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 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, 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.

3.1.1.4 Coastal Zone Management Act Consistency Determination

The Coastal Zone Management Act requires any applicant seeking a Federal License or permit that could affect land or water uses or resources of the California coastal zone to perform a Federal Consistency Determination for the proposed project. The determination provides a certification that the 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 3.3-180
- Discussion of CCA Section 30236 - Section 3.3.4.3 page 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 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

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 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 decisionmakers 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:

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

[1] With the exceptions of the East and Westside Facility Decommissioning, 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 analyzed at the programmatic level.

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 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 (see Figure 3.2-1). For the purposes of the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) 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/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 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 of the mouth of the Klamath River.

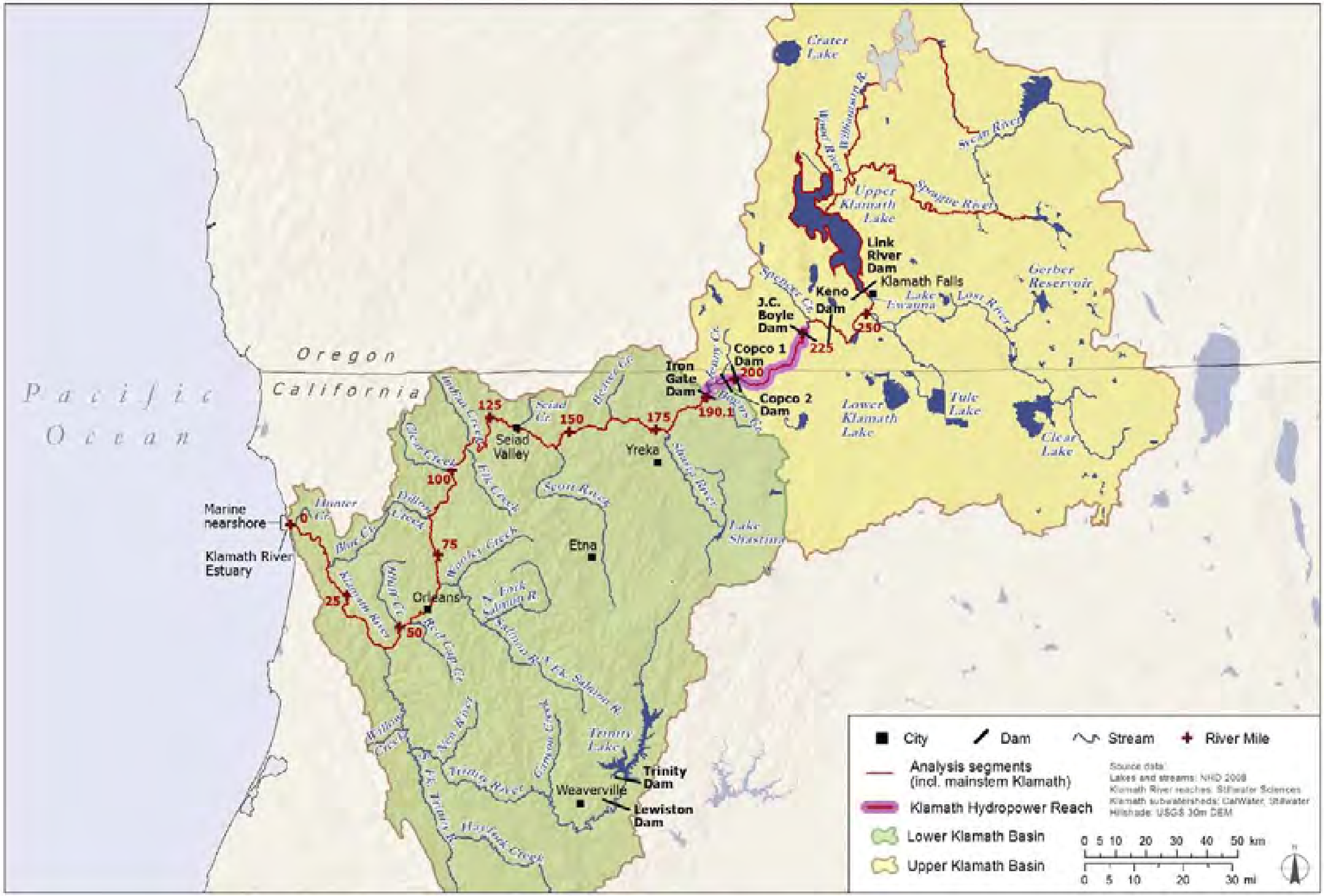

Figure 3.2-1. Water Quality Area of Analysis

3.2.2 Regulatory Framework

Multiple 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 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[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 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	Mariculture (AQUA)
Fish & Wildlife			
Fish & Aquatic 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 (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)
	Industrial Process Supply (PROC)	Industrial Process Supply (PROC)	

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 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]
Hydro Power[4]	Hydropower Generation (POW)	N/A	N/A
Navigation			
Commercial Navigation & 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

3.2.2.2 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 Revised Statutes ORS 468B.025(1) states "...no person shall: (a) Cause pollution of any waters of the 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 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 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.

Table 3.2-3. Oregon Surface-Water Quality Objectives Relevant to the Proposed Action and Alternatives

Parameter	Criteria/Description[1]
	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 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 or 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 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 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 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 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.

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 (NH_3, 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 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[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/Lake Ewauna)			X^{s}	$X^{sp,s,f,w\ (3)}$		$X^{sp,s,f,w}$	X^{s}	
Upper Klamath River Oregon-California State line to Keno Dam (including J.C. Boyle Reservoir)[4]	$X^{sp,s,f,w}$ (5)			$X^{sp,s,f,w\ (3)}$				
California								
Lower Lost River (Tule Lake, Lower Klamath Lake National Wildlife Refuge, and Mt Dome)			X		X			
Middle Klamath River Oregon-California State line to Iron Gate Dam (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[7]	X			X	X			X
Lower Klamath River-Trinity River to Mouth	X	X		X	X			

Notes:

[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] Oregon lists specific reaches of the Klamath River by river mile and includes specific seasons, in some cases (Kirk et al. 2010).

[3] Listed for dissolved oxygen only (non-spawning) (Kirk et al. 2010).

[4] Oregon defines particular river miles for their listings.

[5] Non-spawning (Kirk et al. 2010).

[6] 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).

[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 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 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 Web site http://www.deq.state.or.us/WQ/TMDLs/klamath.htm and for the California TMDLs on the North Coast Regional Water Quality Control Board 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	2012
California				
Lower Lost 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[4]	NCRWQCB	1992 (Temperature and nutrients), 1998 (Dissolved oxygen), 2006 and 2010 (Microcystin)	2010
Shasta River	Temperature and dissolved oxygen	NCRWQCB	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 (Sediment), 1996 (Temperature)	2006
Salmon River	Temperature	NCRWQCB	1992	2005
Trinity	Sediment	USEPA	1992	2001
South Fork Trinity	Sediment	USEPA	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.

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 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 line and (2) impounded and riverine sections of the Lost River from the State line downstream from the Malone Dam to the State line upstream of Tule Lake, and the Klamath Straits Drain from the 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. 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 line near Anderson-Rose Dam to the Klamath Straits Drain at the Oregon-California 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 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, 2007).

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

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[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).

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 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 the background sediment delivery rate (USEPA 2001). Examples of ongoing implementation actions include, but are not limited to, completing watershed and road analyses in 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 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 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 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 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 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 groundwater springs, such as the Wood River and the mainstem Klamath River downstream 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] 2004). However, current power-peaking operations at the J.C. Boyle Powerhouse contribute to the availability of cold water in the river just downstream 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 allowing cold groundwater to dominate flows in the river (PacifiCorp 2006a). Water temperatures in the Bypass Reach can decrease by 5–15°C (9–27°F) when 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 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 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 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 from the dam (Karuk Tribe of California 2009, 2010; see Appendix C for more detail). By the Salmon River (RM 66), the effects of the Four Facilities on water temperature are significantly diminished. Downstream from the Salmon River, the influence of the dams on water temperature in the Klamath River is not discernable from the modeled data (PacifiCorp 2005, NCRWQCB 2010a, Dunsmoor and Huntington 2006).

Downstream 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 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, 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 suspended material in the water column. Bed materials, such as gravels and 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 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 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, 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 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 from Iron Gate Dam (RM 190.1), summer and fall suspended sediment concentrations become relatively low. Between Iron Gate Dam and Seiad Valley (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 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 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 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 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 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 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 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, and in the case of TP can be transported downstream to the Lower Klamath River where they may stimulate periphyton growth.

Downstream 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 from the dam. TN concentrations in the river downstream 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 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 3.4, Algae).

