creation of additional storage. A specific objective is included in the plan that groundwater pumping would not reduce flow greater than 6 percent to springs upstream of Copco Dam; which includes the Klamath, Wood and Williamson Rivers. ~~The voluntary water management plan~~ Implementation of the On-Project Plan would partially offset the expected supply reductions. The improvements in water supply generated by implementation of the On-Project Plan and Water Diversion Limitations would not be expected to contribute to effects of hydroelectric facility removal analyzed above.

Water is delivered to Reclamation's Klamath Project water users under contractual obligations between the United States and the water districts subject to the availability of water and in accordance with the Project water rights. The Project also provides water to the refuges when available, which is usually after meeting contractual deliveries. Additionally, Reclamation has an obligation to ensure that the refuges receive adequate water to fulfill their Federal reserved water rights, when in priority and when water is available. Beginning in 1995, in compliance with the ESA and tribal trust

responsibilities, water was first made available to meet the needs of the ESA listed fishes in Upper Klamath Lake and the Klamath River, then to meet contractual irrigation deliveries and then to the refuges. Under the proposed KBRA flows, the refuges would receive a specific annual allocation unless all demands cannot be met. The KBRA provides for sharing of shortage between the Project irrigators and the refuges in drought and severe drought years. Shortages are expected to be offset by measures to be provided through the On Project Plan and other KBRA actions designed to reduce demand, conserve water and increase supply. **Implementation of the On-Project Plan is anticipated to benefit water rights and supply. Implementation of the On-Project Plan will require future environmental compliance as appropriate.**

Future Storage Opportunities

The study of additional off-stream storage opportunities in the Upper Klamath Basin to identify new storage opportunities could affect water supply. Reclamation plans to identify and study additional off-stream storage opportunities. KBRA parties would support ongoing investigations and acquisition of additional storage. ~~The addition of 10,000 acre-feet of storage is a milestone in implementation of the KBRA.~~ Off-stream storage is likely to improve water supply reliability and assist with alleviating short-term impacts related to water supply delivery during ~~Water Diversion Limitations (another KBRA program) helping to offset a portion of the deficiencies.~~droughts. Additionally the development of future storage opportunities would not be expected to contribute to any changes in water supply generated by the hydroelectric facility removal action. **Implementation of Future Storage Opportunities would result in no change from existing conditions for water supply. Implementation of the Future Storage Opportunities will require future environmental compliance investigations as appropriate.**

Water Use Retirement Program (WURP)

Implementation of the WURP increases instream flow to Upper Klamath Lake which could affect water rights and water supply upstream of Upper Klamath Lake. The WURP is a voluntary program for the purpose of supporting fish populations restoration by permanently increasing inflow to Upper Klamath Lake by 30,000 acre-feet per year. Deliveries to these users would decrease, but it would be a completely voluntary program and would not affect users that do not request participation. A variety of management measures and irrigation water use changes would help to accomplish an inflow increase and are described in Section 2.4.3.~~9.~~10. Some measures include implementing water efficiency projects, increasing natural storage through wetland or improved riparian area performance, and purchase and retirement of water rights from willing sellers. Increases to inflow rates from these measures are for instream flows and are not meant for diversion and use and there would be no additional increases available for downstream diversions. ~~The geographic separation between the actions proposed under this program and the hydroelectric facility removal actions analyzed above eliminate the potential for negative water supply effects generated by this program from contributing to water supply effects generated by facility removal.~~ Changes in flows upstream from Upper Klamath Lake would not contribute to any changes in water supply or water rights associated with removal of the Four Facilities because the actions are in different parts of

the watershed. **Implementation of the WURP is anticipated to have a less than significant impact to water rights because rights would be voluntarily retired. Implementation of the WURP is expected to have no effect to water supply because there would be no changes to diversions. Implementing the WURP will likely require future environmental compliance investigations as appropriate.**

Off-Project Water Settlement (OPWAS)

Implementation of OPWAS negotiations could affect water rights and adjudicated rights upstream of Upper Klamath Lake. The intent of OPWAS is to negotiate a settlement of long-standing water disputes between the Upper Klamath Water Users Association, Klamath Tribes, ~~and~~ the Bureau of Indian Affairs~~.~~, and potentially other water users in the Upper Basin. OPWAS includes terms that: 1) resolve the Off-Project Irrigators' contests to claims in Tribal Cases; 2) in the event that not all such contests are resolved, provide reciprocal assurances for maintenance of instream flows and reliable irrigation water deliveries consistent with applicable law; and 3) in all cases provide for a WURP. The effects of these settlement actions could provide an amicable and quicker solution for those who are affected by the ongoing Klamath Basin Adjudication. The negotiated settlements would resolve certain contests to significant major water right claims in the Upper Klamath Basin. The improvements in water supply generated by the settlement of water disputes would not be expected to contribute to effects of hydroelectric facility removal analyzed above.~~-~~ **Implementation of OPWAS would be a beneficial effect to resolve water rights and adjudicated rights and a less than significant impact to unresolved cases due to reciprocal assurances. Implementation of OPWAS will require future environmental compliance as appropriate.**

Off-Project Water Reliance Program

Implementation of Off-Project Water Reliance Program could change water deliveries for irrigation upstream of Upper Klamath Lake to Off-Project water users affecting water supplies. The Off-Project Water Reliance Program would not be implemented until full implementation of the WURP and 30,000 acre-feet of additional flow is added to Upper Klamath Lake and Water Diversion Limitations are fully implemented. The agreement establishes a program consistent with the WURP to avoid or mitigate the immediate effects of unexpected circumstances affecting water availability for irrigation in the Off~~-~~-Project area. Activities under the Off-Project Water Reliance Program may include: funding water leasing to increase water supply availability for irrigation in the Upper Klamath Basin or mitigating the economic impacts of lost agricultural production by Off~~-~~-Project irrigators. ~~The geographic separation between the actions proposed under this program and the hydroelectric facility removal actions analyzed above eliminate any potential for negative water supply effects generated by this program contributing to water supply effects generated by facility removal.~~ Changes in irrigation deliveries upstream from Upper Klamath Lake would not contribute to any changes in water supply or water rights associated with removal of the Four Facilities because these facilities are not used as water supply for irrigation. **Implementation of the Off-Project Water Reliance Program to provide additional water availability and help minimize reductions in water supply in the Off-Project Area would help to maintain or improve water supply conditions but may not fully remedy negative water supply**

effects. This would be a less than significant impact. Implementation of the Off-Project Water Reliance Program will require future environmental compliance as appropriate.

Emergency Response Plan

Implementation of an Emergency Response Plan could result in a change to water supply deliveries in the event of failure to a facility in Reclamation's Klamath Project or dike on Upper Klamath Lake or Keno Impoundment/Lake Ewauna. The purpose of the plan is to prepare water managers for an emergency affecting the storage and delivery of water needed for necessary to meet the commitments of the KBRA implementation.. The components of the Emergency Response Plan are described in Section 2.4.3.910 and includes providing a supplynotice and response in case of a failure of a Klamath Reclamation Project facility, such as a pump or dike. Response actions such as groundwater substitution or groundwater sharing, similar to the ongoing drought plan, and affects of these actions could improve short-term water supply reliability and could have short-term groundwater elevation effects. The improvements in water supply generated by development of off-stream storage would not be expected to contribute to effects of hydroelectric facility removal analyzed above. Emergency response actions would include any necessary measures to reduce damage to property or injury to persons and to restore water diversions or releases back to their intended uses as quickly as possible. The Emergency Response Plan would provide a framework for minimizing the effects of an emergency on water supply. **Implementation of an Emergency Response Plan would be a beneficial effect to water supply deliveries during emergency periods because management actions would help to continuerestore supply as well as improve water supply reliability.quickly as possible. Implementation of the Emergency Response Plan will require future environmental compliance as appropriate.**

Climate Change Assessment and Adaptive Management

Implementation of Climate Change Assessment and Adaptive Management could result in changes to water deliveries depending on climatic changes. One of the main purposes of Climate Change Assessment and Adaptive Management is to respond to and protect basin interests from the adverse affects of climate change. Water deliveries could be affected during periods of water shortages or surplus conditions. Klamath Basin Parties including technical experts would be involved in development of the assessment and adaptive management strategies. Assessments and development of adaptive management strategies would be implemented continuously to respond to predicted climate changes. Climate change assessments would be conducted to identify indications of effects of climate change, such as a wider range of wet and dry years. Management of water resources would include actions such as improving storage capabilities during the wet years and conservation during dry years. The improvements in water supply generated by development of off-stream storage would not be expected to contribute to effects of hydroelectric facility removal analyzed above. **While water supply could be adversely impacted by climate change, implementation of Climate Change Assessment and Adaptive Management would be a beneficial effect to water supply because it will help to reduce the effects of climate change. Implementation of Climate Change**

Assessment and Adaptive Management will require future environmental compliance as appropriate.

Interim Flow and Lake Level Program

Implementation of Interim Flow and Lake Program during the interim period could change water deliveries affecting water supply. The goal of the Interim Flow and Lake Level Program is to "further the goals of the Fisheries Program" during the interim period. This would be accomplished with, among other actions, an interim program of water purchases and leases during the interim period prior to full implementation of the On-Project Plan and WURP. Leases and purchases of water under this interim program shall be from willing sellers and counted towards instream water supply. ~~Additionally the geographic separation between the actions proposed under this program and the hydroelectric facility removal actions analyzed above eliminate any potential for negative water supply effects generated by this program contributing to water supply effects generated by facility removal.~~ Additionally, changes in water deliveries during the interim period would not contribute to any changes in water supply or water rights associated with removal of the Four Facilities because these facilities are not used as water supply for irrigation. **Therefore, implementation of the Interim Flow and Lake Level Program would cause a less than significant impact to water rights and water supply. Implementation of the Interim Flow and Lake Level Program will require future environmental compliance as appropriate.**

Drought Plan

Implementation of Drought Plan water and resource management actions could result in changes to water supply deliveries for Klamath Basin interests during drought years. The purpose of the plan is to take management actions so that no Klamath Basin interest shall bear an unreasonable portion of burdens imposed or the risk of loss or injury as a result of drought or extreme drought. Response actions could include releasing stored water, paid forbearance agreements, conservation, groundwater substitution, or groundwater sharing. The effects of these actions could improve short-term water supply reliability and could have potential short-term groundwater elevation effects. Because users would have a choice between irrigating and being compensated for not irrigating, the current priority system in place within ~~the~~Reclamation's Klamath Project might not be necessary during most year types. The improvements in water supply generated by development of off-stream storage would not be expected to contribute to effects of hydroelectric facility removal analyzed above. **Implementation of a Drought Plan would be a beneficial effect to water supply deliveries during drought periods because management actions would help to offset shortfalls in supply as well as improve water supply reliability. Implementation of the Drought Plan will require future environmental compliance as appropriate.**

Water Rights Assurances Related to Tribal Water Rights

Implementation of KBRA Section 15.3 Water Rights Assurances Related to Tribal Water Rights could affect tribal trust water rights and water supply. In 1908, the U.S. Supreme Court issued its decision in *Winters v. United States*, 207 U.S. 564 (1908). In that decision, the Court found that the agreement creating the Fort Belknap Reservation impliedly reserved water necessary to irrigate its lands and to provide water for other purposes. Under the *Winters* Doctrine, as it has become known, water rights necessary to

meet the purposes of Federal reservations, including Indian reservations and Indian allotments held in trust, have been reserved pursuant to Federal law.

Similar to water law concepts in the western United States, *Winters* rights – or Federal reserved water rights – have a priority date no later than the date of the treaty, statute, or executive order that established the Federal reservation. Certain Federal Indian reserved water rights, such as those addressed in the *Adair* litigation with respect to the Klamath Reservation, may have an aboriginal or "time immemorial" priority. Unlike State-based water rights in the West, *Winters* rights cannot be lost for non-use under State-law concepts such as abandonment or forfeiture.

As a general matter, Federal Indian reserved water rights may attach to a variety of water sources, such as rivers, lakes, and springs, "which arise on, border, traverse, underlie, or are encompassed within Indian reservations." COHEN 585 (1982 ed.); *see also* COHEN 1176-77 (2005 ed.) (same). Consistent with U.S. Supreme Court precedent in both *Winters* and *United States v. Winans*, 198 U.S. 371 (1905) (*Winans*), some courts have also recognized that Federal Indian reserved water rights may attach to waters outside of an Indian reservation as necessary to support reserved fishing rights. In the on-going Klamath River adjudication in the State of Oregon, the United States and the Klamath Tribes filed claims to support the fishing rights reserved to the Klamath Tribes in their 1864 Treaty, both in areas within the former Klamath Reservation as well as in areas outside the former Reservation.

To date, only the Federal Indian reserved water rights of the Klamath Tribes, both as part of the *Adair* litigation and now as part of the on-going Klamath River Adjudication in Oregon, have been the subject of a water rights adjudication within the Klamath Basin. No claims were filed by or on behalf of the California tribes as part of the Oregon adjudication, and no adjudication in California has addressed the nature and extent of the *Winters* rights of the California tribes. In other contexts, DOI has opined generally in support of *Winters* rights to support the reserved fishing rights of the Hoopa Valley and Yurok Tribes, and DOI has also recently implemented a new instream flow regime in the Trinity River based on these rights as well as related statutory directives.

KBRA Section 15.3 and related provisions provide certain assurances related to Reclamation's Klamath Project operations in Oregon and directly tie into claims filed as part of the Oregon adjudication. As noted above and as referenced in these KBRA sections, the only tribal water rights being litigated there involve claims filed by the United States and the Klamath Tribes, not to any other Indian tribe in the Klamath Basin. Under the KBRA, these claims--to Upper Klamath Lake (Case 286 in the Oregon adjudication) and to the Klamath River from the Lake to the Oregon border (Case 282)--will be subordinated in relation to Reclamation's Klamath Project as specified in the KBRA. In particular, Section 15.3.9 (the KBRA "no-call" provision) affects the ability of the United States or other parties to alter Reclamation's Klamath Project's water budget in the future if the Secretary were to make an Affirmative Determination

regarding dam removal, the KBRA were implemented, dams were removed, and certain KBRA conditions were met.

As important (and controversial) as this section of the KBRA has been in relation to tribal water rights, it is also important to emphasize what this section does not do. First, no provision of the KBRA waives or releases water, fishing, or any other rights in California held by the United States or any Indian tribe, something reaffirmed by KBRA Section 15.3.2.A. Second, nothing in that section or any other part of the KBRA determines any tribal rights in California. Third, the KBRA does not affect the ability of the California tribes or others to challenge or limit other users in Oregon as may be appropriate. Fourth, nothing in the KBRA or otherwise affects the ability of California tribes to continue exercising whatever rights they have, in the interim or otherwise and with or without an adjudication or negotiated settlement to define their rights with specificity. Fifth, nothing in the KBRA affects the ability of the United States or any other tribe to develop and assert water rights claims in California in the context of a State adjudication or other action. Sixth, DOI has also committed to identify other potential mitigation tools, including additional releases from Trinity Reservoir, as necessary to protect Trinity River-based fishery resources as well (KBRA Section 2.2.12).

Finally, whether or not the KBRA becomes law and gets implemented, the United States will not have unfettered discretion to alter Reclamation's Klamath Project operations in the future. Even in the absence of the KBRA, the Oregon adjudication will ultimately determine both claims related to Reclamation's Klamath Project operations as well as claims filed by the United States and the Klamath Tribes for Upper Klamath Lake and the Klamath River in Oregon. Thus, Reclamation's Klamath Project diversions and associated Klamath River flows from Oregon will be defined either through an adjudicated decree or through a negotiated settlement and not by determinations of DOI and its agencies.