Downstream 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. 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). While the California Basin Plan water quality objective for biostimulatory substances 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/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/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 high oxygen demand from water in the upstream reach from Link River Dam through the Keno Impoundment/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 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 from Iron Gate Dam during summer 2004–2006, show that roughly 45 to 65 percent of measurements immediately downstream from the dam did not achieve 8 mg/L. Daily fluctuations of up to 1–2mg/L measured in the Klamath River downstream 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 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 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 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

Because 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 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 line; Table 3.2-3) and the California pH maximum is 8.5 units (for the river downstream from State line; Table 3.2-4). Longitudinally, the lowest pH values were recorded downstream from 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 from 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 Lower 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 produce cyanotoxins (e.g., cyclic peptide toxins such as microcystin that act on the liver, alkaloid toxins such as anatoxin-a and saxitoxin that act on the nervous system). 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 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 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/Lake Ewauna are due to large populations of algae, predominantly *A. flos-aquae*, entering the Klamath River from Upper Klamath Lake in summer (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 two largest reservoirs (i.e., Copco 1 and Iron Gate) in the Hydroelectric Reach, chlorophyll-*a* concentrations increase again. 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 (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 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 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 a source of inorganic and organic contaminants to the lower Sprague and Williamson river sub-basins (Rabe and Calonje 2009). Arsenic is an exception to this; 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 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 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 (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 pathways were evaluated, which generally correspond to potential effects evaluated in this Klamath Facilities Removal EIS/EIR.

Based on comparisons of sediment chemistry to (1) screening levels (SLs) 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 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; 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 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 (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. Results of the laboratory bioaccumulation 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).

[2] There are currently 13.1 million yd^3 of sediment deposits stored within J.C. Boyle, Copco 1 and 2, and Iron Gate Reservoirs (Reclamation 2012) (see also Section 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).

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 Statewide. 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 were 3–4 orders of magnitude lower than OEHHA thresholds of 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), 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 fish tissue (i.e., arsenic, DDE/DDT, dieldrin, endrin, mercury, mirex, selenium, and total PCBs) 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 for the hydrology, water temperature, and suspended sediment modeling conducted as part of Secretarial Determination studies was WY2012 (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 1.2.4):

- 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 ongoing with pilot study data available from 2008 and 2010 and thus this interim measure is included as part of existing conditions IM 5, Iron Gate Flow Variability, would alter flow variability, but the flows would stay within the range of 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 and was completed during November 2011. 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.

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 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[3]
- 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-

[3] This action is not included in the project description (Section 2) since it will occur only in tributaries to the middle and 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.

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 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)[4] and long term (2–50 years following dam removal/construction of fish passage facilities). 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 (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

[4] 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 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) (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 context, results of these modeling scenarios are generally interpreted in this EIS/EIR with respect to starting assumptions (i.e., model boundary conditions) about water temperature. One boundary condition that differs from the Proposed Action is that, in the T1BSR, TOD2RN, and TCD2RN scenarios (but not T4BSRN), Keno Dam is replaced by the historical natural Keno Reef, such that the Keno Reach is still 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 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 Reclamation are used to provide estimates of short-term (<2 years following dam removal) suspended sediment concentrations (SSCs[5]) downstream 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 the City of 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, 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 (e.g., algal-derived) sediments, is applied herein to the 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, 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 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 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 productivity and microbially mediated nutrient cycling, and potential light limitation 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 Klamath River under all of the alternatives, results

[5] 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).

of the T4BSRN, TOD2RN and TCD2RN Klamath TMDL scenarios (Tetra Tech 2009) are presented. To place the Proposed Action analysis in context, results of the TOD2RN and TCD2RN scenarios are generally 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 the degree to which seasonal TP and TN concentrations downstream 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 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 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 from Iron Gate Dam due to oxygen demand from mobilized reservoir sediments during dam removal. In the 1-dimensional, steady-state model, the different short-term oxygen demand 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 Reclamation hydrology and sediment transport modeling assessment (i.e., typical dry, median, and typical wet water years) (see 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 (Reclamation 2012). This would allow maximum SSCs to occur during winter months when flows are naturally high in the mainstem river (Stillwater Sciences 2008, 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 context, the TOD2RN and TCD2RN model predictions (Tetra Tech 2009) are 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 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 changes in nutrient availability, water temperatures, and the availability of lacustrine (lake or reservoir) conditions would correspondingly 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 quality standards and beneficial uses is included in the water quality effects determinations. There are no quantitative models predicting algal toxin trends under 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 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 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, State and Federal standards for water quality; the comparison is first performed 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 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 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 also apply to water quality parameters that would experience degradation within the EIS/EIR short-term time from of less than 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

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.

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 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 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 µg/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] 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*.

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 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 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 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 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, 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.

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 Keno Dam to the Oregon-California State line exceed 20°C (68°F) in June through August and result in non-attainment of the designated beneficial use (Redband or Lahonton cutthroat trout 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 reduced diel variation in water temperatures in the Bypass Reach. Just downstream, in the J.C. Boyle Peaking Reach, water temperatures vary on a 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 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 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 cannot be increased by more than 2.8^{o}C (5^{o}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^{o}C [0.9^{o}F] for Copco 1 and 2 reservoir tailraces and 0.1^{o}C [0.18^{o}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 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 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/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 20°C (68°F) numeric water quality objective for the support of Redband and Lahonton cutthroat trout in Oregon during June–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 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). 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 summer and fall water temperatures on the order of 2–3°C (3.6–5.4°F) (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 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 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 from Iron Gate Dam. Under existing conditions, the Four Facilities 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 Klamath River, with the largest effects occurring just downstream 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 downstream from the Salmon River (RM 66) (see Section 3.2.3.2). Summer MWMTs in the Klamath River downstream 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 may result in minor increases in water temperatures in the Klamath River downstream from Iron Gate Dam during summer and fall months[6]. The California Klamath River TMDLs were developed based on compliance with water quality objectives at the Oregon-California 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 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 from Iron Gate Dam to approximately the Salmon River (RM 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 from Iron Gate Dam to the Salmon River with the Four Facilities in place. The model-predicted lack of compliance from Iron Gate Dam to the Salmon River underlies the TMDL requirement for PacifiCorp to address water temperature and dissolved oxygen improvements (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.

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

[6] 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).

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) 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. Considering together the available sources for climate change predictions, annual average water temperatures in the Lower Klamath Basin are expected to increase 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 Lower Klamath Basin. Within the range of late summer/fall improvements expected by the TMDLs (2–10 °C [3.6–18 °F] immediately downstream from 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; 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 from Iron Gate Dam to the Salmon River (RM 66) are adverse.[7] 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.

[7] 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 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 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 including downstream tributaries (see also Section 3.11.3.3 for 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) (see Section 3.2.3.3). 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 (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 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 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 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 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 from the Oregon-California 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 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 from Iron Gate Dam, increasing to levels greater than 150 mg/L in the mainstem downstream 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 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 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 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 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 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 from Iron Gate Dam. Under existing conditions, concentrations of summer and fall (June–October) algal-derived (organic) suspended material in the Klamath immediately downstream 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 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 the KHP reservoirs due to 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 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 offset improvements expected from successful TMDL implementation throughout the Lower Klamath Basin; however, the magnitude of the offset is unknown.

Existing transport of seasonally high algal-derived (organic) suspended material from the reservoirs to the Klamath River downstream 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.

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 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 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 can occur during late summer and fall months when it could stimulate in-reservoir algal blooms. Nutrients infrequently meet 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 support nutrient retention, particularly in the case of phosphorus (Snyder and 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 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 the TMDLs. Full attainment could require decades to achieve and is highly dependent on reducing nutrient loads exiting Upper Klamath Lake and 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 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 to the Klamath River downstream from Iron Gate Dam on a seasonal basis. On an annual basis, nutrients in the Klamath River downstream from Iron Gate Dam currently tend to be lower than those in upstream reaches, due to dilution from the natural springs downstream from J.C. Boyle Dam and settling of particulate matter and associated nutrients in Copco 1 and Iron Gate Reservoirs (see Section 3.2.3.4). Further decreases in nutrient levels occur with distance downstream 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 Copco 1 and Iron Gate Reservoirs on an annual basis may be beneficial to the Klamath River downstream 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). In late-summer and fall (i.e., August-November), TP concentrations can increase downstream from the KHP reservoirs due to release of TP (as ortho-phosphorus) which is formed during periods of seasonal hypolimnetic anoxia in Copco 1 and Iron Gate Reservoirs. This seasonal release during late summer and fall periods may stimulate periphyton growth in the Klamath River downstream 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 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

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 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). 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 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.

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 concentrations in summer and fall are substantially below (i.e., do not meet) water quality objectives and infrequently support designated beneficial uses in Oregon for cool water aquatic life and redband or Lahonton cutthroat trout; see Table 3.2-3), and in California for COLD, WARM, and SPWN beneficial uses (see 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/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/Lake Ewauna is settling and decomposition of algae exported from Upper Klamath Lake (see Section 3.2.3.5), 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 can be highly influenced by the 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 3.2.3.5).

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 Upper Klamath Lake and downstream reaches. These resource management actions are discussed again with respect to water quality effects under the KBRA (see Section 3.2.4.3.2.11).