Similar to other water uses, dam removal and associated KBRA activities may result in some short-term adverse effects. Tribal water rights are important to support the continued health of their salmonid fishery. In the short-term, reservoir drawdown associated with dam removal would result in the release of high suspended sediment concentrations. These suspended sediment concentrations are expected to result in lethal and sub-lethal effects on a specific part of fish populations; in particular, coho salmon smolts and steelhead trout in the mainstem Klamath River would be affected during the peak sediment release from early January through mid-March (See Section 3.3, Aquatic Resources). However, the timing of release was scheduled to coincide with existing periods of naturally high sediment concentrations that fish have adapted to, and at a time that much of the fish population would be in tributaries rather than the mainstem of the river.

Full implementation of the agreements promises, not just dam removal, Project diversion limitations, and habitat restoration activities throughout the Basin, but the KBRA also offers Project drought planning for water-short years, water acquisition, and

other actions to protect the Basin fishery during the interim period. This finding is supported by the scientific analysis summarized in the Klamath Dam Removal Overview Report for the Secretary of the Interior (Overview Report) and this Klamath Facilities Removal EIS/EIR. Table 3.8-3 (also Table 5-9 from the Overview Report) summarizes these findings related to long-term benefits for tribal interests.

Table 3.8-3. Common Benefits to all Indian Tribes with Dam Removal and Implementation of the KBRA

Water Resources	
Hydrology	More natural river hydrology. Natural flushing flows would benefit aquatic species and riparian vegetation.
Water Quality	Natural temperature regime and improved water quality would benefit aquatic life.
Toxic Blue Green Algae	Free flowing river segments would deter conditions that lead to toxic algal blooms and reduce human health concerns.
Aesthetics	Improvements in water quality would improve aesthetics and ceremonial opportunities that require a healthy river.
Aquatic Resources	
Traditional Lifestyle	Greater fisheries abundance would bolster opportunities for transmitting traditional knowledge to successive generations, including the important practice of giving fish to elders. Improved social cohesion and function among Indian populations through strengthened sense of tribal identity.
Cultural and Religious Practices	Improved fish abundance would facilitate the tribes' ability to reinstate and continue to practice ceremonies in their historic, complete forms at the appropriate times of the year, thereby improving tribal identity.
Standard of Living	Increased fish abundance would contribute to greater food supply and food security for the Indian population, enhancing standard of living.
Health	Greater opportunity for healthy food consumption associated with increased subsistence fishing opportunities, which would improve overall health conditions.

The six Klamath Basin tribes are sovereign governments individually, and the Yurok, Karuk, and Klamath Tribes signed the KBRA to bring a degree of certainty to their goal of restoring the Klamath River fisheries. These three tribes have exercised their sovereignty by choosing not to assert certain of their claims for tribal water rights in the Klamath River in return for the assurances and commitments to limit water diversions by the Upper Basin water users. This limitation of the exercise of their water rights will exist in the future so long as the Project users stay within the limits set by the KBRA in Section 15.3 and other beneficial actions for fisheries occur. These provisions include:

- Implementation of the Project water plan that limits diversions to the agreed upon water allocation rule
- Projects that increase the storage capacity of Upper Klamath Lake are completed
- Full funding is authorized to implement the Water User Retirement Program above Upper Klamath Lake

- Drought Plan is adopted
- Fisheries Reintroduction Plan is finalized
- Dams are removed
- Establish a rigorous adaptive management regime in which tribal scientists will play a central role.

Pursuing adjudication of tribal water rights in State courts has considerable costs and risks as does the FERC relicensing process for the four project dams. Without the KBRA and KHSA there would be no funds for habitat remediation, fisheries restoration or dam removal. Restoration activities contained in the KBRA would be consistent with any Federal trust responsibility regarding Klamath River resources, regardless of the potentially affected tribe and even including those tribes who currently oppose the KBRA and its authorizing legislation. The KBRA improves community relationships and attitudes, and shortens the time to improved conditions for the natural resources. For these reasons, the Secretary believes that the KBRA and KHSA may provide a better path forward in the management of water and other natural resources used by the both signatory and non-signatory tribes.

Another relevant concern pertains to a narrow waiver of potential claims against the United States for past water management decisions above the California/Oregon border. This provision is also described in Section 15.3 of the KBRA and is again contingent upon specific restoration actions and water retirement. In this provision, the Tribes essentially state that, in return for the Federal Government's participation in the restoration of the Basin, the Tribes will not assert potential legal claims for past water management decisions in the Upper Basin which *arose before the Agreement*. (There is no agreement regarding claims against the United States which might arise *after* the Agreement.) This promise too, is not effective unless certain conditions are realized:

- The legislation needed to implement the agreement has been passed
- The terms of Section 15.3.4 have been met (see above)
- Funding for the following plans has been *appropriated*: Fisheries Restoration Plan, Fisheries Reintroduction Plan, Fisheries Monitoring Plan, Water Retirement Program, Interim Flow and Lake-level Program, and Regulatory Assurances Program
- The four dams are removed.

Overall, restoration would be consistent with any trust obligation to all Basin tribes, including those who currently oppose the KBRA and its authorizing legislation. Conversely, litigation or adjudication of these and other issues entails considerable risks and costs, takes years if not decades to resolve, and ultimately does not provide the opportunity, both in programs and appropriations, that the KBRA and related activities will if enacted. In fact, the Oregon adjudication originated in the mid-1970s, begun in earnest in the mid-1990s, and has yet to complete the first of two major phases.

Implementation of KBRA Section 15.3 Assurances Related to Tribal Water Rights would be beneficial to water rights and water supply.

3.8.4.3.6 Alternative 3: Partial Facilities Removal of Four Dams

Under the Partial Facilities Removal of Four Dams Alternative the impacts would be the same as those described for the Proposed Action. **Impacts associated with relocation of the Yreka water supply pipeline and removal of recreation facilities at reservoirs would have no effect to water supply or water rights. Flow changes downstream of Iron Gate Dam and implementation of IMs would have a less than significant impact to water supply and water rights. Sediment release during reservoir drawdown has the potential to significantly affect water intake pumps by sediment deposits. Mitigation measure WRWS-1 would reduce this impact to less than significant.**

Keno Transfer
The effects of the Keno Transfer would be the same as those described for the Proposed Action.

East and ~~*West Side*~~Westside Facilities – Programmatic Measures
The effects of the decommissioning of the East and ~~West Side~~Westside Facilities would be the same as those described for the Proposed Action.

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures
The effects of the relocating Yreka's Water Supply Pipeline would be the same as those described for the Proposed Action.

KBRA – Programmatic Measures
The KBRA would also be implemented under the Partial Facilities Removal Alternative. Impacts on water supply and water rights would be the same as described for the Proposed Action.

3.8.4.3.7 Alternative 4: Fish Passage at Four Dams
Under the Fish Passage at Four Dams Alternative, the drawdown and sediment impacts described under the Proposed Action would not occur. Flow rates downstream of Iron Gate Dam and water supply operations would be similar to those under the No Action/No Project Alternative to provide adequate flows for fish. **Under the Fish Passage at Four Dams Alternative, there would be no impact on water rights and water supply.**

Trap and Haul – Programmatic Measures
Implementation of trap and haul measures could require water rights to divert water for the fish handling facilities. Fish handling facilities to collect fish downstream of Keno Dam and at Link River Dam would require water sources. The facilities would not consumptively use the water; the water would pass through the facilities for release back into the system. **Because the fish handling facility would not increase consumptive use on the Klamath River system, the impacts of the trap and haul measures in the Fish Passage at Four Dams Alternative on water supply/water rights would be less than significant.**

3.8.4.3.8 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate
Under this alternative, only Iron Gate and Copco 1 Dams would be removed and fish passage would be installed at Copco 2 and J.C. Boyle Dams. The impact of sediments deposited downstream would be smaller, because sediment would be retained behind J.C. Boyle and Copco 2 Dams. After the drawdown period, flow rates downstream of Iron Gate Dam would be intermediate between the flows modeled for the No Action/No Project Alternative and the Proposed Action.

Impacts associated with removal of recreation facilities at reservoirs would have no effect to water supply or water rights. Flow changes downstream of Iron Gate Dam would have a less than significant impact to water supply and water rights.

Sediment release during reservoir drawdown has the potential to significantly affect water intake pumps by sediment deposits. Mitigation measure WRWS-1 would reduce this impact to less than significant.

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could require water rights to divert water for ~~*the*~~ **fish handling facilities.** ~~Fish handling facilities to collect fish downstream of Keno Dam and at Link River Dam would require water sources. The facilities would not consumptively use the water; the water would pass through the facilities for release back into the system.~~ ~~**Because the fish handling facility would not increase consumptive use on the Klamath River system, the impacts of the trap and haul measures in the Fish Passage at Four Dams Alternative on water supply/water rights would be less than significant.**~~

~~Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate~~

~~Under this alternative, only Iron Gate and Copco 1 Dams would be removed and fish passage would be installed at Copco 2 and J.C. Boyle Dams. The impact of sediments deposited downstream would be smaller, because sediment would be retained behind J.C. Boyle and Copco 2 Dams. After the drawdown period, flow rates downstream of Iron Gate Dam would be between the No Action/No Project Alternative and the Proposed Action.~~

~~**Impacts associated with relocation of the Yreka water supply pipeline and removal of recreation facilities at reservoirs would have no effect to water supply or water rights. Flow changes downstream of Iron Gate Dam would have a less than significant impact to water supply and water rights. Sediment release during reservoir drawdown has the potential to significantly affect water intake pumps by sediment deposits. Mitigation measure WRWS-1 would reduce this impact to less than significant.**~~

~~Trap and Haul – Programmatic Measure~~

~~*Implementation of trap and haul measures could require water rights to divert water for fish handling facilities.*~~ The trap and haul measures around Keno Impoundment/Lake Ewauna and Link River would have the same impacts under the Fish Passage at J.C~~.~~ . Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative as the Fish Passage at Four Dams Alternative. **Because the fish handling facility would not increase consumptive use on the Klamath River system, the impacts of trap and haul measures in the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on water supply/water rights would be less than significant.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The effects of the relocating Yreka's Water Supply Pipeline would be the same as those described for the Proposed Action.

3.8.4.4 Mitigation Measures

3.8.4.4.1 Mitigation Measure by Consequences Summary

Mitigation Measure WRWS-1 - Assess each pump location at legitimate points of diversion. Following dam removal, investigate intake and pump sites at the request of the water user. If effects on water supply intakes occur as a result of dam removal, the Dam Removal Entity (DRE) will complete modifications to intake points as necessary to reduce effects to a less-than-significant level. Modifications will allow the water right holder to divert water on the same pattern (including amounts and timing) as before the project. Before reservoir drawdown, the DRE will notify water right holders about the project and request information about their diversion patterns to obtain a baseline with which to verify that impacts are fully mitigated.

3.8.4.4.2 Effectiveness of Mitigation in Reducing Consequences

Implementation of WRWS-1 will ensure that intake points of diversion affected by sediment deposition downstream of dam removal activities are dealt with individually and on an as-needed basis.

3.8.4.4.3 Agency Responsible for Mitigation Implementation

The DRE will coordinate with affected water users to determine appropriate solutions on a site-by-site basis.

3.8.4.4.4 Remaining Significant Impacts

No remaining significant adverse impacts on water rights and water supply are anticipated.

3.8.4.4.5 Mitigation Measures Associated with Other Resource Areas

Mitigation REC-1 would create a plan to develop new recreational facilities and access points along the newly formed river channel between J.C. Boyle Reservoir and Iron Gate Dam. Recreation facilities, such as campgrounds and boat ramps, currently located on the edge of the reservoir would need to be replaced in appropriate areas near the new river channel once the reservoirs are removed. Water supplies for the campgrounds would most likely be supplied through wells placed on the new sites as appropriate. **There would be no impact to water rights or supplies from the implementation of REC-1.**

3.8.5 References

Bureau of Reclamation (Reclamation). 2000. Klamath Project Historic Operation, November 2000.

~~Department of the Interior (DOI). 2011. Technical Report No. SRH-2011-02 DRAFT~~
_____. 2012. "Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration ~~Klamath River, Oregon and California.~~," Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO.

Cosens, Barbara. 2006. Truth or Consequences: Settling Water Disputes in the Face of Uncertainty, 42 Idaho L. Rev. 717 (2006)

_____. 2006. 2005 Indian Water Rights Settlement Conference Keynote Address, 9 U. Denv. Water L. Rev. 285 (2006).

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, DC, Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing.

Greimann, Blair P. 16 March 2011. (Hydraulic Engineer, Bureau of Reclamation, Denver Federal Center). Email correspondence with Chris Park of CDM, Sacramento, California.

Library of Congress, Congressional Research Service. 2005. Klamath River Basin Issues and Activities: An Overview. Order Code RL33098. September 2005.

Oregon, State of. 2009. Water Rights in Oregon, Oregon Water Resources Department Centennial Edition 2009~~-~~. Available at: http://cms.oregon.gov/owrd/pubs/docs/centennial_aquabook.pdf. Accessed on ~~the web at http://www.oregon.gov/OWRD/ADJ/docs/Status_of_the_Adjudication.pdf downloaded on December 15, 2010~~: September 18, 2012.

~~Oregon, State of.~~_____. 2010a. Water Management Brief. Available at: http://www.leg.state.or.us/comm/commsrvs/background_briefs2010/briefs/NaturalResources/WaterManagement.pdf. Accessed on ~~the web at http://www.leg.state.or.us/comm/commsrvs/background_briefs2010/briefs/NaturalResources/WaterManagement.pdf. downloaded on~~: January 5, 2011.

~~Oregon, State of.~~_____. 2010b. WRIS (Water Rights Information System). Accessed on the ~~web~~Web at http://www.wrd.state.or.us/OWRD/WR/wris.shtml. ~~downloaded May 2~~ Downloaded May 2, 2010.

State Water Resource Control Board. 2010. California Electronic Water Rights Information Management System. Available at: http://www.swrcb.ca.gov/ewrims/. Accessed on the web at http://www.swrcb.ca.gov/ewrims/, downloaded: December 17, 2010.

Taylor, Rob. 2010. Personal communication between R. Taylor, Water Manager for the City of Yreka, and Tom Hepler, Lead Engineer, Bureau of Reclamation. August 24.

Thorson, John et al. 2006. Dividing Western Waters: A Century of Adjudicating Rivers and Streams, Part II, U. Denv. Water L. Rev. 299 (2006)

U.S. Department of Agriculture, Natural Resource Conservation Service. 2004. Upper Klamath Basin, Opportunities for Conserving and Sustaining Natural Resources on Private Lands. September, 2004.

Wood, T.M., G.R. Hoilman, and M.K. Lindenberg. 2006. Water-quality conditions in Upper Klamath Lake, Oregon, 2002–04: U.S. Geological Survey Scientific Investigations Report 2006-5209.

Yreka, City of. 2010. City of Yreka Public Scoping Comment Letter from Steven W. Baker, City Manager. Addressed to Ms. Tanya Sommer on July 20, 2010.

3.9 Air Quality

This section discusses potential air quality impacts from the Proposed Action and alternatives. This discussion describes the affected environment/environmental setting, analysis methods, significance criteria, and impacts for each of the alternatives. Appendix M provides a summary of the existing emission sources and monitoring data, detailed emission calculation methodologies, and detailed emission inventories.