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 line would meet Oregon's 6.5 mg/L numeric objective for supporting the cool water aquatic life beneficial use. 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 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 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 is highly dependent on improvements in dissolved oxygen, nutrients, and organic matter export from Upper Klamath Lake and the upstream reach from Link River Dam to J.C. Boyle Dam (particularly Keno Impoundment/Lake Ewauna).

Climate change is expected to cause a small 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 the subsection, Upper Klamath Basin, in Section 3.2.4.3.1). 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 [68–75.2 °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 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 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 the continued release of seasonally low dissolved oxygen concentrations from Iron Gate Reservoir 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. Under existing conditions, dissolved oxygen in the Klamath River exhibits seasonal low levels immediately downstream 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 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 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 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 downstream from the dam prior to 2020. 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 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 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 from the confluence with the Shasta River (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 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 from Iron Gate Dam, 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 August–September, 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 objectives under TMDL compliance conditions immediately downstream from Iron Gate Dam 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 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 Iron Gate 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. The TMDL Action Plan includes a requirement for PacifiCorp to submit a proposed Implementation Plan that 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).

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 requirements. Predicted dissolved oxygen would infrequently meet the Hoopa Valley Tribe numeric dissolved oxygen objective of 8 mg/L (see Table 3.2-6), which applies at ≈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 Klamath River, daily fluctuations in dissolved oxygen during July–October would occur due to colonization of periphyton mats in the river and the associated 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 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, 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 these changes is unknown.

Existing seasonal dissolved oxygen levels immediately downstream 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.

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, 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. 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 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 line in the Hydroelectric Reach, would meet water quality objectives for Oregon. Similarly, in California from the 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.

<u>Lower Klamath Basin</u>

Continued impoundment of water at the Four Facilities could result in long-term seasonal and daily variability in pH in the Klamath River downstream from Iron Gate Dam. Under existing conditions, pH during late-summer and early-fall months (August–September) in the Klamath River downstream 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 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 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 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 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 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.

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 3.2.3.7). 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, and which could affect nutrients, are ongoing in the Upper Klamath Basin (see

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 Upper Klamath Lake, Link River, and the Keno Impoundment/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.

<u>Lower Klamath Basin</u>

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., microcystin) transported into the Lower Klamath River and likely the Klamath Estuary and the marine nearshore environment. Under existing conditions, chlorophyll-*a* concentrations during summer through fall in the Klamath River downstream from Iron Gate Dam can be greater than those in the river directly upstream of Copco 1 Reservoir due to in-reservoir algal blooms that are transported into the lower river (see Appendix C, Section C.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. The CUL beneficial use is applicable in the Klamath River from State line to the Klamath River Estuary (see Table 3.2-2). 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 (see also Section 3.12.3). 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.

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). 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 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.

Inorganic and Organic Contaminants

<u>Upper Klamath Basin</u>

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 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), 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). Similarly, based on comparison to appropriate human health sediment screening 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 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 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 cause minor or limited adverse effects (i.e., toxicity or bioaccumulation) to freshwater aquatic species (Figure 3.2-2).

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 Reach. Continued impoundment of water at the Four Facilities 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	● (green)	● (blue)	--	--
Pathway 2	Long-term exposure to exposed reservoir terrace and or river bank deposits	--	--	● (black) (1)	● (blue) (2)
Pathway 3	Long-term exposure to new river channels and river bed deposits	● (blue)	--	--	● (blue)
Pathway 4	Long-term exposure to marine / near shore deposits	--	● (blue)	--	--
Pathway 5	Long-term exposure to reservoir sediments	● (green)	--	--	● (green)

● (black)	No adverse effects based on lines of evidence
● (blue)	One or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence
● (green)	One or more chemicals present at levels with potential to cause minor or limited adverse effects based on the lines of evidence
● (red)	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 310 and 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 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 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 3.2.3.8]) and mercury in fish residing in the lacustrine environment of the Keno Impoundment/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 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 methylmercury released from bottom waters. Bioaccumulation of algal toxins (i.e., microcystin) has been documented in fish and mussel tissue in the Klamath River downstream 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 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 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.

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 overall water temperatures and diel water temperature variation in the J.C. Boyle Bypass and 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 Bypass Reach immediately downstream from J.C. Boyle Dam would be similar to those under the No Action/No Project Alternative, but there would be relatively *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 diel water temperature variation immediately downstream from the dam under existing conditions (NCRWQCB 2010a). Greater diel variation would also occur further downstream in the J.C. Boyle Bypass Reach because it would no longer be dominated by cold groundwater inputs at a relatively constant temperature of 11–12 ^{o}C (Kirk et al. 2010, data from electronic appendices of Asarian and Kann 2006b). Water temperatures in this short river reach (i.e., downstream from the cold springs) would increase during summer months due to the elimination of bypass operations and associated increase in streamflows; however, 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 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 model results indicate that water temperatures under the Proposed Action would exhibit slightly lower daily maximum values (0.0–2 °C [0–3.6 °F]) as compared to those predicted under the No Action/No Project and would exhibit *lower* 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 2006b). At these locations the relative difference in diel water temperature variation between the Proposed Action and the No Action/No Project Alternative is due to the elimination of peaking operations and the associated large artificial temperature swings. Overall, the TMDL model results indicate that June through October riverine water temperatures from J.C. Boyle Reservoir to the Oregon-California State line would meet the Oregon narrative natural conditions criterion that supersedes the numeric objective (i.e., 20 °C [68 °F], see Table 3.2-3) for support of coolwater habitat.

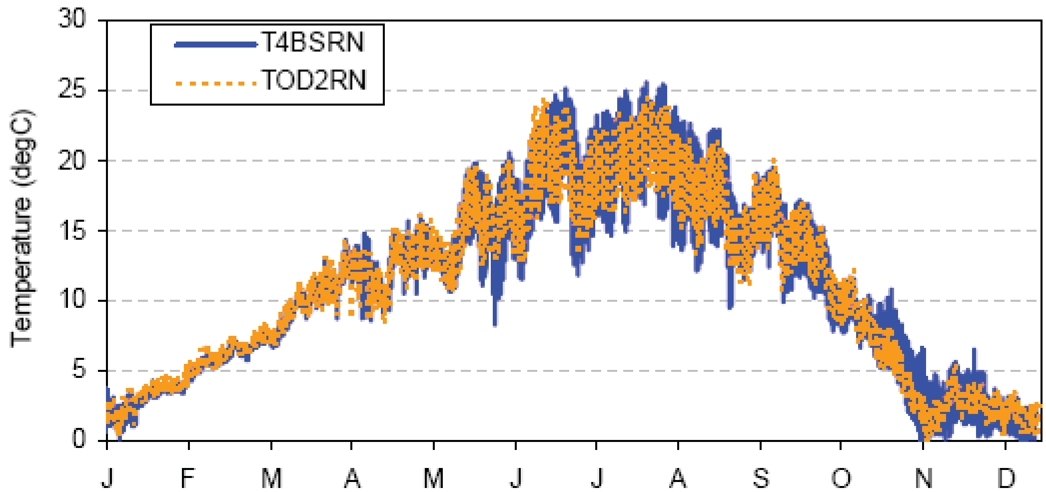

Figure 3.2-3. Predicted Water Temperature at the California-Oregon State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

Under the *Proposed Action*, the 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, returning the river to a more natural thermal regime. Removal of the Project reservoirs would 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), 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.

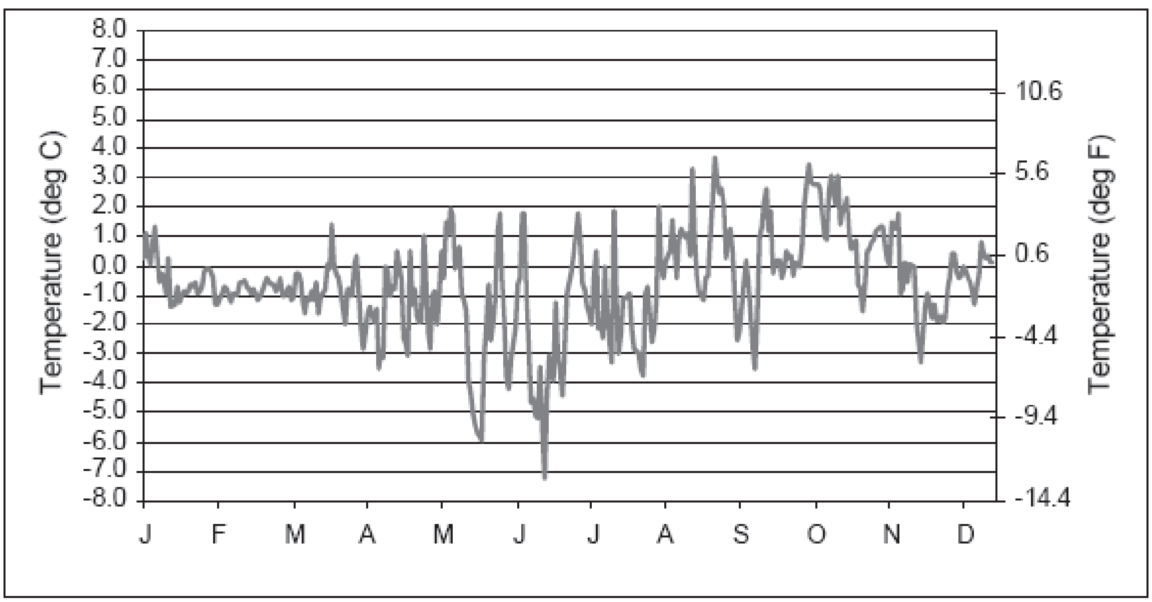

Figure 3.2-4. Estimated Changes in Daily Maximum Klamath River Water Temperatures at ≈RM 198 due to the Presence of Copco 1 and 2 Reservoirs for the 2000 Calendar Year. Positive Values Represent an Increase above Modeled Natural Conditions. Source: NCRWQCB 2010a.

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 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, 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 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 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 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 diel temperature variation in the reservoir reaches and the riverine reaches immediately downstream from Iron Gate Reservoir (RM 190.1; see Figure 3.2-5) (Deas and Orlob 1999, PacifiCorp 2005). As with the seasonal temperature effect, the dampening influence on diel temperature variation is 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).

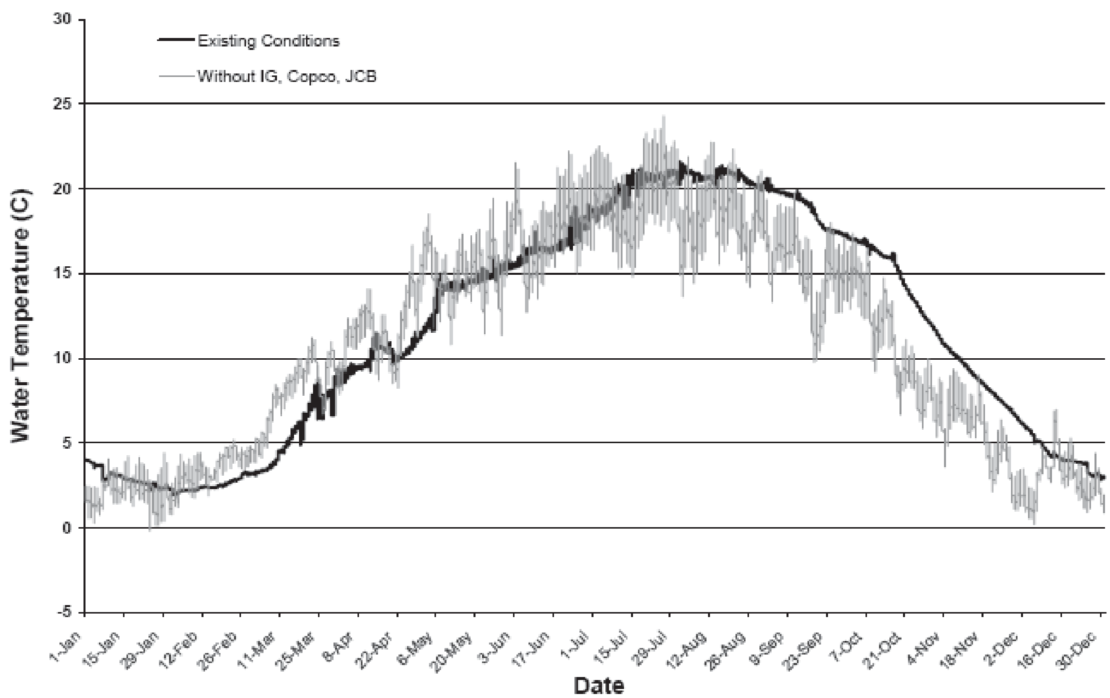

Figure 3.2-5. Simulated Hourly Water Temperature Downstream from Iron Gate Dam (RM 190.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005.

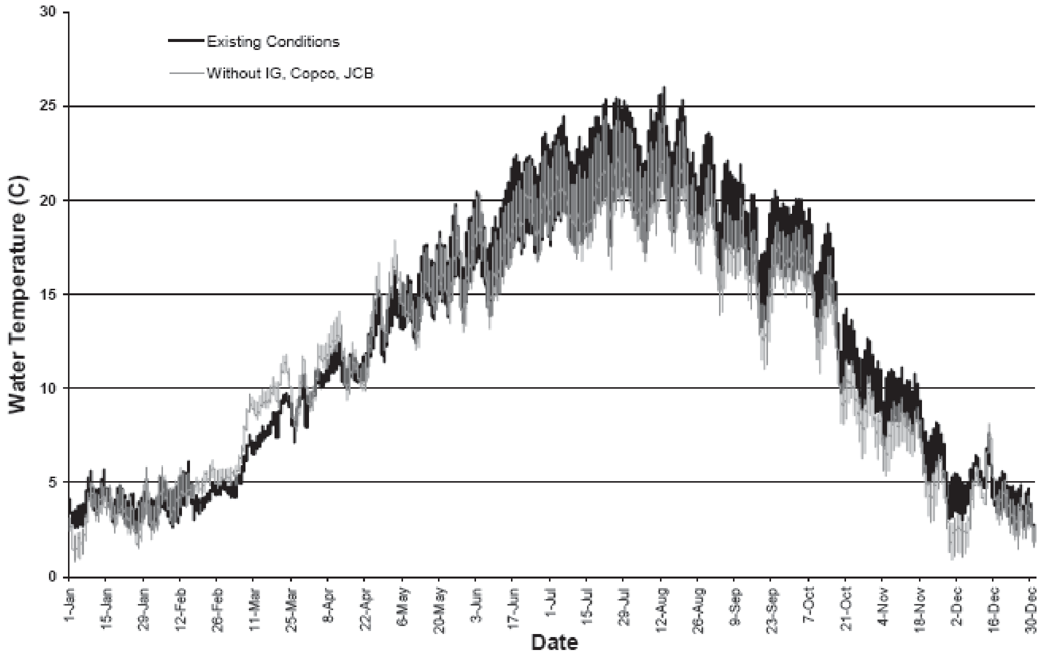

Figure 3.2-6. Simulated Hourly Water Temperature Immediately Upstream of the Scott River Confluence (RM 143.9) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005.

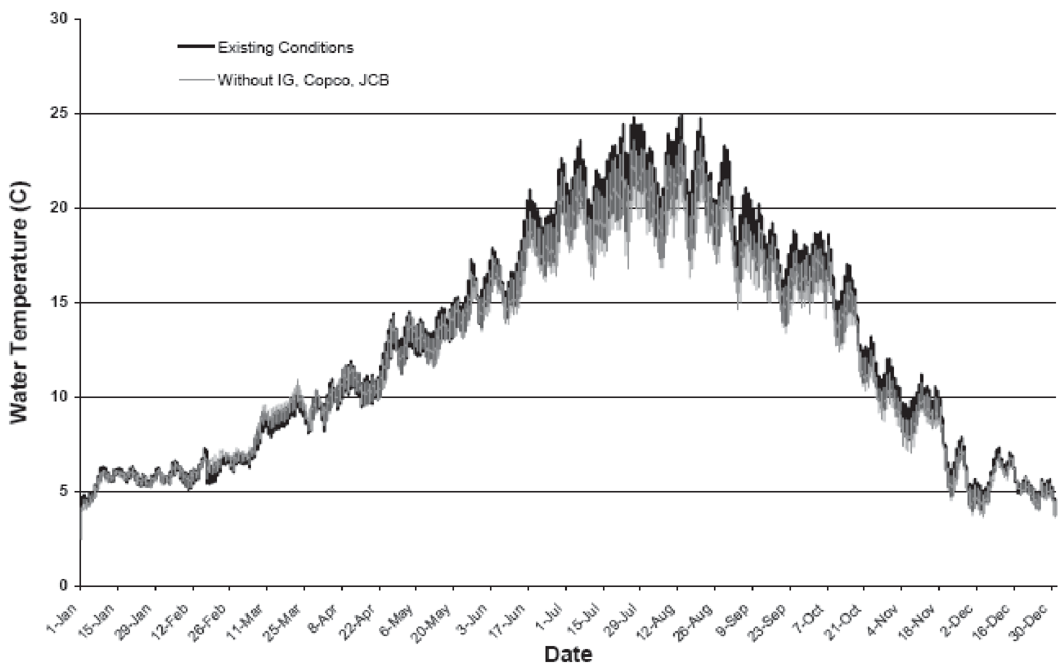

Figure 3.2-7. Simulated Hourly Water Temperature Downstream from the Salmon River Confluence (≈RM 66) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco 1, Copco 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005.