3.9.1 Area of Analysis

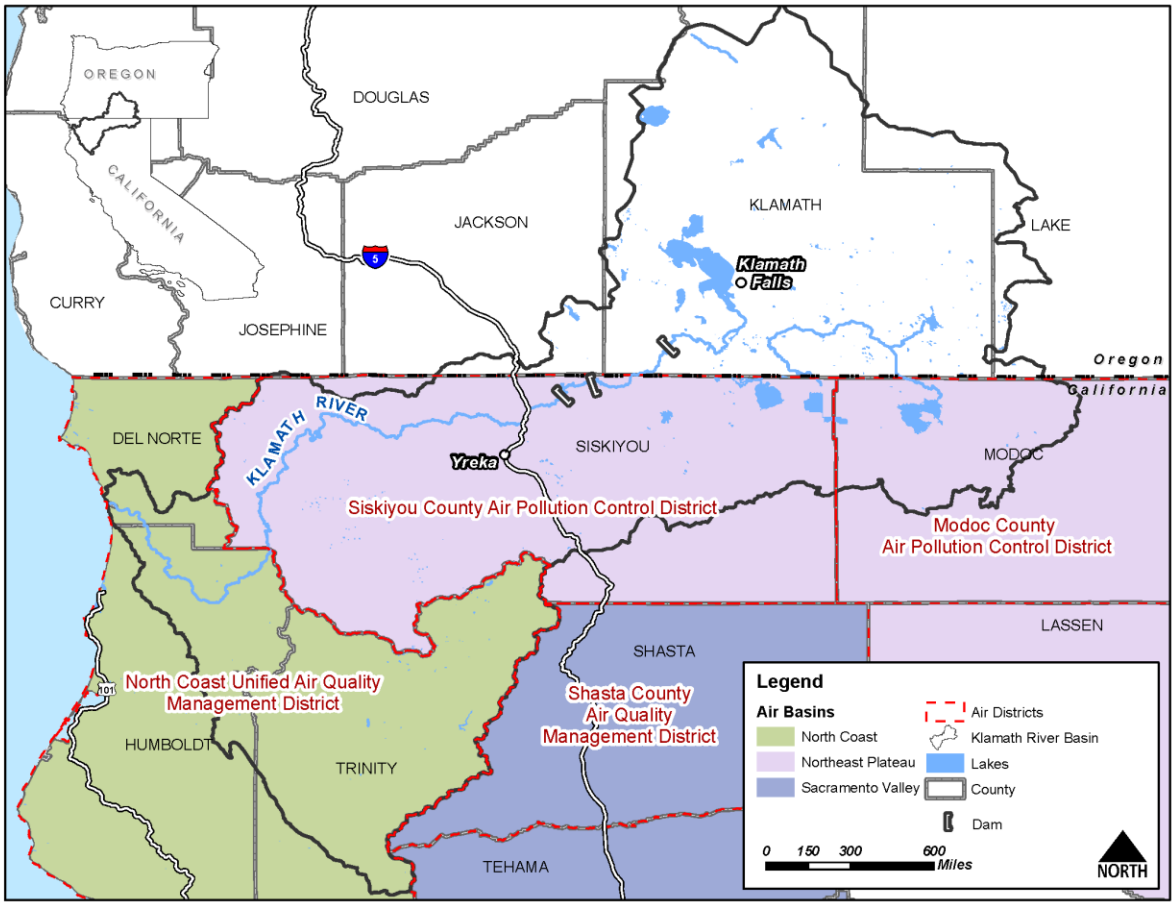
The area of analysis includes multiple counties in northern California and southern Oregon. Direct air quality impacts from the Proposed Action and alternatives would be limited to Siskiyou County, California and Klamath County, Oregon for dam removal activities, while additional impacts could occur in Jackson County, Oregon and Shasta County, California from haul truck or construction worker travel. The quantitative analysis for the alternatives was limited to these four counties.

The area of analysis includes the Curry County in Oregon and Del Norte, Humboldt, Modoc and Trinity counties in California for a qualitative analysis of the impacts that would be caused by implementation of programmatic elements of the alternatives.

California is divided into fifteen different air basins based on common geographic and political boundaries. The North Coast, Northeast Plateau, and Sacramento Valley Air Basins cover the portion of the Klamath Basin within California. The geographic scope of the analysis also includes the jurisdictions of the North Coast Unified Air Quality Management District, the Siskiyou County Air Pollution Control District, the Modoc County Air Pollution Control District, and the Shasta County Air Quality Management District. Figure 3.9-1 identifies the air quality area of analysis.

3.9.2 Regulatory Framework

~~Air quality management and protection responsibilities are regulated by federal, state, tribal, and local levels of government, which are listed below.~~



~~*Source: California Air Resource Board (CARB) 2010a.*~~

~~**Figure 3.9-1. Area of Analysis for both KHSA and KBRA**~~

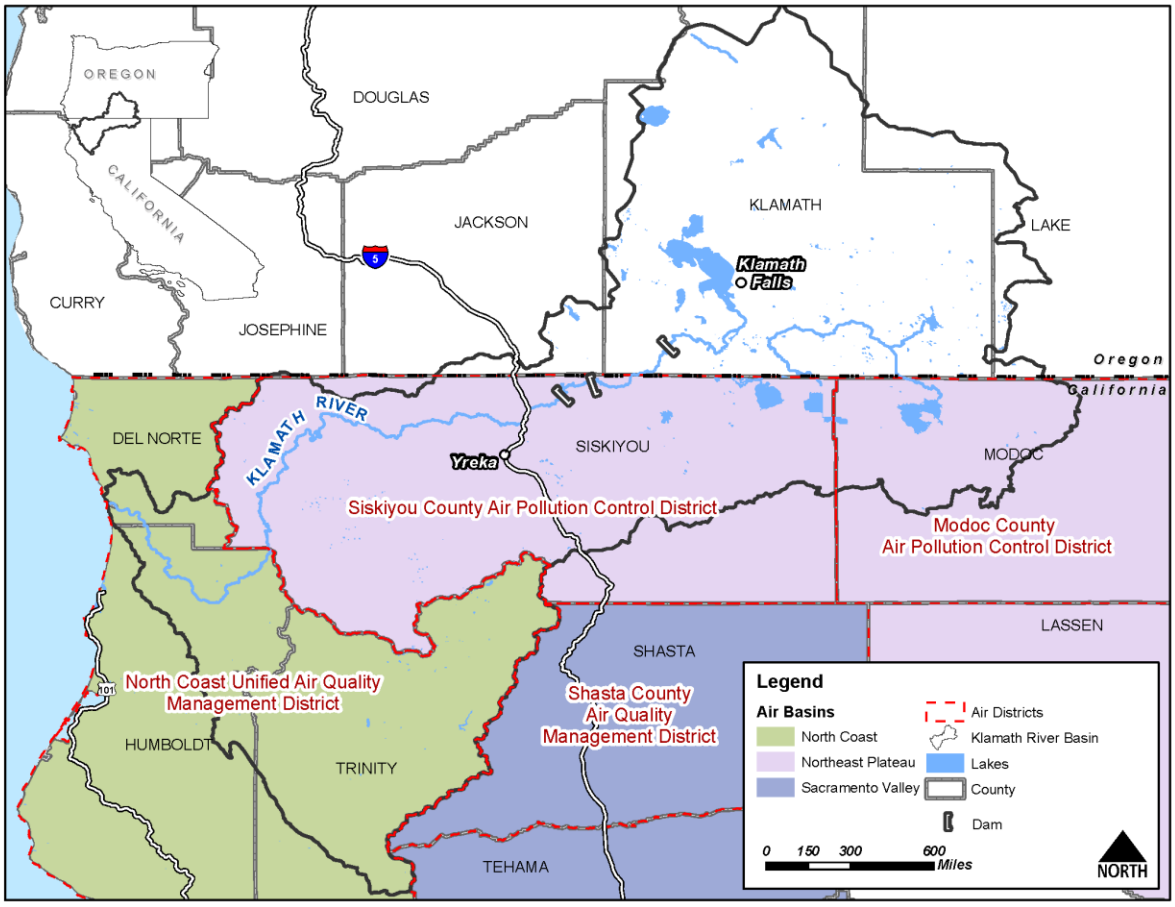
~~*3.9.2.1 Federal Authorities and Regulations*~~

- ~~Clean Air Act (40 CFR 50-88)~~
- ~~General Conformity (40 CFR 93, Subpart B)~~

The Klamath Falls, Oregon Nonattainment Area is designated as a nonattainment area for fine particulate matter <2.5 microns ($PM_{2.5}$), while the Klamath Falls Urban Growth Boundary (UGB) is designated as a maintenance area for carbon monoxide (CO) and inhalable particulate matter <10 microns (PM_{10}). Additionally, the Medford-Ashland Air Quality Maintenance Area (AQMA) in Oregon, is designated as a maintenance area for PM_{10} and CO. As a result, the following de minimis thresholds for general conformity apply to these two urban areas:

- $PM_{2.5}$ (nonattainment): 100 tons per year

- Sulfur dioxide (SO_2) (as $PM_{2.5}$ precursor): 100 tons per year
- Nitrogen oxides (NOx) (as $PM_{2.5}$ precursor): 100 tons per year
- CO (maintenance): 100 tons per year
- PM_{10} (maintenance): 100 tons per year



Source: California Air Resource Board (CARB) 2010a.

Figure 3.9-1. Area of Analysis for both the Klamath Hydroelectric Settlement Agreement (KHSA) and the Klamath Basin Restoration Agreement (KBRA).

Air quality management and protection responsibilities are regulated by Federal, State, tribal, and local levels of government, which are listed in Section 3.9.1

3.9.2.1 Federal Authorities and Regulations

- Clean Air Act (40 CFR 50-88)
- General Conformity (40 CFR 93, Subpart B)

3.9.2.2 State Authorities and Regulations

- California Clean Air Act (H&S Code, §39000 et seq.)
- Oregon Administrative Rules (Chapter 340, Divisions 200-268)
- Oregon Revised Statutes (Chapter 468A)

- Medford Maintenance Plan for CO (Oregon Department of Environmental Quality [ODEQ] 2001)
- Klamath Falls PM_{10} Maintenance Plan (ODEQ 2002)
- Medford-Ashland AQMA PM_{10} State Implementation Plan (ODEQ 2004)

3.9.2.3 Local Authorities and Regulations

- Siskiyou County Air Pollution Control District
- Modoc County Air Pollution Control District
- Shasta County Air Quality Management District
- North Coast Unified Air Quality Management District (Del Norte, Humboldt, and Trinity Counties)
- Klamath County Clean Air Ordinance (Ordinance No. 63.05)

3.9.2.4 Tribal Air Quality Management

- Karuk Tribe *Eco-Cultural Resources Management Plan* (2010)
- Yurok Tribe Air Quality Ordinance

3.9.3 Existing Conditions/Affected Environment

Siskiyou County, California is dominated by volcanic peaks (e.g., Mount Shasta) and forested mountains. The county is sparsely populated. Agricultural activities (including rangeland) are primarily in areas that are not wooded. The climate generally features hot summer days with cool nights and mild winters in the low valleys. The mountainous areas have cool summers and severe winters. Various recreational activities and hunting also occur in Siskiyou County.

Klamath County is generally characterized by high desert prairie with a variety of mountain ranges and isolated peaks. As with Siskiyou County, the area is largely rural and agricultural, while recreation and hunting activities dominate.

3.9.3.1 Existing Air Quality Conditions

The air quality conditions for the area are typically the result of existing emission sources in the area and meteorological conditions that affect the dispersion of the emissions once they enter the atmosphere.

3.9.3.1.1 Attainment Designations

Regions are designated as nonattainment, maintenance, or attainment areas with respect to the various National and California ambient air quality standards, based on their compliance with the standards. A nonattainment area is defined as a region that does not meet the ~~f~~Federal or ~~s~~State ambient air quality standards. Maintenance areas are those areas that previously did not meet the air quality standards (i.e., nonattainment), but are now consistently meeting the requirements. If an area consistently meets the air quality

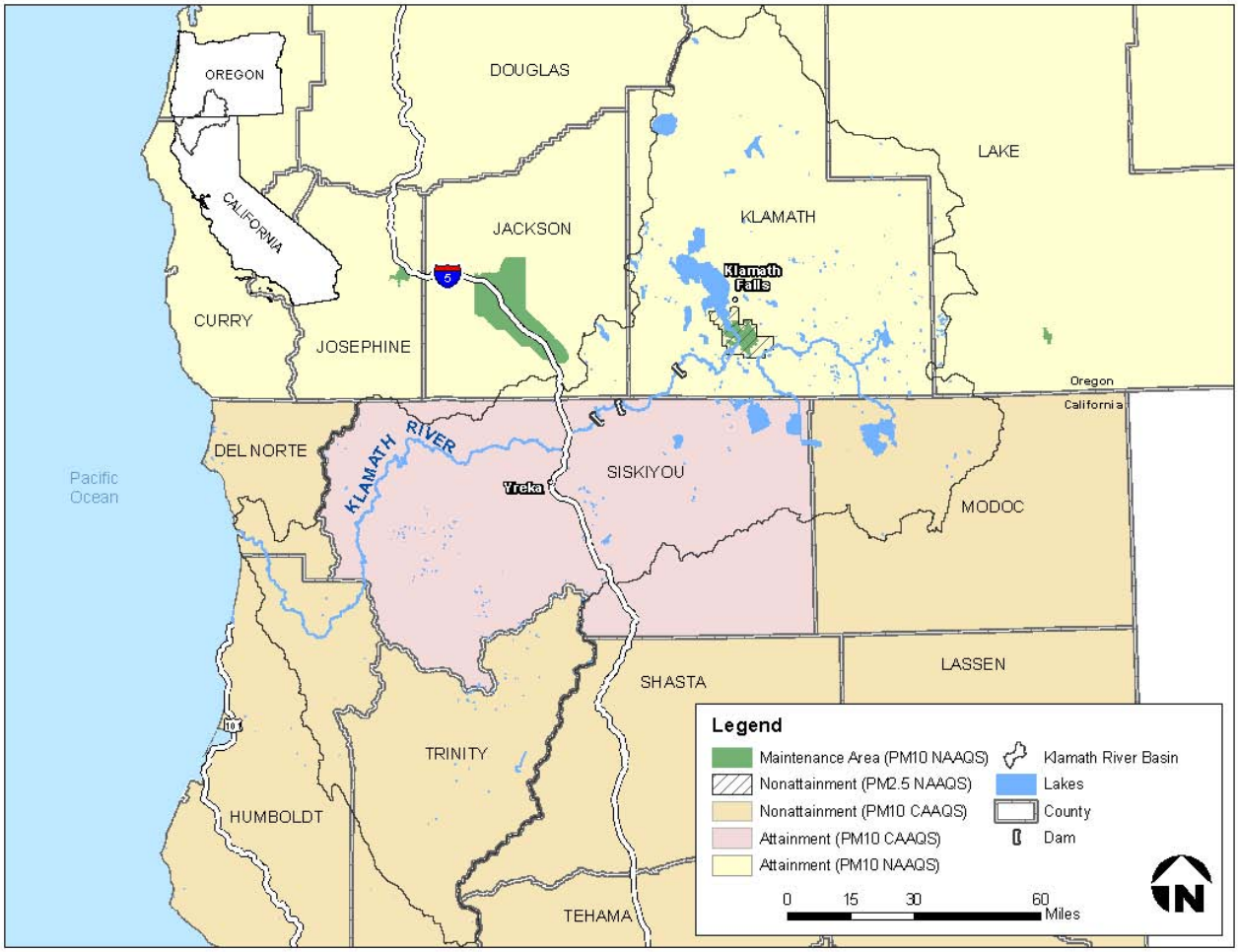
standards, then it is designated as an attainment area. The affected counties in California are all currently designated as a ~~f~~Federal attainment area for all pollutants. The Klamath Falls UGB in Oregon is designated as a maintenance area for CO and PM_{10}; the Medford-Ashland AQMA is designated as a maintenance area for CO and PM_{10}; and the Klamath Falls Nonattainment Area is designated as a nonattainment area for $PM_{2.5}$. Table 3.9-1 presents the attainment designations for each of the ~~f~~Federal criteria air pollutants.