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 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 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) diel variation in ambient air temperatures. As with KRWQM, these impacts of removal of the Four Facilities would decrease in magnitude with distance downstream from Iron Gate Dam, and they would not be evident 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 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 1–2.3 °C (1.8–4.1 °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 0.05 °C (0.09 °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 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 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 from the dam. Just downstream from Iron Gate Dam, water temperatures under the Proposed Action including climate change would average 2 °C greater in May than those under the No Action/No Project Alternative, while during October water temperatures would average 4^{o}C cooler. At the confluence with the Scott River, the differences would be diminished, but there would still be a slight warming (<1 °C) in the spring and cooling (1–2 °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 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 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 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 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*.**

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 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 Klamath River indicate high short- term loads immediately downstream from Iron Gate Dam under the Proposed Action (Reclamation 2012, Stillwater Sciences 2008). Modeled SSCs[8] downstream 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 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 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 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 Hydroelectric Reach downstream from J.C. Boyle Dam would be a significant impact.**

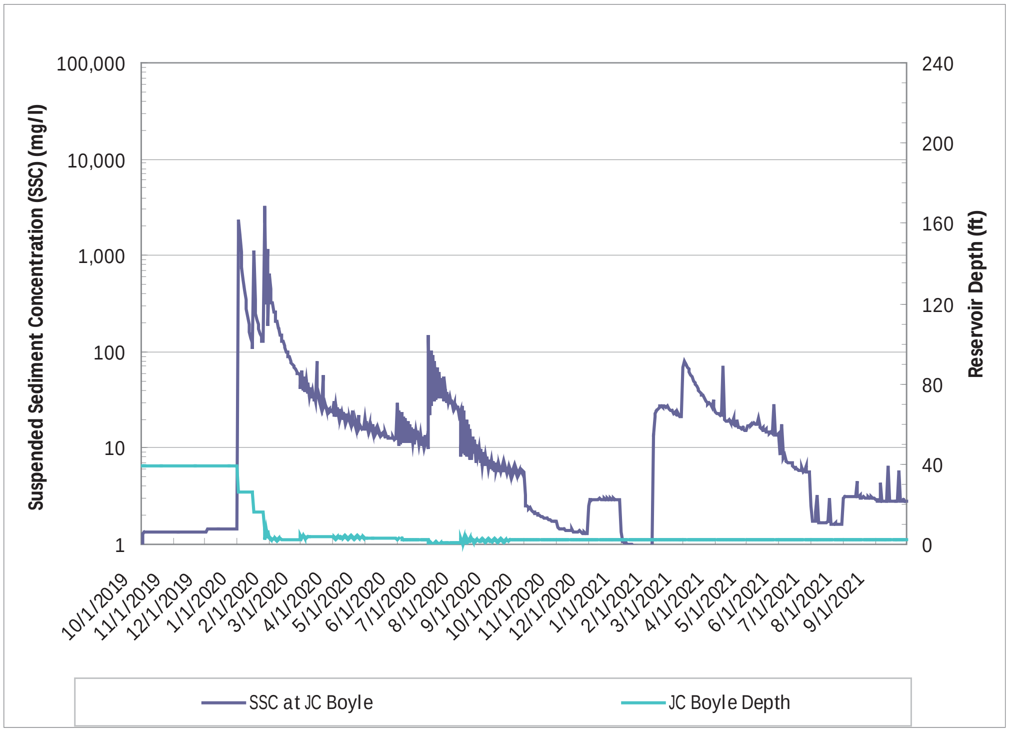

Figure 3.2-8. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Dry Hydrology (WY2001).

[8] 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).

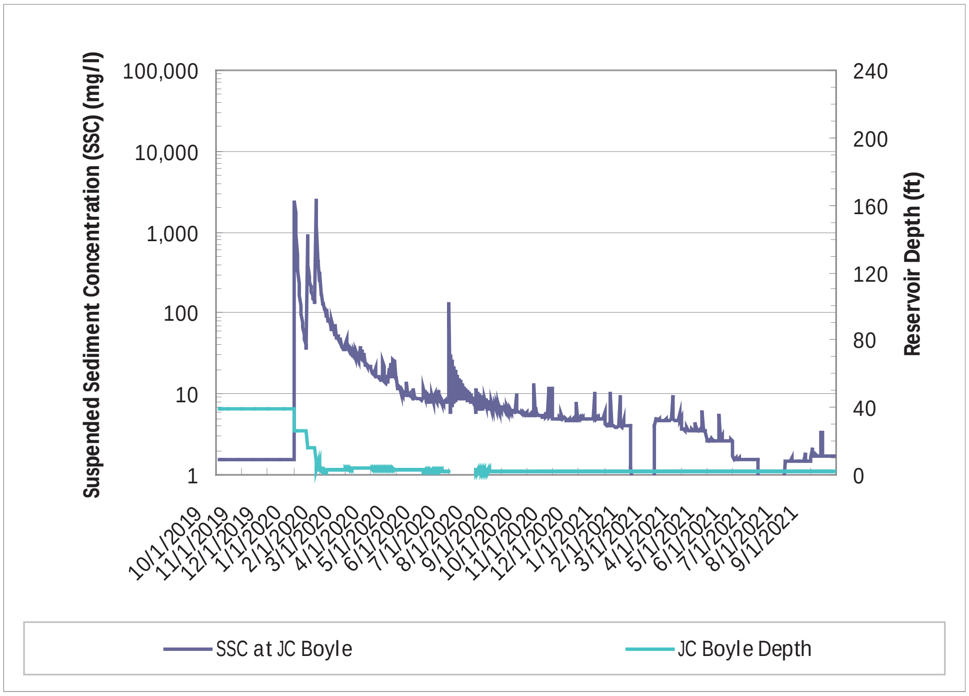

Figure 3.2-9. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Median Hydrology (WY1976).

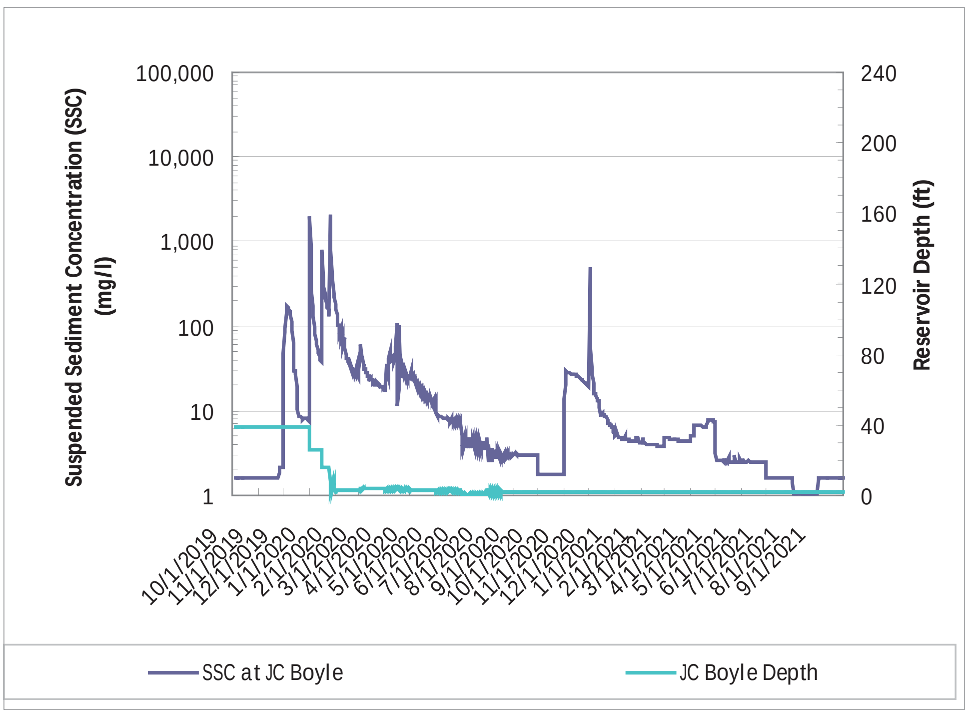

Figure 3.2-10. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Action Assuming Typical Wet Hydrology (WY1984).

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 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 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 from the enhancement sites through the implementation of BMPs for construction activities (Appendix B) (BLM 2011). 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. **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.**

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/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 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 Klamath River and the Klamath Estuary. Sediment transport modeling of the impacts of dam removal on suspended sediment in the Lower Klamath River indicates high short-term loads immediately downstream from Iron Gate Dam under the Proposed Action (Reclamation 2012, Stillwater Sciences 2008). The Proposed Action involves 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 (Reclamation 2012), which allows maximum SSCs[9] 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 three water year types (dry, median, wet) considered as part of the Secretarial Determination process. Model predictions are discussed below and summarized in Table 3.2-11.

[9] 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).

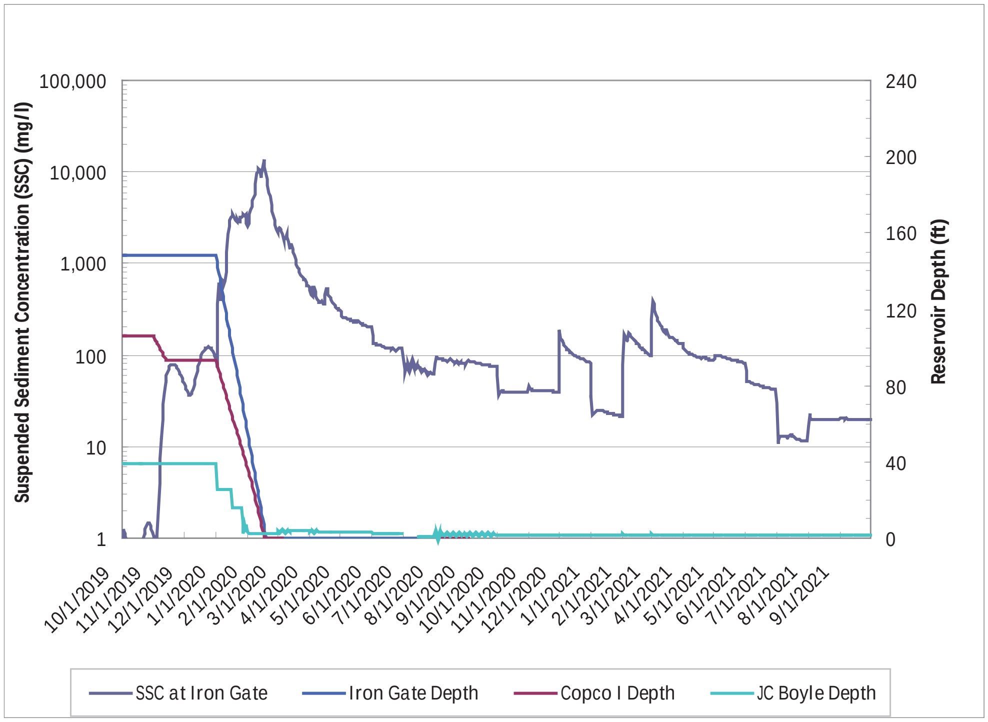

Figure 3.2-11. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Action Assuming Typical Dry Hydrology (WY2001).

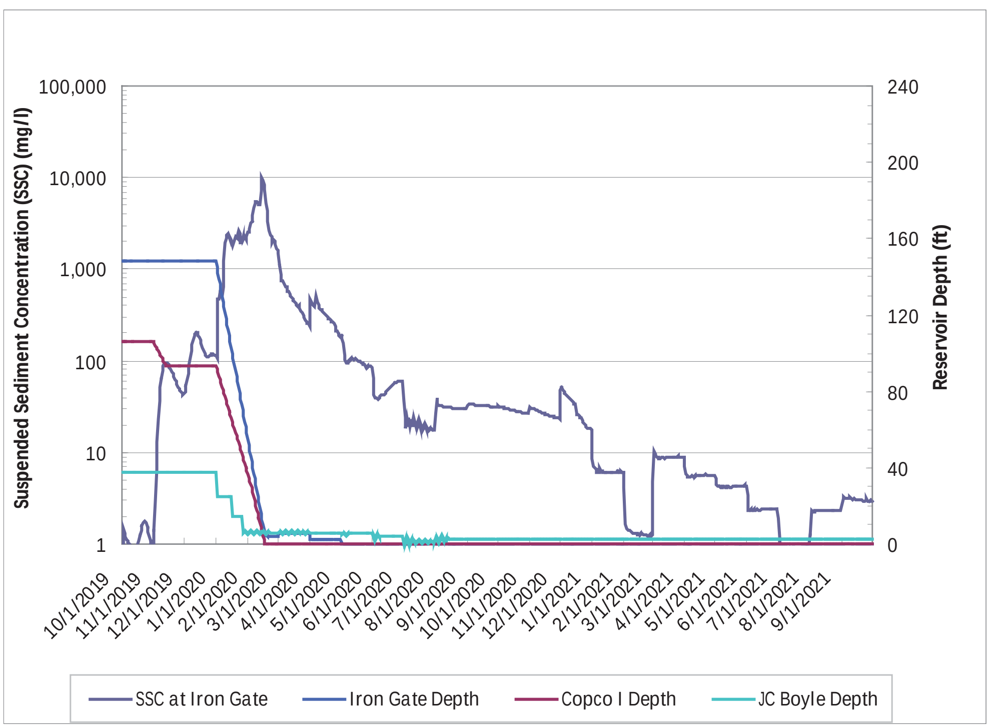

Figure 3.2-12. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Action Assuming Median Hydrology (WY1976).

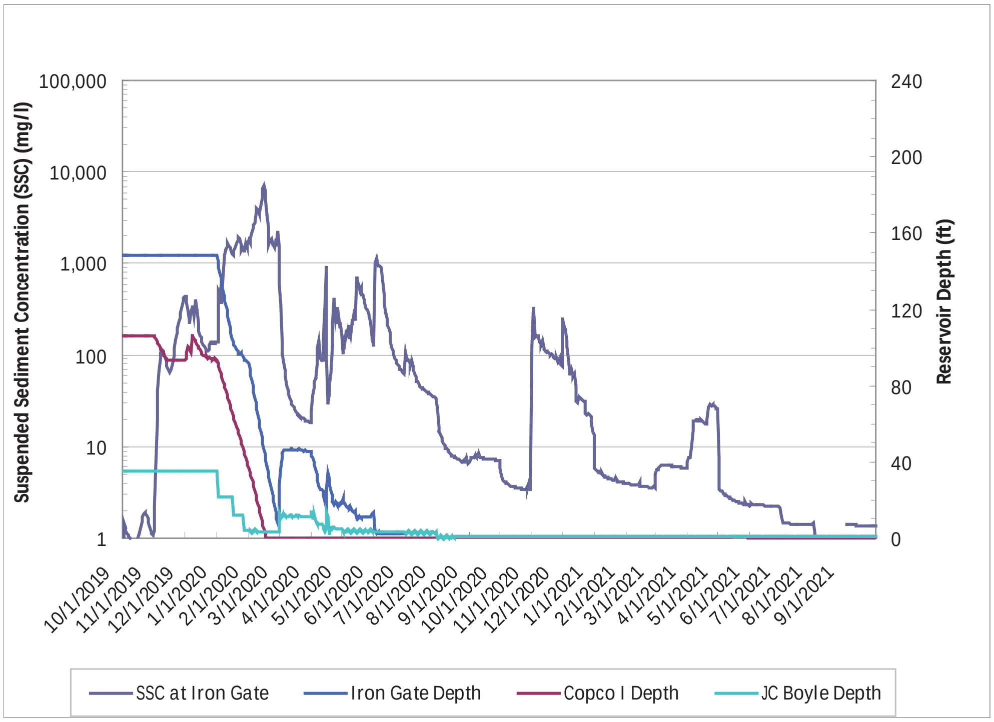

Figure 3.2-13. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Action Assuming Typical Wet Hydrology (WY1984).

Table 3.2-11. Summary of Model Predictions for SSCs in the Klamath River Downstream 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 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. 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 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 from Iron Gate Dam are predicted to be lower for the median year condition, reaching levels just under 10,000 mg/L. Relative 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 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 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 Klamath River decrease to 60–70 percent of their value at Iron Gate Dam by Seiad Valley (RM 129.4) and to 40 percent of their value at Iron Gate Dam by about RM 59, downstream from Orleans (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 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 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 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), within a factor of 2 uncertainty for the model results it can be conservatively assumed that SSCs in the 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 (Reclamation 2012). A more detailed analysis of the anticipated suspended sediment effects on key fish species in the lower river is presented in 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 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 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. Sediment transport modeling predicted that 1.2 to 2.3 million tons of sediment (5.4 to 8.6 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 (4 million tons/yr of fine sediment and 1.8 million tons/yr of sand and larger sediment). Farnsworth and Warrick (2007) estimate that the annual average silt and clay discharge is 1.2 million tons/yr. There is considerable uncertainty in the annual 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 loads in the Klamath River is large. A single 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 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.