Table 3.9-1. Federal Attainment Status of the Study Area

Pollutant	Federal Status
Ozone (O_3)	Attainment
Inhalable particulate matter (PM_{10})	Maintenance (Klamath Falls UGB and Medford-Ashland AQMA) Attainment (all other areas)
Fine particulate matter ($PM_{2.5}$)	Nonattainment (Klamath Falls Nonattainment Area) Attainment (all other areas)
Carbon monoxide (CO)	Maintenance (Klamath Falls UGB and Medford-Ashland AQMA) Attainment (all other areas)
Nitrogen dioxide (NO_2)	Attainment
Sulfur dioxide (SO_2)	Attainment

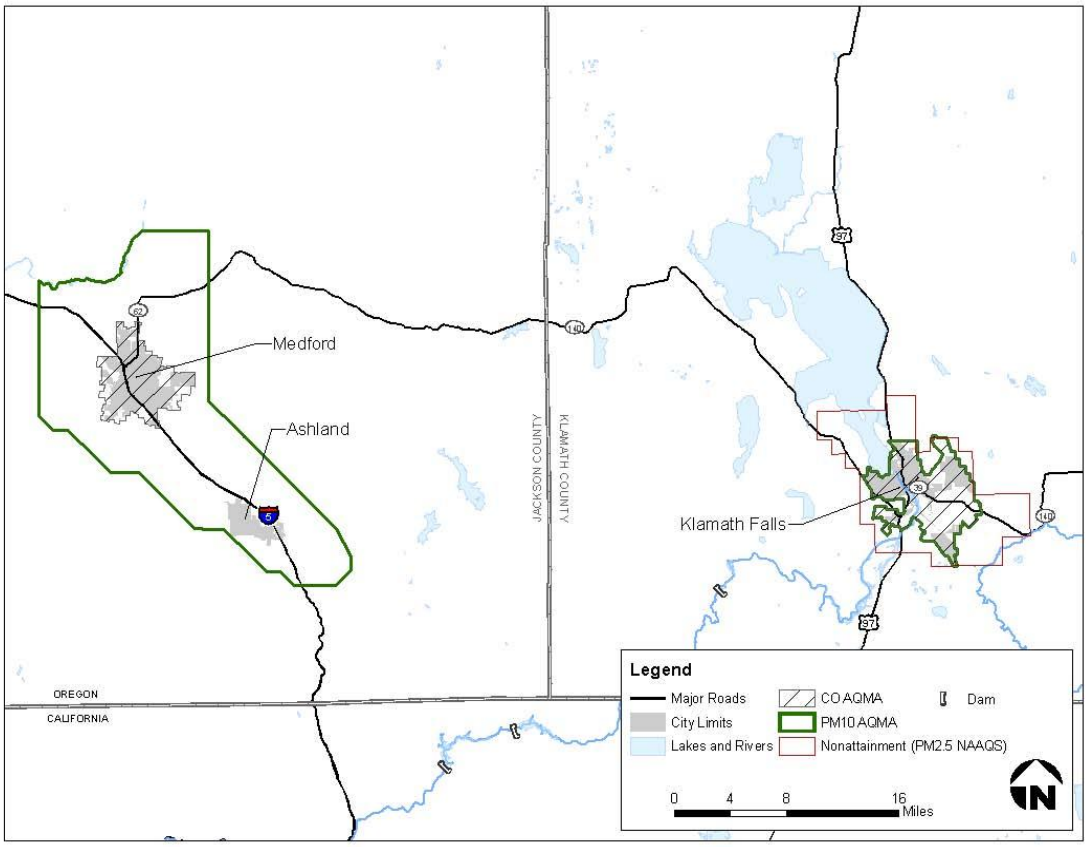
Source: United States Environmental Protection Agency (USEPA) 2010a; OAR 340-204.
AQMA: Air Quality Maintenance Area
UGB: urban growth boundary

The J.C. Boyle Dam is in Klamath County and not in the Klamath Falls UGB or the Klamath Falls $PM_{2.5}$ Nonattainment Area; therefore, the dam is in an area that is designated an attainment area for all pollutants. The Medford-Ashland AQMA is currently a maintenance area for the PM_{10} and CO National Ambient Air Quality Standards (NAAQS). Although this area is outside of the Klamath Basin, trucks and/or construction workers could travel through this region. Figure 3.9-2 shows the location of particulate matter (PM_{10} and $PM_{2.5}$) nonattainment and maintenance areas for the NAAQS in relation to the Klamath Basin. Figure 3.9-3 shows the Klamath Falls UGB, the Klamath Falls Nonattainment Area, and the Medford-Ashland AQMA.



Source: California Air Resources Board (CARB) 2010a; United States Environmental Protection Agency (USEPA) 2010b.

Figure 3.9-2. Particulate Matter (PM_{10} and $PM_{2.5}$) NAAQS and California Ambient Air Quality Standards (CAAQS) Designations.



Source: Oregon Department of Environmental Quality 2008

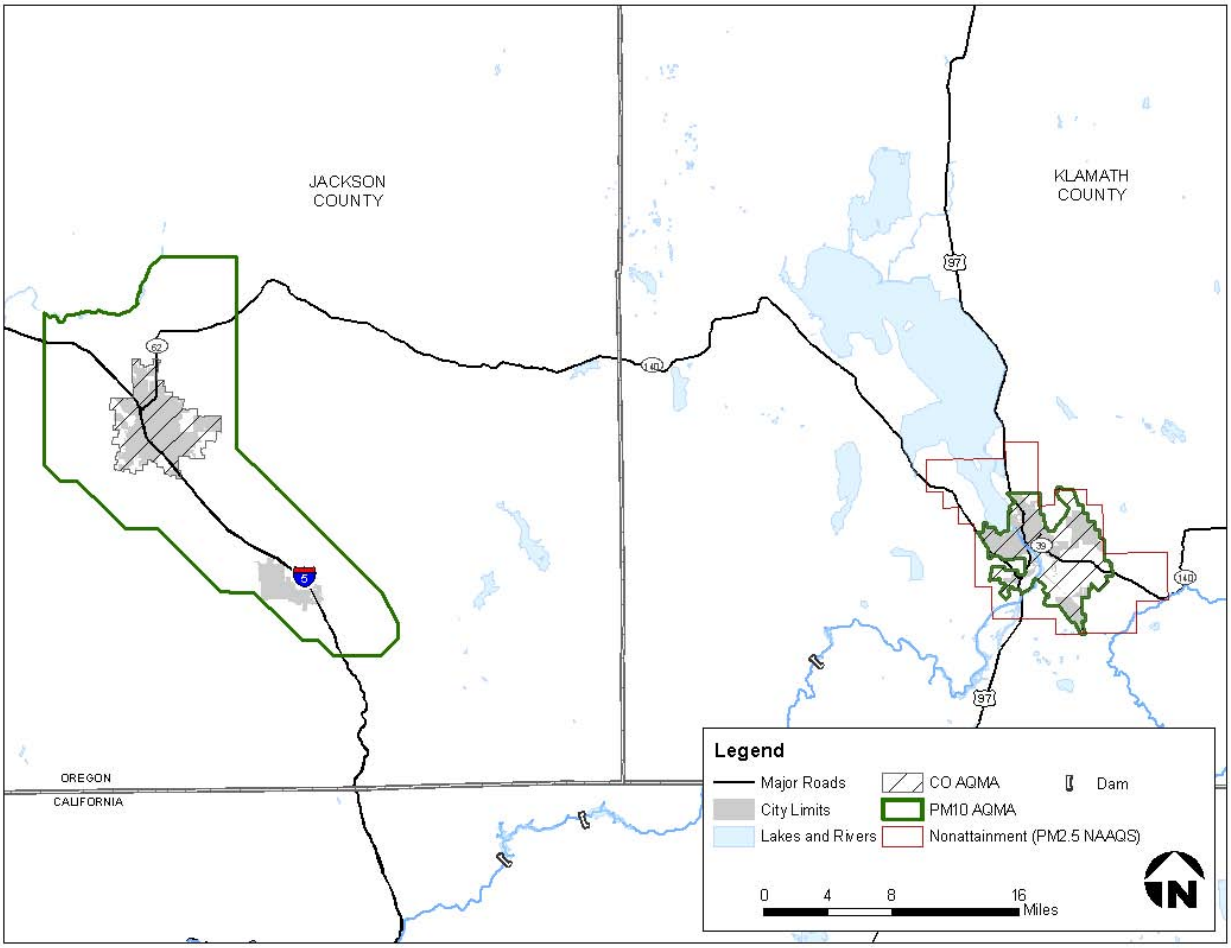


Figure 3.9-3. Particulate Matter (PM_{10} and $PM_{2.5}$) and Carbon Monoxide (CO) NAAQS Designations in Oregon.

Siskiyou County is currently a nonattainment-transitional area[1] for the California ozone (O_3) standard, whereas Shasta County is a nonattainment area for the ~~s~~State O_3 California Ambient Air Quality Standard (CAAQS). All other California counties within the Klamath Basin are in attainment of the O_3 CAAQS. Siskiyou County is in attainment of the California PM_{10} standards, but the other California counties in the Klamath Basin are in nonattainment of the PM_{10} CAAQS. All California counties in the project area are in attainment of the $PM_{2.5}$, CO, nitrogen dioxide (NO_2), and SO_2 CAAQS. Table 3.9-2 lists the attainment status for each pollutant with regard to CAAQS. Figure 3.9-2 identifies the attainment status for the PM_{10} CAAQS and Figure 3.9-4 identifies the attainment status for the O_3 CAAQS.

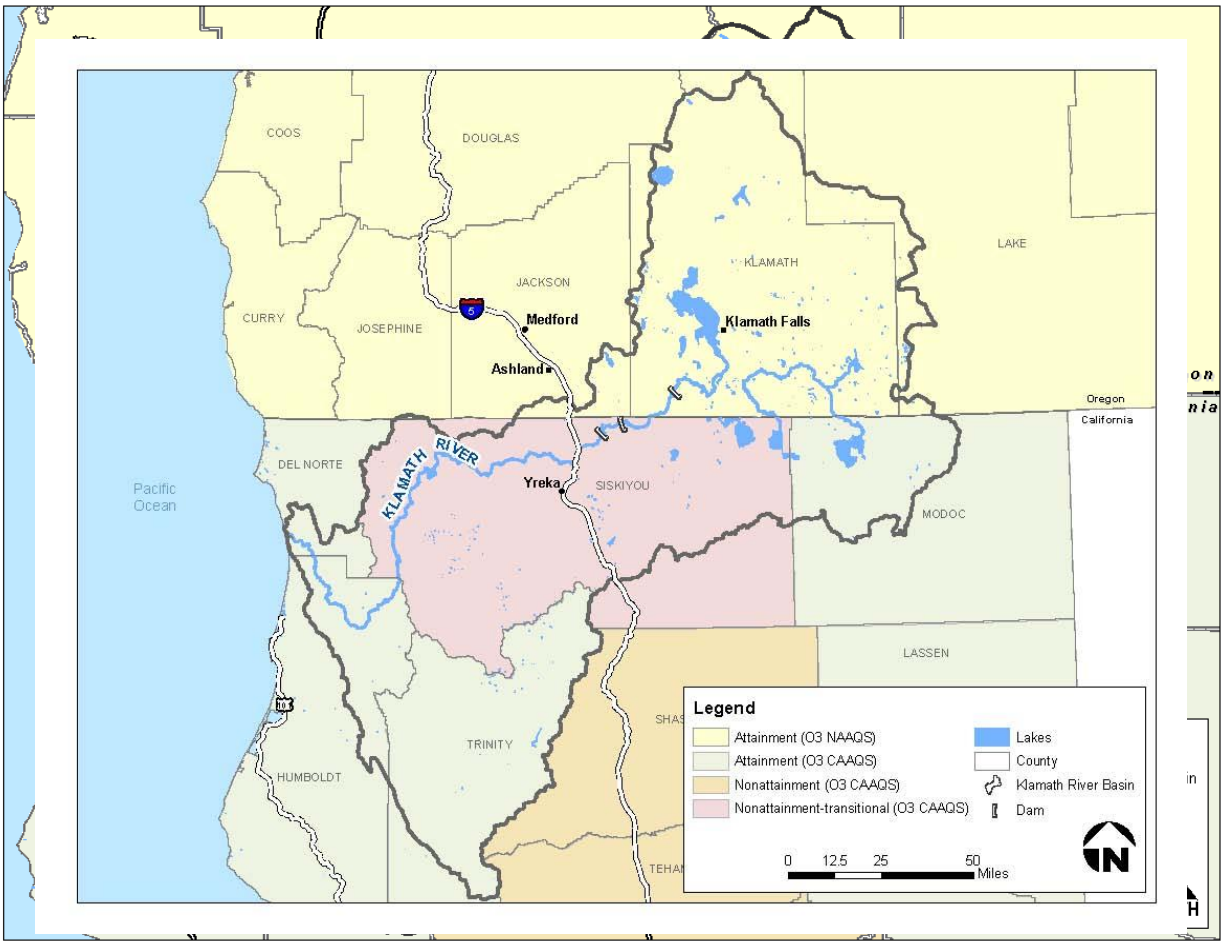
[1] An area classified "nonattainment-transitional" for O_3 has had three or fewer exceedances at each site during the last year. This classification means that the area is close to attaining the standard for the given pollutant.

~~Public Draft~~

Table 3.9-2. California Air Quality Attainment Status for the Study Area

Pollutant	California Status
Ozone (O_3)	Nonattainment-Transitional (Siskiyou County) Nonattainment (Shasta County) Attainment (Del Norte, Humboldt, Modoc, and Trinity Counties)
Inhalable particulate matter (PM_{10})	Attainment (Siskiyou County) Nonattainment (Del Norte, Humboldt, Trinity, Shasta, and Modoc Counties)
Fine particulate matter ($PM_{2.5}$)	Attainment/Unclassified (All counties)
Carbon monoxide (CO)	Attainment/Unclassified (All counties)
Nitrogen dioxide (NO_2)	Attainment (All counties)
Sulfur dioxide (SO_2)	Attainment (All counties)

Source: CARB 2010b.



Source: CARB 2010a; United States Environmental Protection Agency (USEPA) 2010b.

Figure 3.9-4. Ozone (O_3) NAAQS and CAAQS Designations.

3.9.4 Environmental Consequences

3.9.4.1 Environmental Effects Determination Methods

This analysis uses estimates of emissions that would occur from the removal of the dams or the installation of fish passage structures. These estimates came from a variety of emissions models and spreadsheet calculations:

- CARB Urban Emissions (URBEMIS) model, Version 9.2.4 (fugitive dust calculations from construction equipment, cut/fill activities, and building demolition)
- CARB EMFAC2007 model (on-road vehicle emissions factor model for California)
- United States Environmental Protection Agency (USEPA) MOBILE6.2[2] (on-road vehicle emissions factor model for Oregon)
- CARB OFFROAD2007 (off-road vehicle emissions factor model for California)
- USEPA NONROAD2008a (off-road vehicle emissions factor model for Oregon)
- Midwest Research Institute (1996), *Improvement of Specific Emission Factors* (paved road dust emissions)
- *Compilation of Air Pollutant Emission Factors (AP-42)* (USEPA 2006)

Appendix M provides detailed information on the emission calculations.

3.9.4.2 Significance Criteria

For the purposes of this analysis, an air quality impact would be significant if one or more of the following criteria are met:

- The effects would cause an air quality standard to be violated
- Activities or emissions would result in a cumulatively considerable net increase of:
  - O_3 in Siskiyou County or Shasta County, California (O_3 nonattainment-transitional and nonattainment areas, respectively)
  - PM_{10} in Del Norte, Humboldt, Trinity, Shasta, and Modoc Counties, California (PM_{10} nonattainment areas)
- Cause release of emissions that exceed 250 pounds per day for NOx, volatile organic compounds (VOC), PM_{10}, $PM_{2.5}$, or sulfur oxides (SOx); or 2,500 pounds per day for CO (Siskiyou County Air Pollution Control District Rule 6.1)
- Expose sensitive receptors to substantial pollutant concentrations (defined by pollutant thresholds)

[2] Although the USEPA recently developed the Motor Vehicle Emission Simulator (MOVES) to replace MOBILE6.2, MOVES has only been approved for use in SIPs and Transportation Conformity (75 FR 9411). Because it has not yet been approved for project-level analyses, MOBILE6.2 was used to estimate emissions from on-road vehicles in Oregon.

- Activities or emissions would be inconsistent with Oregon's Regional Haze Plan (ODEQ 2009)
- Activities or emissions would be inconsistent with California's Regional Haze Plan (CARB 2009)

The Proposed Action would also occur within close proximity (within 100 kilometers[3]) of several mandatory fFederal Class I areas, which are areas in which visibility was declared by Congress to be an important value (Clean Air Act, Section 169A). The following Class I areas could be affected by the Proposed Action or its alternatives.

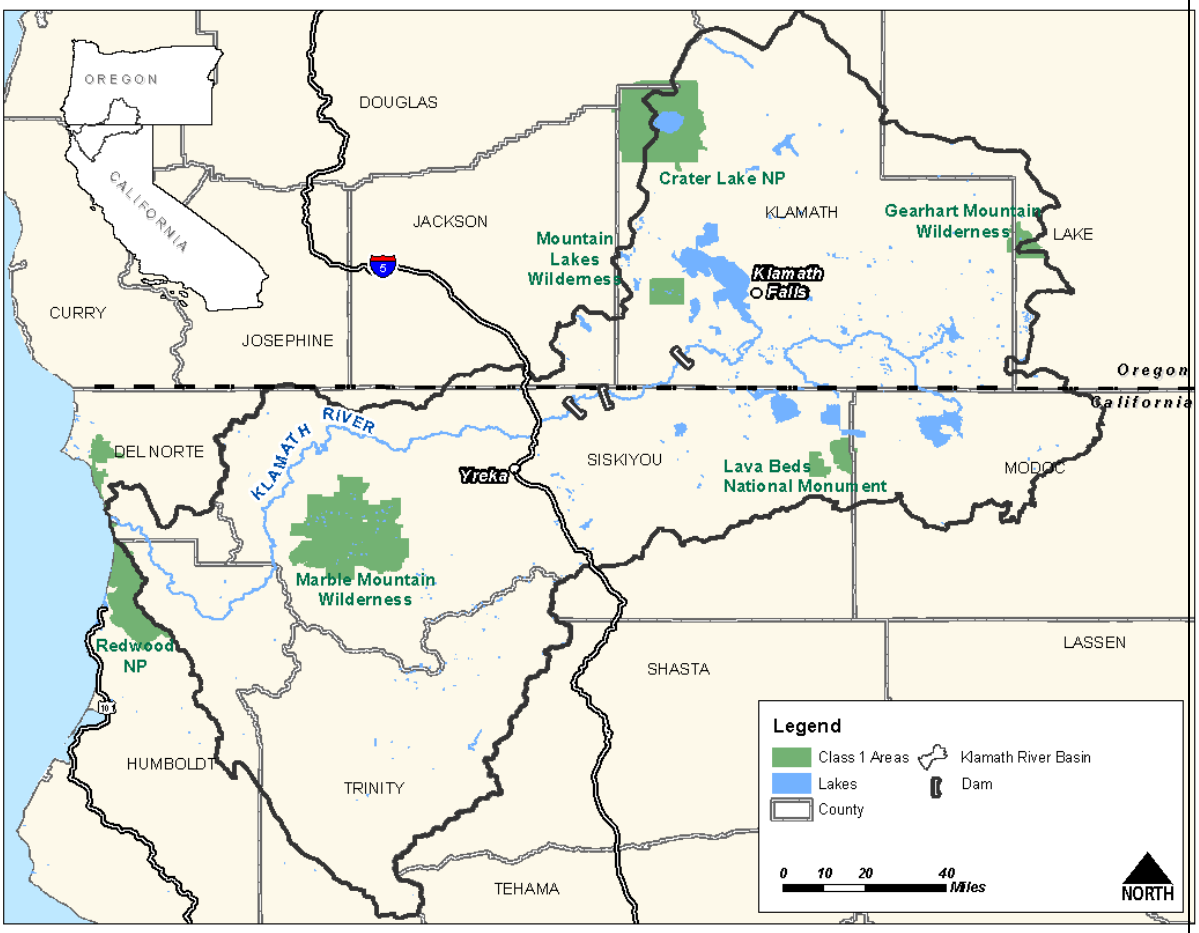
- Crater Lake National Park (Oregon)
- Gearhart Mountain Wilderness (Oregon)
- Lava Beds National Monument (California)
- Marble Mountain Wilderness (California)
- Mountain Lakes Wilderness (Oregon)

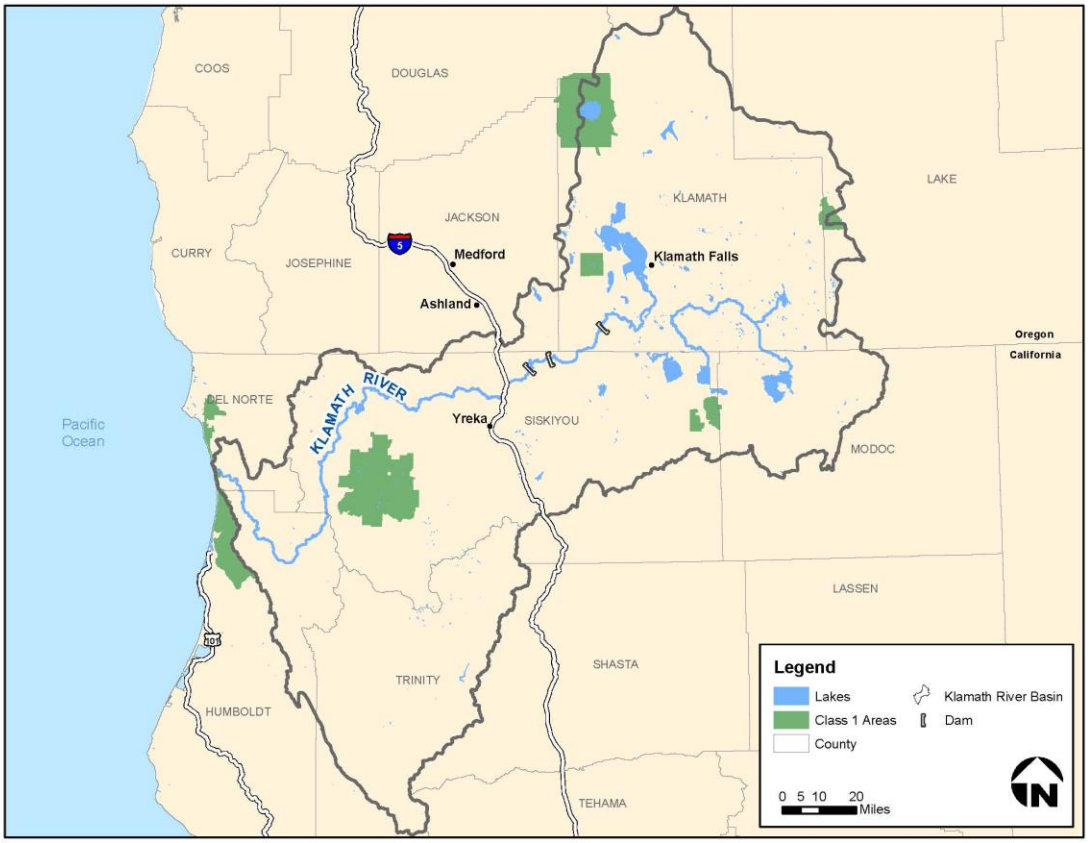
Oregon's *Regional Haze Plan* (ODEQ 2009) indicates that the current rules addressing construction-related activities in Oregon are sufficient to prevent visibility impairment in Oregon Class I areas. Several rules that address construction activities include Oregon Administrative Rule (OAR) 340-208-0110, which sets opacity limits for visible emissions from any air contaminant source and OAR 340-208-0210, which addresses fugitive emissions from a variety of sources.

California's *Regional Haze Plan* (CARB 2009) indicates that CARB's In-Use Off-Road Diesel Vehicle Regulation (adopted on July 26, 2007) will reduce particulate matter and NOx emissions by 74 percent and 32 percent, respectively, from current levels. CARB expects this measure to be sufficient to mitigate visibility impacts from construction activities.

Figure 3.9-5 shows the Federal Class I areas that are within the Klamath Basin.

[3] The 100-kilometer distance is based on a memorandum from the USEPA (1979) to Regional Administrators that indicated that "[v]ery large sources…may be expected to affect 'air quality related values' at distances greater than 100 kilometers." Although the distance is related to the Prevention of Significant Deterioration permitting program, the distance is being used as a proxy for activities associated with the Proposed Action.


OREGON
CALIFORNIA
DOUGLAS
JACKSON
CURRY
JOSEPHINE
KLAMATH
LAKE
Crater Lake NP
Mountain Lakes Wilderness
Klamath Falls
Gearhart Mountain Wilderness
Oregon
California
DEL NORTE
KLAMATH RIVER
Yreka
SISKIYOU
Lava Beds National Monument
MODOC
Marble Mountain Wilderness
Redwood NP
SHASTA
LASSEN
HUMBOLDT
TRINITY
TEHAMA
Legend
Class 1 Areas
Lakes
County
Klamath River Basin
Dam
0 10 20 40 Miles
NORTH



Source: National Park Service 2010.

Figure 3.9-5. Federal Class I Areas.

3.9.4.3 Effects Determinations

No operational sources are part of the Proposed Action; therefore, this analysis considers only construction-related air quality impacts. Appendix M describes the methods by which construction impacts were estimated.

3.9.4.3.1 Alternative 1: No Action/No Project Alternative

Vehicle exhaust from continued maintenance and operation of the Four Facilities could cause emissions of air pollutants. Under the No Action/No Project Alternative, none of the activities under the Klamath Hydroelectric Settlement Agreement (KHSA) would be completed. Operational emissions that would occur from employees commuting to the Four Facilities, vendor trips, or other emission sources would continue to occur under the No Action/No Project Alternative. **These emissions are expected to be minimal and were not quantified for this analysis.**

Activities associated with Interim Measures (IMs) could result in short-term and temporary increases in criteria pollutants from vehicle exhaust and fugitive dust that

could exceed Siskiyou County's thresholds of significance. Several IMs would be implemented under the No Action/No Project Alternative. Several of these measures could result in increased criteria pollutant emissions:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement
- IM 8: J.C. Boyle Bypass Barrier Removal

IM 7 would require PacifiCorp to place suitable gravels in the J.C. Boyle Bypass and Peaking reaches using a passive approach before high flow periods or to provide for other habitat enhancement. The No Action/No Project Alternative includes only one year of this measure. Criteria pollutant emissions could occur from trucks hauling gravel to the J.C. Boyle Bypass and Peaking reaches; however, the number of trucks required to deliver gravel is expected to be minor.

IM 8 requires the removal of the sidecast rock barrier located approximately 3 miles upstream of the J.C. Boyle Powerhouse in the J.C. Boyle Bypass Reach. Potential air quality emissions are expected to be less than those quantified for the removal of Copco 1 from blasting activities.

Based on the limited amount of construction equipment expected to be used simultaneously, peak daily emissions are not expected to exceed the significance criteria described previously. **The impact on air quality from implementation of the IMs would be less than significant.**

Ongoing Restoration Activities

Construction activities from several ongoing restoration actions could cause emissions of air pollutants. Under the No Action/No Project Alternative, several projects would be assumed to proceed over time. These resource management actions could receive additional funding and could be expanded or accelerated through the ~~KBRA;~~Klamath Basin Restoration Agreement (KBRA); however, they were started or under consideration before the KBRA was developed and would move forward even without the KBRA. The Fish Habit Restoration activities could result in criteria pollutant emissions. **This project would involve some limited construction activities that could result in short-term temporary air emissions in the upper basin. The effects of these activities would be fully analyzed in separate National Environmental Policy Act evaluations for each project as they are designed.**

3.9.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

Vehicle exhaust and fugitive dust emissions from dam removal activities could increase emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ to levels that could exceed Siskiyou County's thresholds of significance. Emission sources include exhaust emissions from off-road construction equipment, on-road trucks, construction worker employee

commuting vehicles; and fugitive dust emissions from unpaved roads and general earth moving activities. General earth moving activities that could generate fugitive dust include the operation of construction equipment on the site and removal of excavated materials (cut/fill activities). The Iron Gate Fish Hatchery would be operated for eight years after the dam removal, but the hatchery would not be rebuilt or relocated. While additional water may be ~~routed~~supplied to the hatchery to support its operation, an increase in emissions would not occur. Operational emissions were therefore not estimated for the hatchery.

Table 3.9-3 summarizes predicted uncontrolled peak daily and annual emission rates for VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ for the Proposed Action. This analysis uses the conservative assumption that the peak day of construction could occur at the same time for each dam; therefore, the peak daily emissions are additive. The analysis assumes that dust control measures like watering and erosion control fabrics would be required by the United States Department of the Interior (DOI). In addition, the calculations assume that all haul roads would be covered in gravel with minimal silt content. As a result, these measures are included as part of the project and are not considered to be mitigation measures.

Cofferdams would be constructed at the Four Facilities during deconstruction activities. Concrete rubble, rock, and earthen materials that would come from the dam removal activities would be used as possible to construct the cofferdams. Since the cofferdams would be constructed from materials salvaged from the dam demolition activities, emissions associated with construction would already be included in the emissions inventory. Additional emissions could occur when the cofferdams are later demolished, but this activity would not cause any changes to the significance determinations.

As Table 3.9-3 shows, total emissions of NOx and PM_{10} exceed the significance criteria for the four sites. The greatest source of NOx emissions from each of the dams would be off-road construction equipment, followed by on-road trucks, and then employee commuting vehicles. The major sources of PM_{10} emissions would be fugitive dust from unpaved roads and then cut/fill activities. Any adverse impacts would be temporary.

Demolition of Copco 1 dam could generate concrete dust, which has a high pH. Dust control measures as described in mitigation measure AQ-4 would be used to control concrete dust to the maximum extent feasible. Management of the high pH content is discussed further in Section 3.5, Terrestrial Resources. **The impact on air quality from emissions of NOx and PM_{10} from the demolition of the Four Facilities would be a significant impact. Implementation of mitigation measures AQ-1 through AQ-4 would reduce emissions of NOx to a less than significant level; however, emissions of PM_{10} would remain significant and unavoidable.**

Table 3.9-3. Uncontrolled Emissions Inventories for the Proposed Action

Location	Peak Daily Emissions (pounds per day)[1]					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
Iron Gate	67	272	**348**	2	210	50
Copco 1	27	176	129	1	174	165
Copco 2	22	83	113	1	17	6
J.C. Boyle	15	54	60	5	103	27
Grand Total	131	584	**650**	9	**503**	248
California Total[3]	116	531	**590**	4	**401**	221
Oregon Total	15	54	60	5	103	27
Significance Criterion[4]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Iron Gate	3	11	14	<1	10	2
Copco 1	1	7	5	<1	8	7
Copco 2	1	3	5	<1	<1	<1
J.C. Boyle	1	3	5	<1	3	1
Total (2020)	6	24	28	1	20	11
California Total[3]	5	21	23	<1	18	10
Oregon Total	1	3	5	<1	3	1
De Minimis Threshold[5]	n/a	100	100	100	100	100

Notes:
[1] Values shown in **bold** are significant.
[2] Where emission factors were only provided for PM_{10}, appropriate PM size profiles were used to estimate $PM_{2.5}$ emissions. Appendix M.
[3] California total includes emissions for activities at Iron Gate, Copco 1, and Copco 2 Dams.
[4] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.
[5] General conformity de minimis thresholds from 40 CFR 93.153.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

~~Demolition of Copco 1 dam could generate concrete dust, which has a high pH. Dust control measures as described in mitigation measure AQ-4 would be used to control concrete dust to the maximum extent feasible. Management of the high pH content is discussed further in Section 3.5, Terrestrial Resources.~~ ~~**The impact on air quality from emissions of NOx and PM_{10} from the demolition of the Four Facilities would be a significant impact. Implementation of mitigation measures AQ-1 through AQ-4 would reduce emissions of NOx to a less than significant level; however, emissions of PM_{10} would remain significant and unavoidable.**~~

~~*Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary increases in criteria pollutant emissions from vehicle exhaust and fugitive dust that could exceed Siskiyou County's thresholds of significance.* On- and off-road construction~~

~~Public Draft~~
~~equipment would be used to complete the relocation and construction of the Yreka water supply pipeline. These construction activities would occur before demolition activities at Iron Gate and would not overlap with other construction or demolition activities. Typical equipment that would be expected to be used to complete construction of the pipeline would include excavators, graders, loaders, and scrapers. Based on the limited amount of construction equipment expected to be used simultaneously, peak daily emissions are not expected to exceed the significance criteria described previously. **The impact on air quality from the construction of the Yreka water supply pipeline would be less than significant.**~~

Activities associated with several IMs could result in short-term and temporary increases in criteria pollutants from vehicle exhaust and fugitive dust that could exceed Siskiyou County's thresholds of significance. Prior to construction, IMs as described in the KHSA (KHSA Section 1.2.4) would be implemented and would control operations of the hydroelectric facilities. Several of the IMs in the Proposed Action could result in increased criteria pollutant emissions:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement
- IM 16: Water Diversions

IM 7 would require PacifiCorp to place suitable gravels in the J.C. Boyle bypass and peaking reach using a passive approach before high flow periods or to provide for other habitat enhancement. The Proposed Action includes seven years of implementing this measure. Criteria pollutant emissions could occur from trucks hauling gravel to the J.C. Boyle bypass and peaking reach; however, the number of trucks required to deliver gravel is expected to be minor.