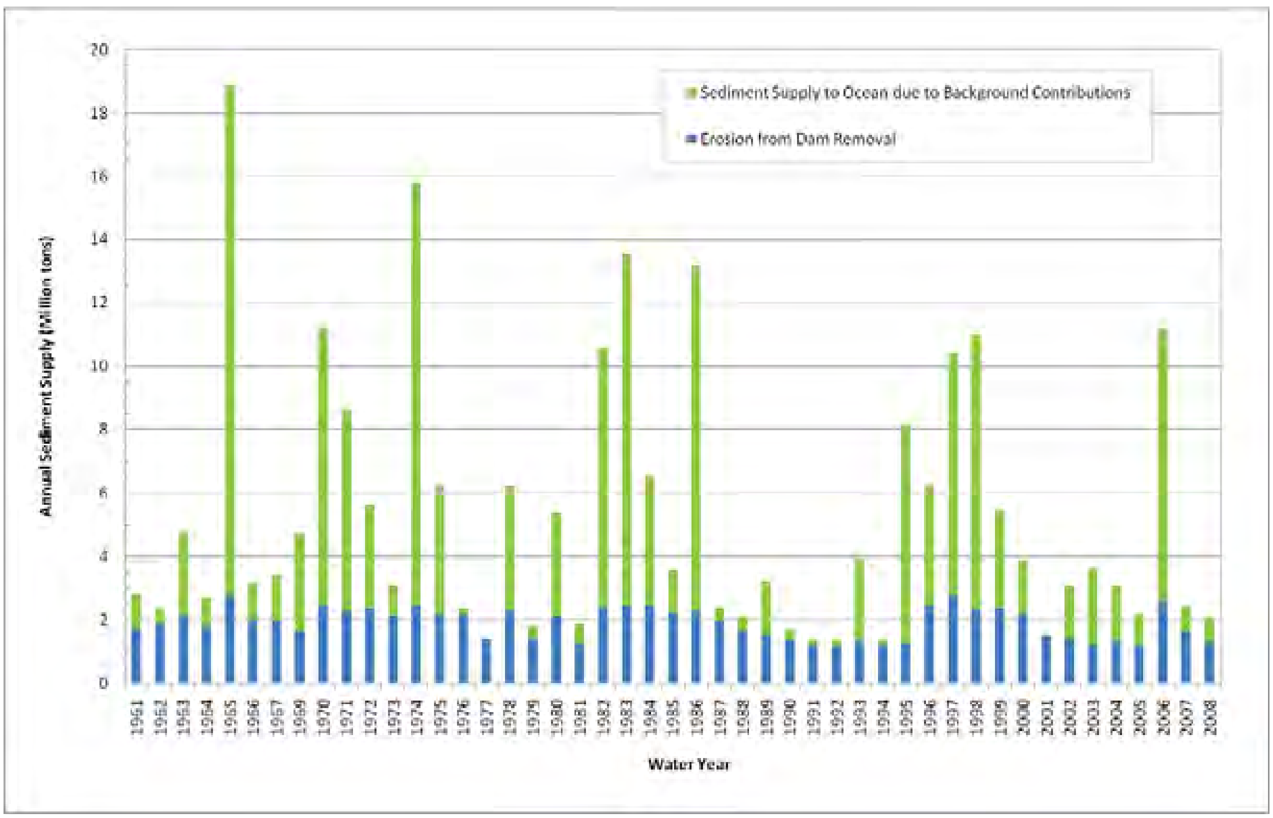

Figure 3.2-14. Annual predicted sediment delivery to the Pacific Ocean under the Proposed Action and the No Action (background conditions) by Water Year. Note: model results are only valid for the year of dam removal. No significant increase in sediment loads is predicted in years following dam removal (Source: Reclamation 2012).

After exiting the river mouth, the high SSCs (>1,000 mg/L) transported by the Lower 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.

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 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 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 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 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 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 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 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/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 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 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 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 Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

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 (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 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 from Iron Gate Dam would increase on an annual basis, the majority of the results are focused on the Klamath Basin downstream from Iron Gate Dam.

However, modeling conducted for development of the California Klamath River 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 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 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. 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 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 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 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 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 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 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 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).

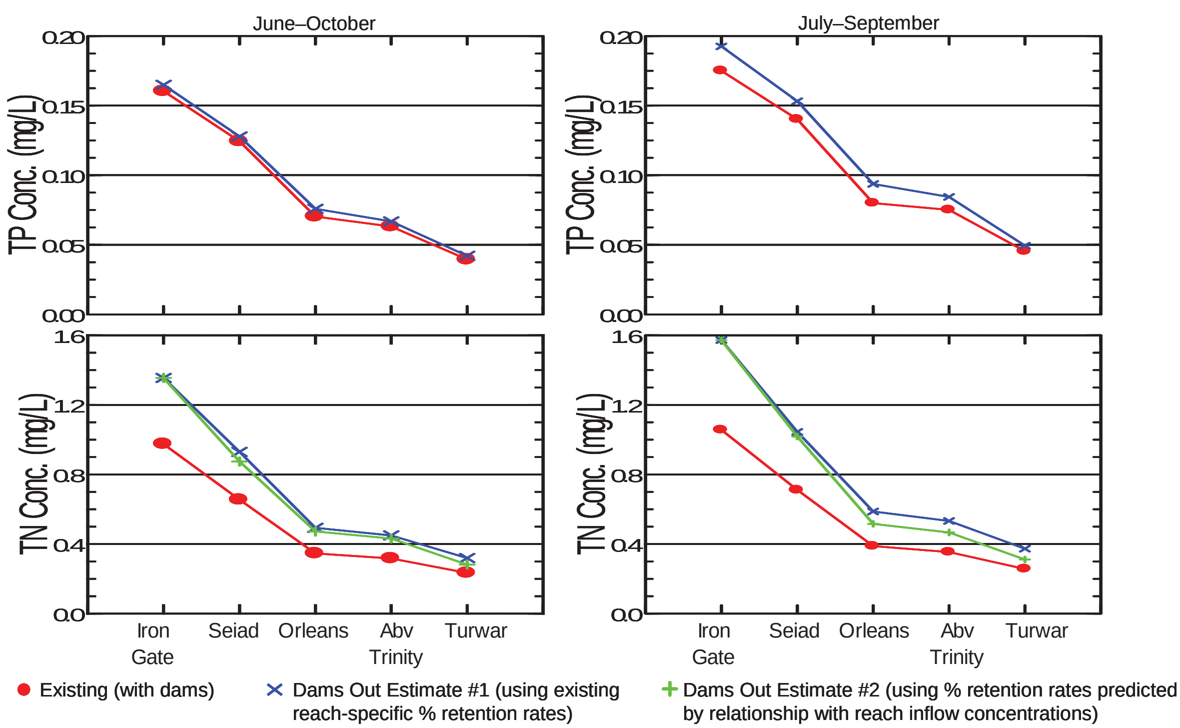

Figure 3.2-15. Comparison of TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.8) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate using 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 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 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 periphyton growth because it will be accompanied by only a relatively minor increase in TP. Existing data regarding TN:TP ratios suggest the potential for the Klamath River to be generally N-limited (TN:TP). 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 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 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 reductions in the Klamath Basin. **Under the *Proposed Action*, the long-term (2–50 years following dam removal) increase in nutrients in the Lower Klamath River and the Klamath Estuary would be a less-than-significant impact.**

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 from J.C. Boyle Reservoir. While modeled oxygen demand is not available downstream from J.C. Boyle Reservoir, model results are available downstream 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 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 from J.C. Boyle Dam would be the same as those for the Lower Klamath River. This is a conservative assumption because peak SSCs downstream 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 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 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 from J.C. Boyle Dam to the Oregon-California 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 from J.C. Boyle Dam and at the Oregon-California 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 immediately downstream from J.C. Boyle Dam during this same period would be greater under the Proposed Action (TCD2RN) than the No Action/No Project Alternative (T4BSRN) (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 oxygen production and respiratory consumption in the free-flowing river, 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).

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.

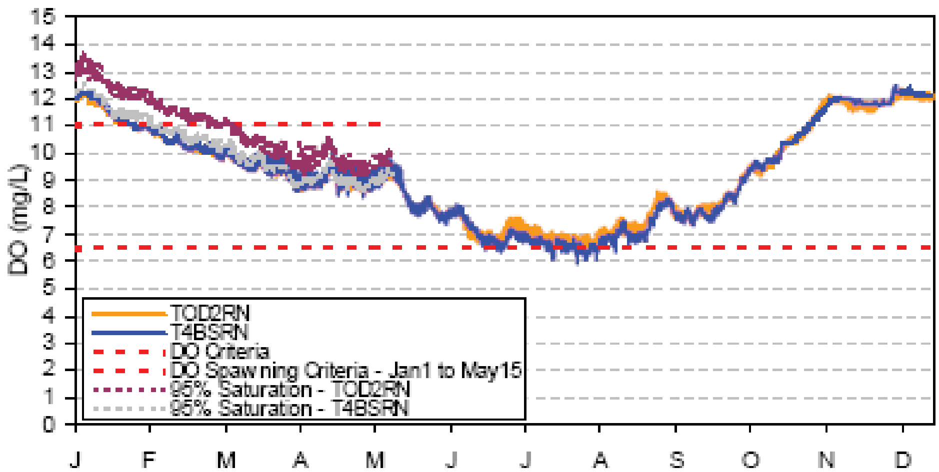

Figure 3.2-16. Predicted Dissolved Oxygen Downstream from J.C. Boyle Dam (RM 224.7 to 228.3) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

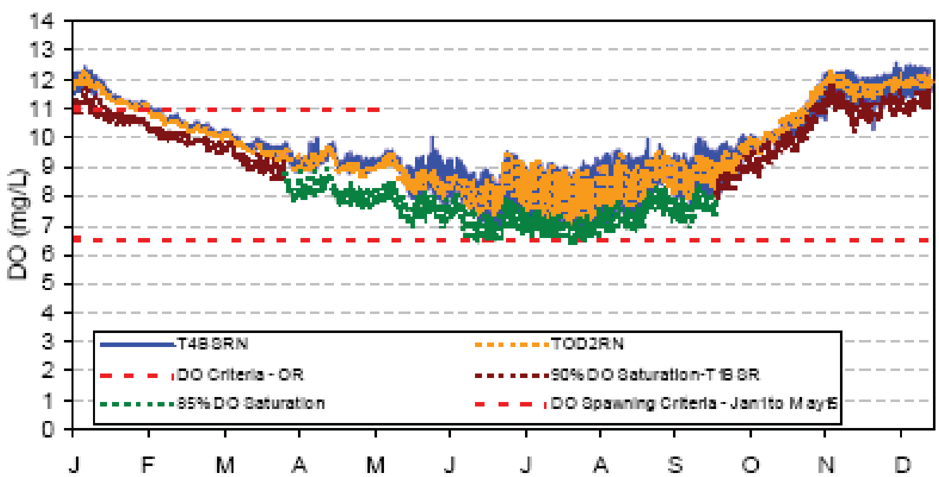

Figure 3.2-17. Predicted Dissolved Oxygen at the Oregon-California State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

Under the *Proposed Action*, 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.