IM 16 would eliminate three screened diversions from Shovel and Negro Creeks and would also require the installation of screened irrigation pump intakes, as necessary, in the Klamath River. Limited construction equipment and haul trucks would be required to remove the screened diversions or to construct new diversions.

Based on the limited amount of construction equipment expected to be used simultaneously, peak daily emissions are not expected to exceed the significance criteria described previously. ~~Limited construction equipment and haul trucks would be required to remove the screened diversions or to construct new diversions.~~

~~Based on the limited amount of construction equipment expected to be used simultaneously, peak daily emissions are not expected to exceed the significance criteria described previously.~~ **The impact on air quality from implementation of the IMs would be less than significant.**

Restoration actions could result in short-term and temporary increases in criteria pollutant emissions from vehicle exhaust and fugitive dust from the use of helicopters, trucks, and barges. Following drawdown of the reservoirs, revegetation efforts would be

initiated to support establishment of native wetland and riparian species on newly exposed river-side sediment. Upper areas of the reservoir basins would be reseeded from a barge until the reservoir levels become too low to operate and access the barge. Aerial application would be necessary for precision applications of material near sensitive areas and the newly established river channel. Aerial hydroseeding is scheduled to begin on March 15, 2020 and last for 10 days at Iron Gate and 20 days at Copco. Trucks would also be used as necessary to provide seeding. Additional fall seeding may be necessary to supplement areas where spring hydroseeding was unsuccessful~~. These revegetation actions would be happening simultaneously to the demolition of the Four Facilities; therefore, emissions would contribute to those already occurring for the Proposed Action. **Helicopters, trucks, and barges from restoration actions would cause a temporary significant air quality impact and would increase the significant air quality impacts generated by dam deconstruction in and around the dam sites. Available mitigation measures would not reduce emissions to less than significant levels; therefore, emissions would remain significant and unavoidable**~~.

Annual greenhouse gas (GHG) emissions were estimated using information provided in the *Detailed Plan for Dam Removal – Klamath River Dams* (Reclamation 2012). A combination of techniques was used to estimate emissions from reservoir restoration activities. Emissions from aerial application were estimated using the Federal Aviation Administration's Emissions and Dispersion Modeling System. Emissions from barges were estimated using the following sources:

- *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data* (United States Environmental Protection Agency [USEPA] 2000)
- AP-42, Chapter 3.3: Gasoline and Diesel Industrial Emissions (USEPA 1996)
- Title 17 California Code of Regulations, Section 93115.7: Air Toxic Control Measure for Stationary Compression Ignition Engines – Stationary Prime Diesel-Fueled Compression Ignition Engine (>50 bhp) Emission Standards
- Title 13 California Code of Regulations, Section 2423: Exhaust Emission Standards and Test Procedures—Off-Road Compression-Ignition Engines

Emissions from ground support equipment were estimated using the emission factors for off-road engines identified above and EMFAC for on-road motor vehicle emissions. Table 3.9-4 summarizes emissions from reservoir restoration.

Table 3.9-4. Uncontrolled Emissions from Reservoir Restoration (Reseeding)

Phase	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
Ground Equipment	3	8	15	2	<1	<1
Barges	16	54	153	18	3	3
Aerial (Rotary Aircraft)	15	39	3	1	<1	<1
Maximum Daily[1]	19	62	168	20	3	3
Significance Criterion[2]	250	2,500	250	250	250	250

	Annual Emissions (tons per year) – 2020					
Total	9	33	33	2	20	11
De Minimis Threshold[3]	n/a	100	100	100	100	100

Notes:
[1] Barge and aerial application will not happen simultaneously; therefore, maximum daily emissions summarizes the peak day that consists of ground equipment and barges operating at the same time.
[2] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.
[3] General conformity de minimis thresholds from 40 CFR 93.153.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

As shown in Table 3.9-4, emissions would not exceed the significance criteria. **The impact on air quality from reservoir restoration activities would be less than significant.**

Relocation and demolition of various recreation facilities could result in short-term and temporary increases in criteria pollutant emissions from vehicle exhaust and fugitive dust.~~Relocation and demolition of various recreation facilities could result in short-term and temporary increases in criteria pollutant emissions from vehicle exhaust and fugitive dust.~~ The demolition of the Four Facilities would change recreational opportunities from lake-based recreation to river-based recreation. This change would require several recreation facilities to be re~~l~~construc~~a~~ted or demolished. On- and off-road construction equipment would be used to complete these activities, which would occur after the dam demolition actions.~~ Furthermore, although there are multiple~~ Annual GHG emissions were estimated using information provided in the *Detailed Plan for Dam Removal – Klamath River Dams* (Reclamation 2012) and CalEEMod. Table 3.9-5 summarizes emissions from the relocation and demolition of recreation facilities~~ being demolished or relocated, the facilities would likely not be removed simultaneously. Based on the limited size of each recreation facility, typical equipment to be used during construction activities would include dozers, scrapers, loaders, and graders. The amount of equipment expected to be used simultaneously is expected to be minimal; therefore, peak daily emissions are not expected to exceed the significance criteria described previously.~~.

Table 3.9-5. Uncontrolled Emissions from Relocation and Demolition of Recreation Facilities

Location	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
J.C. Boyle	4	32	31	<1	3	1
Copco	2	13	16	<1	2	1
Iron Gate	6	32	38	<1	5	3
Total Emissions	12	77	85	<1	11	5
Significance Criterion[1]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Total	0.1	0.7	0.8	<0.1	0.1	0.1
De Minimis Threshold[2]	n/a	100	100	100	100	100

Notes:
[1] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.
[2] General conformity de minimis thresholds from 40 CFR 93.153.
Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

As shown in Table 3.9-5, emissions would not exceed the significance criteria. **The impact on air quality from the relocation and demolition of the various recreation facilities would be less than significant.**

Vehicle exhaust and fugitive dust emissions from dam removal activities could exceed the de minimis thresholds in 40 CFR 93.153 that would require the development of a general conformity determination. Emissions from trucks and employee commuting could occur within the Klamath Falls UGB, the Klamath Falls Nonattainment Area ($PM_{2.5}$), or the Medford-Ashland AQMA; therefore, emissions that would occur within these areas are subject to the requirements of general conformity. If the total of direct and indirect emissions are below the general conformity de minimis thresholds in 40 CFR 93.153, then no further action is needed and a general conformity determination is not required.

While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total.~~While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total.~~ As a result, total emissions from haul trucks and employee commuting was compared to the general conformity de minimis thresholds as a conservative analysis. Emissions from trucks and employee commuting are less than the general conformity de minimis thresholds identified in Section 3.9.2.1 (see Tables 3.9-3 through 3.9-5) and therefore a conformity determination is not necessary for any of the maintenance or nonattainment areas. **As a result, a general conformity determination is not required.**

Fugitive dust emissions from demolition activities could impair visibility in Federal Class I areas. Demolition activities would be conducted in compliance with Oregon and California regulations related to fugitive dust emissions. In addition, any fugitive dust emissions would be short ~~-~~term and temporary and would not have long-term effects related to visibility. **Impacts related to visibility would be less than significant.**

Keno Transfer

Implementation of the Keno Transfer could have adverse effects on air quality.~~Keno Transfer~~

~~*Implementation of the Keno Transfer could have adverse effects on air quality.*~~ The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on air quality compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance with agreements and historic practice (KHSA Section 7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and ~~*West Side*~~Westside Facility Decommissioning – Programmatic Measures

Decommissioning the East and ~~West Side~~Westside Facilities could cause adverse air quality effects. Decommissioning of the East and ~~West Side~~Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would ~~redirect~~cease the current diversion of water ~~flows currently diverted at~~ at Link River Dam into the two canals~~, back into~~ from the Link River. These construction activities would be conducted in the years prior to 2020 and would not overlap with other construction or demolition activities. Peak daily emissions would likely be minimal and are not expected to exceed the significance criteria. **The impact on air quality from the East and ~~West Side~~Westside Facilities decommissioning action would be less than significant.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

Construction of a new, elevated Yreka Water Supply Pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary increases in criteria pollutant emissions from vehicle exhaust and fugitive dust that could exceed Siskiyou County's thresholds of significance. On- and off-road construction equipment would be used to complete the relocation and construction of the Yreka Water Supply Pipeline. Construction of the pipeline was assumed to occur in 2020 and would last approximately one month. It was assumed that construction of the 400 foot pipeline would occur over a space of approximately 4 acres. The Sacramento Metropolitan Air Quality Management District's Road Construction Emissions Model (2009) was used to estimate emissions associated with grubbing/land clearing, grading/excavation, and other phases. Table 3.9-6 summarizes maximum daily emissions that would occur from construction of the pipeline.

Table 3.9-6. Uncontrolled Emissions from Construction of Yreka Water Supply Pipeline

Phase	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
Grubbing/Land Clearing	2.3	9.3	16.4	--	10.1	2.6
Grading/Excavation	2.8	16.5	18.4	--	10.3	2.7
Drainage/Utilities/Sub-Grade	2.2	11.3	14.4	--	10.2	2.6
Maximum	2.8	16.5	18.4	--	10.3	2.7
Significance Criterion[1]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Total	<0.1	0.1	0.2	--	0.1	<0.1
De Minimis Threshold[2]	n/a	100	100	100	100	100

Notes:
[1] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.
[2] General conformity de minimis thresholds from 40 CFR 93.153.
Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

As shown in Table 3.9-6, emissions would not exceed the significance criteria. **The impact on air quality from the construction of the Yreka Water Supply Pipeline would be less than significant.**

KBRA – Programmatic Measures

The KBRA has several programs that could cause temporary increases in air quality pollutant emissions, primarily from construction activities. The following KBRA programs could cause air quality impacts from the use of heavy equipment:

- Phases I and II Fisheries Restoration Plans
- Fisheries Reintroduction and Management Plan
- Wood River Wetland Restoration Project
- On-Project Plan
- Water Use Retirement Program
- Fish Entrainment Reduction
- Power for Water Management Program
- Additional Water Conservation and Storage

Construction activities associated with the KBRA programs could result in temporary increases in air quality pollutant emissions from vehicle exhaust and fugitive dust. Potential construction activities include channel construction, mechanical thinning of trees, road decommissioning, fish passage and facilities construction, breaching levees, and fish hauling. Several of these activities would require construction equipment with

the potential to emit air quality pollutants. While the exact geographic location and timing of these programs is not known, it is assumed that some could occur at the same time and in the same area as the hydroelectric facility removal actions analyzed above and could contribute to the severity of the facility removal air quality effects. **Due to the potentially large amount of construction activities that would occur for the various KBRA programs, it is anticipated that the effects from air quality could be significant. Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce the severity of these effects to a less than significant level; however, emissions from any construction actions completed in the same year as hydroelectric facility removal actions may not be reduced to a less than significant level. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Operational activities associated with the Fisheries Reintroduction and Management Plan could result in temporary increases in air quality pollutant emissions from vehicle exhaust associated with trap-and-haul activities. Potential operational emissions could occur from haul trucks moving fish around Keno Impoundment/Lake Ewauna and Link River. Upstream-migrating fish would be collected downstream from Keno Dam and relocated to Upper Klamath Lake or its tributaries. Downstream-migrating fish would be collected at Link River Dam (and the East Side and ~~West Side~~Westside canals) and relocated downstream from Keno Dam. Seasonal trap and haul operations would occur during periods of poor water quality in Keno Impoundment~~.~~/Lake Ewauna. Hauling activities would occur after the peak emission-generating period of facility removal because fish cannot access Keno Dam until after removal of the Four Facilities; however, some construction activities associated with completing removal activities and reservoir restoration may occur at the same time as hauling operations. Construction emissions related to dam removal and hauling operations, taken together, could increase the severity of the air quality effects, but the combined emissions would likely still be less than the peak emissions during dam deconstruction. **Although the exact extent and timing of these hauling activities is not known, it is assumed that air quality impacts would be significant because of the long haul distance that is expected. Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce the severity of these effects to a less than significant level; however, emissions from any construction actions completed in the same year as hydroelectric facility removal actions may not be reduced to a less than significant level. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

3.9.4.3.3 Alternative 3: Partial Facilities Removal of Four Dams Alternative

Under the Partial Facilities Removal Alternative, some of the structures associated with the dams would remain in place. As a result, the area in which removal activities could occur is smaller than under the Proposed Action.

Vehicle exhaust and fugitive dust emissions from dam removal activities could increase emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ to levels that could exceed Siskiyou County's thresholds of significance. As it would be for the Proposed Action, the major source of NOx emissions associated with the Partial Facilities Removal Alternative

would be off-road construction equipment and other sources of exhaust emissions. The major source of PM_{10} and $PM_{2.5}$ emissions would be fugitive dust that is generated from movement on unpaved roads and surfaces. Secondary formation of $PM_{2.5}$ could also occur from NOx and SOx emissions; however, these pollutants are not emitted in sufficient quantities to affect the Klamath Falls Nonattainment Area.

The Iron Gate Fish Hatchery would be operated for eight years after the dam removal, but the hatchery would not be rebuilt or relocated. While additional water may be ~~routed~~supplied to the hatchery to support its operation, an increase in emissions would not occur. Operational emissions were therefore not estimated for the hatchery.

Table 3.9-~~4~~7 is a summary of predicted uncontrolled peak daily and annual emission rates for VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ for the Partial Facilities Removal Alternative. As Table 3.9-~~4~~7 shows, total emissions of NOx and PM_{10} would exceed the significance criteria for the four sites.

Demolition of Copco 1 dam could generate concrete dust, which has a high pH. Dust control measures as described in mitigation measure AQ-4 would be used to control concrete dust to the maximum extent feasible. Management of the high pH content is discussed further in Section 3.5, Terrestrial Resources. **The impact on air quality from emissions of NOx and PM_{10} the Four Facilities would be a significant impact. Implementation of mitigation measures AQ-1 through AQ-4 would reduce emissions of NOx to a less than significant level; however, emissions of PM_{10} would remain significant and unavoidable.**

~~*Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions that could exceed Siskiyou County's thresholds of significance.* Air quality impacts associated with the water supply pipeline construction would be the same as those discussed for the Proposed Action. **The impact on air quality from the construction of the Yreka water supply pipeline would be less than significant.**~~

Activities associated with several IMs could result in short-term and temporary increases in criteria pollutants from vehicle exhaust and fugitive dust that could exceed Siskiyou County's thresholds of significance. Air quality impacts associated with implementation of IMs would be the same as those discussed for the Proposed Action. **The impact on air quality from implementation of the IMs would be less than significant.**

Restoration actions could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions from the use of helicopters, trucks, and barges. Air quality impacts associated with the restoration actions would be the same as those discussed for the Proposed Action.~~**Helicopters, trucks, and barges from restoration actions would cause a temporary significant air quality impact and would increase the significant air quality impacts generated by dam deconstruction in and around the dam sites. Available mitigation measures would not reduce emissions to less than significant**~~

~~Public Draft~~

~~levels; therefore, emissions would remain significant and unavoidable~~ The impact on air quality from reservoir restoration activities would be less than significant.

Relocation and demolition of various recreation facilities could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions. Air quality impacts associated with the recreation facilities would be the same as those discussed for the Proposed Action. **The impact on air quality from the relocation and demolition of the various recreation facilities would be less than significant.**

Table 3.9-~~4.~~7. Uncontrolled Emissions Inventories for the Partial Facilities Removal Alternative

Location	Peak Daily Emissions (pounds per day)[1]					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
Iron Gate	66	270	**344**	2	208	49
Copco 1	27	173	124	1	171	165
Copco 2	21	80	103	1	12	5
J.C. Boyle	14	48	53	5	94	25
Grand Total	128	570	**625**	9	**484**	244
California Total[3]	115	522	**571**	4	**390**	219
Oregon Total	14	48	53	5	94	25
Significance Criterion[4]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Iron Gate	3	11	14	<1	10	2
Copco 1	1	7	5	<1	7	7
Copco 2	1	3	4	<1	<1	<1
J.C. Boyle	1	2	3	<1	2	1
Total (2020)	6	23	26	<1	20	11
California Total	5	21	23	<1	17	10
Oregon Total	1	2	3	<1	2	1
De Minimis Threshold[5]	n/a	100	100	100	100	100

Notes:

1 Values shown in **bold** are significant.

2 Where emission factors were only provided for PM_{10}, appropriate PM size profiles were used to estimate $PM_{2.5}$ emissions. Appendix M includes detailed calculation tables.

3 California total includes emissions for activities at Iron Gate, Copco 1, and Copco 2 Dams.

4 Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.

5 General conformity de minimis thresholds from 40 CFR 93.153.

Key:

VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

Vehicle exhaust and fugitive dust emissions from dam removal activities could exceed the de minimis thresholds in 40 CFR 93.153 that would require the development of a general conformity determination. Emissions from trucks and employee commuting could occur within the Klamath Falls UGB, the Klamath Falls Nonattainment Area ($PM_{2.5}$), or the Medford-Ashland AQMA; therefore, emissions that would occur within these areas are subject to the requirements of general conformity. If the total of direct and indirect emissions are below the general conformity de minimis thresholds in 40 CFR 93.153, then no further action is needed and a general conformity determination is not required.

While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total.~~*Relocation and demolition of various recreation facilities could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions.* Air quality impacts associated with the recreation facilities would be the same as those discussed for the Proposed Action. **Based on the number of recreation facilities that would be relocated or demolished, it is assumed that emissions would be potentially significant. Mitigation measure AQ-1, AQ-2, and AQ-3 would be sufficient to reduce emissions to levels below significance thresholds. The impact on air quality from the relocation and demolition of recreation facilities would be less than significant.**~~

~~*Vehicle exhaust and fugitive dust emissions from dam removal activities could exceed the de minimis thresholds in 40 CFR 93.153 that would require the development of a general conformity determination.* Emissions from trucks and employee commuting could occur within the Klamath Falls UGB, the Klamath Falls Nonattainment Area ($PM_{2.5}$), or the Medford-Ashland AQMA; therefore, emissions that would occur within these areas are subject to the requirements of general conformity. If the total of direct and indirect emissions are below the general conformity de minimis thresholds in 40 CFR 93.153, then no further action is needed and a general conformity determination is not required.While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total.~~ As a result, total emissions from haul trucks and employee commuting was compared to the general conformity de minimis thresholds as a conservative analysis. Emissions from trucks and employee commuting are less than the general conformity de minimis thresholds identified in Section 3.9.2.1 (see Tables 3.9-4 through 3.9-7) and therefore a conformity determination is not necessary for any of the maintenance or nonattainment areas. **As a result, a general conformity determination is not required.**

Fugitive dust emissions from demolition activities could impair visibility in Federal Class I areas.~~*Fugitive dust emissions from demolition activities could impair visibility in Federal Class I areas.*~~ Demolition activities would be conducted in compliance with Oregon and California regulations related to fugitive dust emissions. In addition, any fugitive dust emissions would be short-term and temporary and would not have long-term effects related to visibility. **Impacts related to visibility would be less than significant.**

~~Public Draft~~

Keno Transfer

The effects of the Keno Transfer would be the same as those for the Proposed Action.

~~**Impacts related to visibility would be less than significant.**~~

~~**Keno Transfer**~~

~~The effects of the Keno Transfer would be the same as those for the Proposed Action.~~

East and ~~*West Side*~~Westside Facility Decommissioning – Programmatic Measures

The effects of the East and ~~West Side~~Westside Facilities removal would be the same as those described for the Proposed Action.

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

Construction of a new, elevated Yreka Water Supply Pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions that could exceed Siskiyou County's thresholds of significance. Air quality impacts associated with the water supply pipeline construction would be the same as those discussed for the Proposed Action. **The impact on air quality from the construction of the Yreka Water Supply Pipeline would be less than significant.**

KBRA – Programmatic Measures

The effects of implementing the KBRA would be the same as those described in the Proposed Action.

3.9.4.3.4 Alternative 4: Fish Passage at Four Dams Alternative

The Fish Passage at Four Dams Alternative would not include removal of dams, but would instead include construction of fish passages. Under this alternative, fugitive dust emissions would be caused by movement of construction equipment on the soil and internal haul roads, but not by cut/fill activities, which would not occur.

Vehicle exhaust and fugitive dust emissions from construction of fish passage could increase emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ to levels that could exceed Siskiyou County's thresholds of significance. Table 3.9-~~5~~8 is a summary of predicted uncontrolled peak daily and annual emission rates for VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ for the Fish Passage at Four Dams Alternative. As Table 3.9-5 shows, maximum

daily emissions for all pollutants would not exceed the thresholds of significance. **The impact on air quality from emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ at the Four Facilities would be a less than significant impact.**

Vehicle exhaust and fugitive dust emissions from dam removal activities could exceed the de minimis thresholds in 40 CFR 93.153 that would require the development of a general conformity determination. Emissions from trucks and employee commuting could occur within the Klamath Falls UGB, the Klamath Falls Nonattainment Area ($PM_{2.5}$), or the Medford-Ashland AQMA; therefore, emissions that would occur within these areas are subject to the requirements of general conformity. If the total of direct and indirect emissions are below the general conformity de minimis thresholds in 40 CFR 93.153, then no further action is needed and a general conformity determination is not required.

While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total. As a result, total emissions from haul trucks and employee commuting was compared to the general conformity de minimis thresholds as a conservative analysis. Emissions from trucks and employee commuting are less than the general conformity de minimis thresholds identified in Section 3.9.2.1 (see Table 3.9-8) and therefore a conformity determination is not necessary for any of the maintenance or nonattainment areas. **As a result, a general conformity determination is not required.**

~~Table 3.9-5.~~*Fugitive dust emissions from construction activities could impair visibility in Federal Class I areas.* Construction activities would be conducted in compliance with Oregon and California regulations related to fugitive dust emissions. In addition, any fugitive dust emissions would be short term and temporary and would not have long-term effects related to visibility. **Impacts related to visibility would be less than significant.**

Trap and Haul – Programmatic Measures

Implementation of trap and haul measures could result in temporary increases in air quality pollutant emissions from vehicle exhaust. Potential operational emissions could occur from haul trucks moving fish around Keno Impoundment/Lake Ewauna and Link River. Upstream-migrating fish would be collected downstream from Keno Dam and relocated upstream from Link River Dam. Downstream-migrating fish would be collected at Link River Dam (and the East Side and West Side canals) and relocated downstream from Keno Dam. Seasonal trap and haul operations would occur during periods of poor water quality in Keno Impoundment/Lake Ewauna. **Although the exact extent and timing of these hauling activities is not known, it is assumed that air quality impacts from the trap and haul measures would be significant because of the long haul distance that is expected. Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce the severity of these effects to a less than significant level.**

~~Public Draft~~

Table 3.9-8. Uncontrolled Emissions Inventories for the Fish Passage at Four Dams Alternative

Location	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[1]
Iron Gate	11	63	59	<1	8	3
Copco 1	10	58	45	<1	5	2
Copco 2	10	58	50	<1	5	2
J.C. Boyle	9	16	50	4	11	6
Maximum[2]	11	63	59	4	11	6
Significance Criterion[3]	250	2,500	250	250	250	250
	Annual Emissions (tons per year)					
Iron Gate (2023)	2	10	5	<1	2	1
Copco 1 (2025)	1	7	3	<1	2	<1
Copco 2 (2024)	1	4	1	<1	1	<1
J.C. Boyle (2022)	<1	<1	2	<1	1	<1
Total (2022-2025)	4	22	11	<1	6	1
Maximum	2	10	5	<1	2	1
De Minimis Threshold[4]	n/a	100	100	100	100	100

Notes:

[1] Where emission factors were only provided for PM_{10}, appropriate PM size profiles were used to estimate $PM_{2.5}$ emissions. Appendix M includes detailed calculation tables.

[2] Since demolition activities for each dam site occurs during different years and do not overlap, the maximum daily emissions from each dam site are used to evaluate significance.

[3] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.

[4] General conformity de minimis thresholds from 40 CFR 93.153.

Key:

VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

3.9.4.3.5 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

~~*Vehicle exhaust and fugitive dust emissions from dam removal activities could exceed the de minimis thresholds in 40 CFR 93.153 that would require the development of a general conformity determination.* Emissions from trucks and employee commuting could occur within the Klamath Falls UGB, the Klamath Falls Nonattainment Area ($PM_{2.5}$), or the Medford-Ashland AQMA; therefore, emissions that would occur within these areas are subject to the requirements of general conformity. If the total of direct and indirect emissions are below the general conformity de minimis thresholds in 40 CFR 93.153, then no further action is needed and a general conformity determination is not required.While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total. As a result, total emissions from haul trucks and employee commuting was compared to the general conformity de minimis thresholds as a~~

~~conservative analysis. Emissions from trucks and employee commuting are less than the general conformity de minimis thresholds identified in Section 3.9.2.1 (see Table 3.9-5) and therefore a conformity determination is not necessary for any of the maintenance or nonattainment areas. **As a result, a general conformity determination is not required.** *Fugitive dust emissions from construction activities could impair visibility in Federal Class I areas.* Construction activities would be conducted in compliance with Oregon and California regulations related to fugitive dust emissions. In addition, any fugitive dust emissions would be short-term and temporary and would not have long-term effects related to visibility. **Impacts related to visibility would be less than significant.**~~

~~***Trap and Haul – Programmatic Measure***~~
~~*Implementation of trap and haul measures could result in temporary increases in air quality pollutant emissions from vehicle exhaust.* Potential operational emissions could occur from haul trucks moving fish around Keno Impoundment and Link River. Upstream-migrating fish would be collected downstream from Keno Dam and relocated upstream from Link River Dam. Downstream-migrating fish would be collected at Link River Dam (and the East Side and West Side canals) and relocated downstream from Keno Dam. Seasonal trap and haul operations would occur during periods of poor water quality in Keno Impoundment. **Although the exact extent and timing of these hauling activities is not known, it is assumed that air quality impacts from the trap and haul measures would be significant because of the long haul distance that is expected. Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce the severity of these effects to a less than significant level.**~~

~~Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative~~

The Fish Passage at Two Dams Alternative would include removal of Copco 1 and Iron Gate Dams, but would leave Copco 2 and J.C. Boyle Dams in place with newly constructed fish passages. This alternative would essentially be a combination of the Proposed Action (Full Facilities Removal) and the Fish Passage at Four Dams Alternative, with similar emissions sources.

Vehicle exhaust and fugitive dust emissions could increase emissions of VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ to levels that could exceed Siskiyou County's thresholds of significance. Table 3.9-~~6~~9 is a summary of predicted uncontrolled peak daily and annual emission rates for VOC, NOx, CO, SO_2, PM_{10}, and $PM_{2.5}$ for the Fish Passage at Four Dams Alternative. The Iron Gate Fish Hatchery would be operated for eight years after the dam removal, but the hatchery would not be rebuilt or relocated. While additional water may be routed to the hatchery to support its operation, an increase in emissions would not occur. Operational emissions were therefore not estimated for the hatchery. As Table 3.9-~~6~~9 shows, total emissions of NOx and PM_{10} would exceed the significance criterion for the four sites.

Demolition of Copco 1 Dam could generate concrete dust, which has a high pH. Dust control measures as described in mitigation measure AQ-4 would be used to control

~~Public Draft~~

concrete dust to the maximum extent feasible. Management of the high pH content is discussed further in Section 3.5, Terrestrial Resources. **The impact on air quality from emissions of NOx and PM_{10} from construction work at the Four Facilities would be a significant impact. Implementation of mitigation measures AQ-1 through AQ-4 would reduce emissions to a less than significant level.**

Table 3.9-~~6.~~9. Uncontrolled Emissions Inventories for the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative

Location	Peak Daily Emissions (pounds per day)[1]					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
Iron Gate	67	282	**345**	2	209	49
Copco 1	28	179	129	1	173	165
Copco 2	12	61	82	<1	6	4
J.C. Boyle	10	32	63	4	11	7
Grand Total	117	552	**620**	7	**399**	225
California Total[3]	107	521	**557**	3	**388**	218
Oregon Total	10	32	63	4	11	7
Significance Criterion[4]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Iron Gate	3	12	14	<1	10	2
Copco 1	1	7	5	<1	8	7
Copco 2	<1	1	1	<1	<1	<1
J.C. Boyle	<1	1	2	<1	<1	<1
Total (2020)	4	20	22	<1	18	10
California Total	4	19	20	<1	17	10
Oregon Total	<1	1	2	<1	<1	<1
De Minimis Threshold[5]	n/a	100	100	100	100	100

Notes:

[1] Values shown in **bold** are significant.

[2] Where emission factors were only provided for PM_{10}, appropriate PM size profiles were used to estimate $PM_{2.5}$ emissions. Appendix M includes detailed calculation tables.

[3] California total includes emissions for activities at Iron Gate, Copco 1, and Copco 2 Dams.

[4] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.

[5] General conformity de minimis thresholds from 40 CFR 93.153.

Key:

VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

~~Demolition of Copco 1 Dam could generate concrete dust, which has a high pH. Dust control measures as described in mitigation measure AQ-4 would be used to control concrete dust to the maximum extent feasible. Management of the high pH content is discussed further in Section 3.5, Terrestrial Resources. **The impact on air quality from emissions of NOx and PM_{10} from construction work at the Four Facilities would be**~~

~~**a significant impact. Implementation of mitigation measures AQ-1 through AQ-4 would reduce emissions to a less than significant level.**~~

~~*Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions.* Air quality impacts associated with the Yreka water supply pipeline would be the same as those described for the Proposed Action. **The impact on air quality from the construction of the Yreka water supply pipeline would be less than significant.**~~

Restoration actions could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions from the use of helicopters, trucks, and barges. Air quality impacts related to restoration activities would be similar to those described for the Proposed Action but would only occur near the Iron Gate and Copco 1 Dam sites. ~~**Helicopters, trucks, and barges from restoration actions would cause a temporary significant air quality impact and would increase the significant air quality impacts generated by dam deconstruction in and around the dam sites. Available mitigation measures, including AQ-1 through AQ-3, are not expected to reduce emissions to less than significant levels; therefore, emissions would remain significant and unavoidable**~~ Table 3.9-10 summarizes emissions from reservoir restoration.

Table 3.9-10. Uncontrolled Emissions from Reservoir Restoration (Reseeding)

Phase	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
Ground Equipment	2	6	12	1	<1	<1
Barges	16	54	153	18	3	3
Aerial (Rotary Aircraft)	15	39	3	1	<1	<1
Maximum Daily[1]	18	60	165	20	3	3
Significance Criterion[2]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Total	7	29	26	1	18	10
De Minimis Threshold[3]	n/a	100	100	100	100	100

Notes:
[1] Barge and aerial application will not happen simultaneously; therefore, maximum daily emissions summarizes the peak day that consists of ground equipment and barges operating at the same time.
[2] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.
[3] General conformity de minimis thresholds from 40 CFR 93.153.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

~~Public Draft~~

As shown in Table 3.9-10, emissions would not exceed the significance criteria. **The impact on air quality from reservoir restoration activities would be less than significant.**

Relocation and demolition of various recreation facilities could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions. Recreation facilities near J.C. Boyle Reservoir would stay intact, and the Copco 2 area does not have any developed recreation facilities. Recreation facilities at Iron Gate and Copco 1 would be removed. ~~Sufficient~~ Annual GHG emissions were estimated using information ~~is not currently available to quantify emissions. **Based on**~~provided in the ~~**number of recreation facilities that would be relocated or demolished, it is assumed that**~~*Detailed Plan for Dam Removal – Klamath River Dams* (Reclamation 2011) and CalEEMod. Table 3.9-11 summarizes emissions ~~**would be potentially significant. Mitigation measures AQ-1, AQ-2, and AQ-3 would be sufficient to reduce emissions to levels below significance thresholds. The impact on air quality**~~ from the relocation and demolition of recreation facilities ~~**would be less than significant**~~.

Table 3.9-11. Uncontrolled Emissions from Relocation and Demolition of Recreation Facilities

Location	Peak Daily Emissions (pounds per day)					
	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$[2]
J.C. Boyle	n/a	n/a	n/a	n/a	n/a	n/a
Copco	2	13	16	<1	2	1
Iron Gate	6	32	38	<1	5	3
Total Emissions	8	45	54	<1	7	4
Significance Criterion[1]	250	2,500	250	250	250	250
	Annual Emissions (tons per year) – 2020					
Total	0.1	0.7	0.8	<0.1	0.1	0.1
De Minimis Threshold[2]	n/a	100	100	100	100	100

Notes:
[1] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.
[2] General conformity de minimis thresholds from 40 CFR 93.153.
Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

As shown in Table 3.9-11, emissions would not exceed the significance criteria. **The impact on air quality from the relocation and demolition of the various recreation facilities would be less than significant.**

Vehicle exhaust and fugitive dust emissions from dam removal activities could exceed the de minimis thresholds in 40 CFR 93.153 that would require the development of a general conformity determination. Emissions from trucks and employee commuting could occur within the Klamath Falls UGB, the Klamath Falls Nonattainment Area ($PM_{2.5}$), or the Medford-Ashland AQMA; therefore, emissions that would occur within these areas are subject to the requirements of general conformity. If the total of direct and indirect emissions are below the general conformity de minimis thresholds in 40 CFR 93.153, then no further action is needed and a general conformity determination is not required.

While only emissions that would occur within the designated nonattainment or maintenance areas would be subject to general conformity, it is not possible to separate those emissions from the project total. As a result, total emissions from haul trucks and employee commuting was compared to the general conformity de minimis thresholds as a conservative analysis. Emissions from trucks and employee commuting are less than the general conformity de minimis thresholds identified in Section 3.9.2.1 (see Tables 3.9-~~6~~9 through 3.9-11) and therefore a conformity determination is not necessary for any of the maintenance or nonattainment areas. **As a result, a general conformity determination is not required.**

Fugitive dust emissions from construction and demolition activities could impair visibility in Federal Class I areas. Construction and demolition activities would be conducted in

compliance with Oregon and California regulations related to fugitive dust emissions. In addition, any fugitive dust emissions would be short -term and temporary and would not have long-term effects related to visibility. **Impacts related to visibility would be less than significant.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

Construction of a new, elevated Yreka Water Supply Pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary increases in vehicle exhaust and fugitive dust emissions. Air quality impacts associated with the Yreka water supply pipeline would be the same as those described for the Proposed Action. **The impact on air quality from the construction of the Yreka Water Supply Pipeline would be less than significant.**

Trap and Haul – Programmatic Measures

Implementation of trap and haul measures could result in temporary increases in air quality pollutant emissions from vehicle exhaust. The trap and haul measures around Keno Impoundment/Lake Ewauna and Link River would have the same impacts under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative as the Fish Passage at Four Dams Alternative. **Although the exact extent and timing of these hauling activities is not known, it is assumed that air quality impacts from the trap and haul measures would be significant because of the long haul distance that is expected. Mitigation Measures AQ-1, 2, and 3 would be implemented to reduce the severity of these effects to a less than significant level.**

3.9.4.4 Mitigation Measures

3.9.4.4.1 Mitigation Measure by Consequence Summary

AQ-1 – Any off-road construction equipment (e.g., loaders, excavators, etc.) must be equipped with engines that meet the model year (MY) 2015 emission standards for off-road compression-ignition (diesel) engines (13 CCR 2420-2425.1). Older model year engines may also be used if they are retrofit with control devices to reduce emissions to the applicable emission standards.

AQ-2 – Any on-road construction equipment (e.g., pick-up trucks at the construction sites) must be equipped with engines that meet the MY 2000 or on-road emission standards.

AQ-3 – Any trucks used to transport materials to or from the construction sites must be equipped with engines that meet the MY 2010 or later emission standards for on-road heavy-duty engines and vehicles (13 CCR 1956.8). Older model engines may also be used if they are retrofit with control devices to reduce emissions to the applicable emission standards.

AQ-4 – Dust control measures will be incorporated to the maximum extent feasible during blasting operations at Copco 1 Dam. The following control measures will be used during blasting activities:

- Conduct blasting on calm days to the extent feasible. Wind direction with respect to nearby residences must be considered.
- Design blast stemming to minimize dust and to control fly rock.
- Install wind fence for control of windblown dust

3.9.4.4.2 Effectiveness of Mitigation in Reducing Consequence

Implementation of the various engine control measures (AQ-1, AQ-2, AQ-3, and AQ-4) would substantially reduce NOx and PM_{10} emissions; however, the extent of the reduction would vary based on the size (horsepower), age, and type of equipment[4]. Controlling emissions from equipment operating on the construction site, including both off-road construction equipment (AQ-1) and on-road pick-up trucks (AQ-2), would reduce NOx and PM_{10} emissions by over 80 percent each. Controlling emissions from on-road heavy-duty diesel trucks could also reduce NOx emissions by approximately 20 percent or more. The effectiveness of AQ-4 cannot be quantified, but the mitigation would minimize PM_{10} and $PM_{2.5}$ emissions that would occur during blasting operations at Copco 1. Table 3.9-~~7~~12 summarizes the expected emissions after mitigation.

Table 3.9-~~7.~~12. Summary of Mitigated Emissions by Alternative

Alternative[1]	Peak Daily Emissions (pounds/day)					
	VOC	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Full Facilities Removal	66	405	146	3	**309**	74
Partial Facilities Removal	64	394	137	3	**294**	60
Fish Passage at Two Dams	54	372	156	3	209	44
Significance Criterion[2]	250	2,500	250	250	250	250

Notes:
[1] Alternative 4 (Fish Passage at Four Dams) not shown in Table because mitigation was not required.
[~~3~~2] Based on Siskiyou County Air Pollution Control District Rule 6.1 permitting thresholds.

Key:
VOC = volatile organic compounds
CO = carbon monoxide
NOx = nitrogen oxides
SO_2 = sulfur dioxide
PM_{10} = inhalable particulate matter
$PM_{2.5}$ = fine particulate matter

[4] The vehicular emission factor models used in this analysis, specifically EMFAC2007 for on-road emissions and OFFROAD2007 for off-road emissions in California, assume a specific fleet mix of vehicles. For example, by default, EMFAC2007 contains emission factors and vehicle activity data for model years 1965 through 2040 for each vehicle class. When the model is run for a specific calendar year, then it makes assumptions about the percentage of vehicles for each model year, fuel type, and vehicle class would be operating. As a result, the default model assumptions would contain a mix of vehicles from model year 1965 to 2020 (year of construction).

3.9.4.4.3 Agency Responsible for Mitigation Implementation

The Dam Removal Entity would be responsible for implementing mitigation measures AQ-1 through AQ-3.

3.9.4.4.4 Remaining Significant Impacts

Following implementation of the mitigation measures specified for a given alternative, PM_{10} emissions would remain significant and unavoidable for the Proposed Action and the Partial Facilities Removal Alternative.

3.9.4.4.5 Mitigation Measures Associated with Other Resource Areas

Transporting fish and mollusks under Mitigation Measures AR-1, 2, 5-7 could cause temporary increases in criteria pollutants. These mitigation measures would involve trap and haul of fish and mollusks to protect them from the reservoir drawdown and dam demolition activities. It is anticipated that as many as 150 truck trips would be required to transport juveniles from areas downstream of Iron Gate Dam to the confluence of the Klamath and Trinity Rivers between February and April 2020. The increase in daily truck trips would be minor (approximately 2 trips per day) and would not contribute substantially to the existing emissions. **The air quality impacts associated with these mitigation measures would be less than significant.**

Construction activities associated with Mitigation Measure TR-1 could cause a temporary increase in vehicle exhaust and fugitive dust emissions. Relocation of Jenny Creek Bridge and culverts near Iron Gate Reservoir would occur before the other construction phases of dam removal. On- and off-road construction equipment would be used to complete the necessary construction, but would be minor compared to the dam demolition emissions. **Air quality impacts associated with Mitigation Measure TR-1 would be less than significant.**

Several other mitigation measures may require construction, including Mitigation Measure H-2 (move or elevate structures with flood risk), GW-1 (deepen or replace wells), REC-1 (replacement of recreational facilities), and WRWS-1 (modify water intakes). These measures could produce temporary impacts on air quality during construction activities within localized areas. These activities would take place before or after the primary construction and deconstruction activities associated with the Proposed Action and action alternatives. The same or similar elements as for the Proposed Action and action alternatives would be incorporated into these construction activities to avoid or reduce impacts on air quality. **Mitigation Measures *AQ-1*** through ***AQ-3*** would be implemented, as necessary, to avoid or reduce impacts as under the Proposed Action. **Therefore, impacts on air quality from the implementation of H02, GW-1, REC-1, and WRWS-1 would be less than significant.**

3.9.5 References

Bureau of Reclamation (Reclamation). 2012. "Detailed Plan for Dam Removal – Klamath River Dams." Klamath Hydroelectric Project, FERC License No. 2082, Oregon – California. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, CO.

California Air Resources Board (CARB). 2009. *California Regional Haze Plan*. January 22. Available at: http://www.arb.ca.gov/ planning/reghaze/reghaze.htm. Accessed on: February 13, 2011. ~~Available at: .~~

CARB. 2010a. *ARB's Geographical Information System (GIS) Library*. October 29. Available at: http://www.arb.ca.gov/ei/ gislib/gislib.htm. Accessed on: December 8, 2010. ~~Available at: .~~

CARB. 2010b. *Area Designations Maps / State and National*. September 7. ~~Accessed on: November 26, 2010.~~ Available at : http://www.arb.ca.gov/desig/adm/adm.htm. Accessed on: November 26, 2010.

Karuk Tribe. 2010. *Eco-Cultural Resources Management Plan*; Draft. Department of Natural Resources. June 15. Available at: http://www.karuk.us/karuk2/images/ docs/dnr/ECRMP_6-15-10_doc.pdf. Accessed on: February 13, 2011. ~~Available at: .~~

Midwest Research Institute. 1996. *Improvement of Specific Emission Factors (BACM Project No. 1)*; Final Report. Report prepared for South Coast Air Quality Management District (SCAQMD). March 29.

National Park Service. 2010. *Class I Area Locations*. ~~Accessed on: December 8, 2010.~~ Available at: http://www.nature.nps.gov/air/Maps/classILoc.cfm. Accessed on: December 8, 2010.

Oregon Department of Environmental Quality (ODEQ). 2001. State Implementation Plan Revision for Carbon Monoxide in the Medford Urban Growth Boundary. March 9. Available at: http://www.deq.state.or.us/aq/ planning/docs/medfordmp.pdf. Accessed on: July 21, 2011. ~~Available at: .~~

ODEQ. 2002. *A Plan for Maintaining The National Ambient Air Quality Standards For Particulate Matter (PM_{10}) In Klamath Falls Urban Growth Boundary, Section 4.56 of the State Implementation Plan*. October. Available at: http://www.deq.state.or.us/aq/ planning/kfalls.htm. Accessed on: July 21, 2011. ~~Available at: .~~

ODEQ. 2004. *State Implementation Plan for Particulate Matter (PM_{10}) in the Medford-Ashland Air Quality Maintenance Area. December 10.* ~~Accessed on: July 21, 2011.~~ Available at: http://www.deq.state.or.us/aq/planning/medAsh.htm. Accessed on: July 21, 2011.

ODEQ. 2008. Geographic Information System Data: Air Quality Maintenance and Nonattainment Areas. ~~Accessed on: July 21, 2011.~~ Available at: http://www.deq.state.or.us/msd/gis/gis.htm. Accessed on: July 21, 2011.

ODEQ. 2009. *Oregon Regional Haze Plan for Implementing Section 308 (40 CFR Part 51.308) of the Regional Haze Rule*. June 19. ~~Accessed on: February 13, 2011.~~ Available at: http://www.deq.state.or.us/aq/haze/haze.htm. Accessed on: February 13, 2011.

Sacramento Metropolitan Air Quality Management District. 2009. Roadway Construction Emissions Model, Version 6.3.2. Available at: http://www.airquality.org/ceqa/index.shtml. Accessed on: January 23, 2012.

U.S. Environmental Protection Agency (USEPA). ~~2006.~~ 1996. *Compilation of Air Pollutant Emission Factors (AP-42).* Chapter 3.3: Gasoline and Diesel Industrial Engines. Available at: http://www.epa.gov/ttn/chief/ ap42/ch03/final/c03s03.pdf. Accessed on: January 27, 2012.

USEPA. 2000. Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data. EPA420-R-00-002. Available at: http://www.epa.gov/oms/models/nonrdmdl/c-marine/r00002.pdf. Accessed on: January 23, 2012.

USEPA. 2006. *Compilation of Air Pollutant Emission Factors (AP-42).* Chapter 13.2.2: Unpaved Roads. November. Available at: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf. Accessed on: February 13, 2011. ~~Available at: .~~

USEPA. 2010a. The Green Book Nonattainment Areas for Criteria Pollutants. ~~Accessed on: November 26, 2010.~~ Available at: http://www.epa.gov/airquality/greenbk/. Accessed on: November 26, 2010.

USEPA. 2010b. *Area GIS Download Page.* Available at: http://www.epa.gov/airquality/greenbk/gis_download.html. Accessed on: December 8, 2010. ~~Available at: .~~

USEPA. "Official Release of the MOVES2010 Motor Vehicle Emissions Model for Emissions Inventories in SIPs and Transportation Conformity, Notice of Availability." Federal Register. 75 (2 March 2010): 9411-9414.