<u>Lower Klamath Basin</u>

Sediment release associated with the Proposed Action could cause short-term (<2 years following dam removal) increases in oxygen demand (IOD and BOD) and reductions in dissolved oxygen 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.

Based on results from a dissolved oxygen spreadsheet model (see Section 3.2.4.1), IOD downstream from Iron Gate Dam would be 0–8.6 mg/L and BOD would be 0.3–43.8 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 from Iron Gate Dam would generally remain greater than 5 mg/L (see Table 3.2-13). 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 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

[1] Raw daily water temperature data for 2009 from 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).

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

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	NA [3]
12/1/2019	9.40	0.3	1.5	9.18	188.9	NA
1/21/2020	9.73	1.2	6.9	8.56	188.2	NA
2/15/2020	9.55	4.5	25.1	5.21	188.9	NA
3/1/2020	9.00	0.4	2.1	8.70	188.9	NA
4/15/2020	8.63	0.6	3.3	8.11	188.9	NA
Median Hydrology (WY 1976 Conditions Assumed)						
11/12/2019	7.29	0.1	0.3	7.29	190.1	NA
12/12/2019	9.40	0.1	0.7	9.34	189.5	NA
1/22/2020	9.73	1.6	9.1	8.18	188.2	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	NA
4/7/2020	8.63	0.3	1.8	8.38	189.5	NA
Typical Dry Hydrology (WY 2001 Conditions Assumed)						
11/19/2019	7.29	0.0	0.3	7.29	190.1	NA
12/23/2019	9.40	0.1	0.4	9.40	190.1	NA
1/17/2020	9.73	2.2	12.4	7.62	188.9	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	NA
4/5/2020	8.63	0.3	1.9	8.39	189.5	NA

Source: Stillwater Sciences 2011.

[1] 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. 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# (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.

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) increases in oxygen demand (IOD and BOD) and reductions in dissolved oxygen 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 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 Klamath River, particularly for the reach immediately downstream 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 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 2005). KRWQM output also predicts greater daily variations in dissolved oxygen concentrations downstream 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 from Iron Gate Dam and assumes relatively high nutrient contributions from tributaries (Asarian and Kann 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 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). 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 daily swings in 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 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 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.**

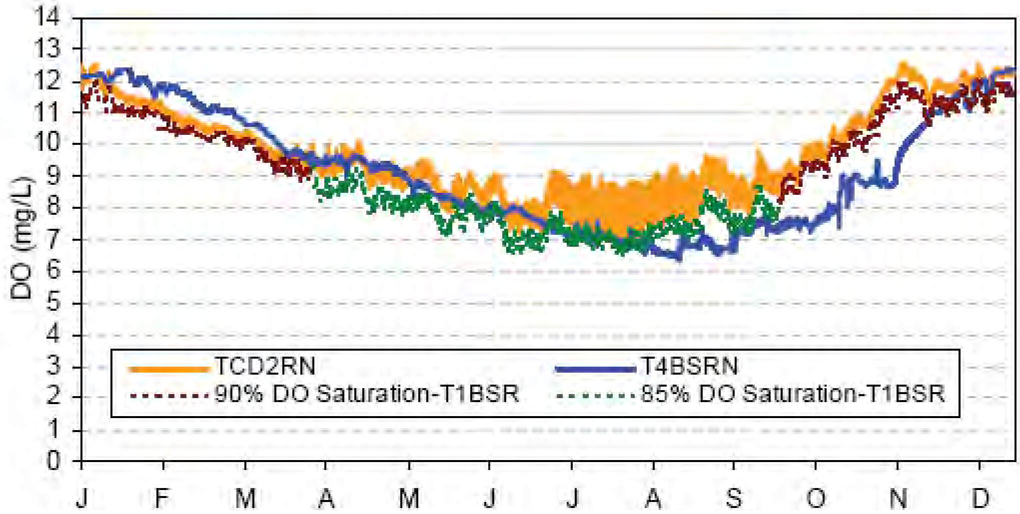

Figure 3.2-18. Predicted Dissolved Oxygen Downstream from Iron Gate Dam (RM 190.1) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

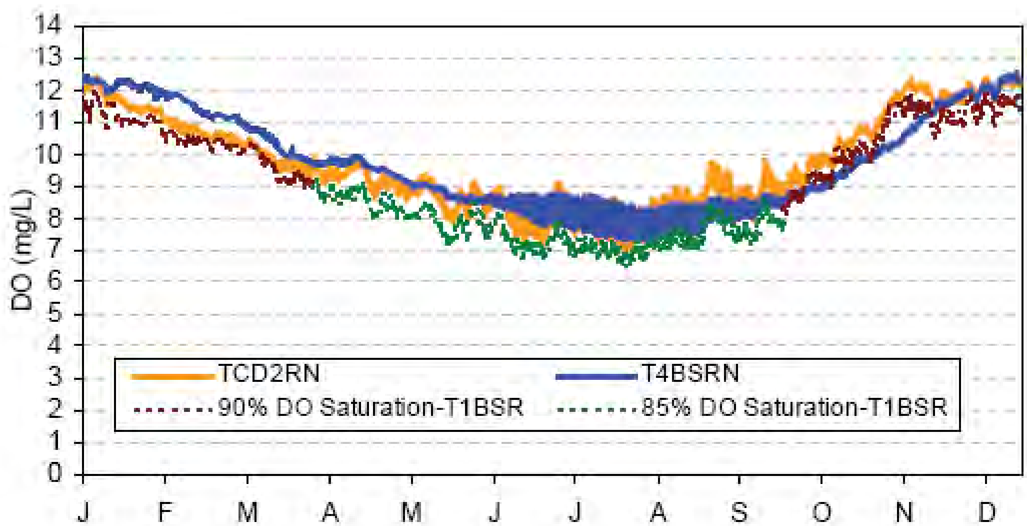

Figure 3.2-19. Predicted Dissolved Oxygen Downstream from the Mainstem Confluence with the Shasta River (RM 176.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

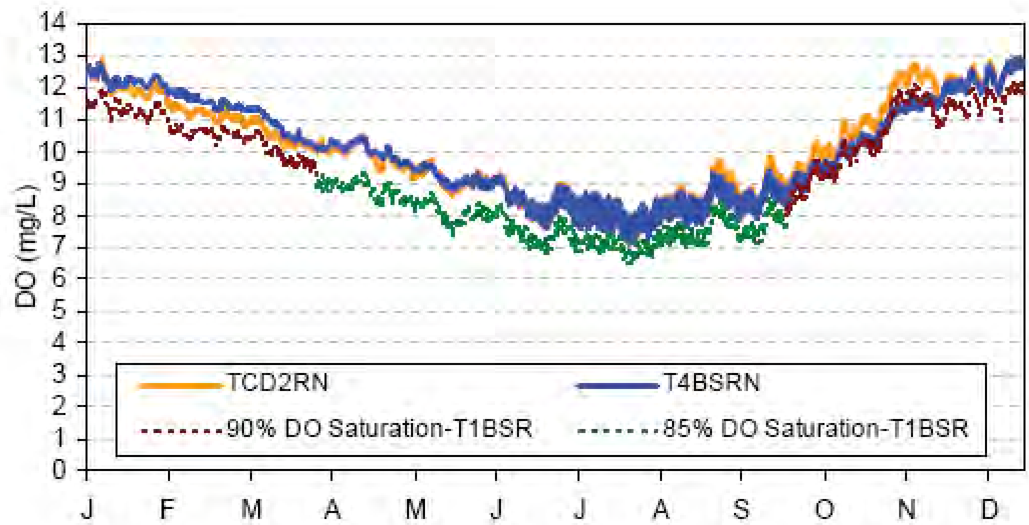

Figure 3.2-20. Predicted Dissolved Oxygen at Seiad Valley (RM 129.4) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

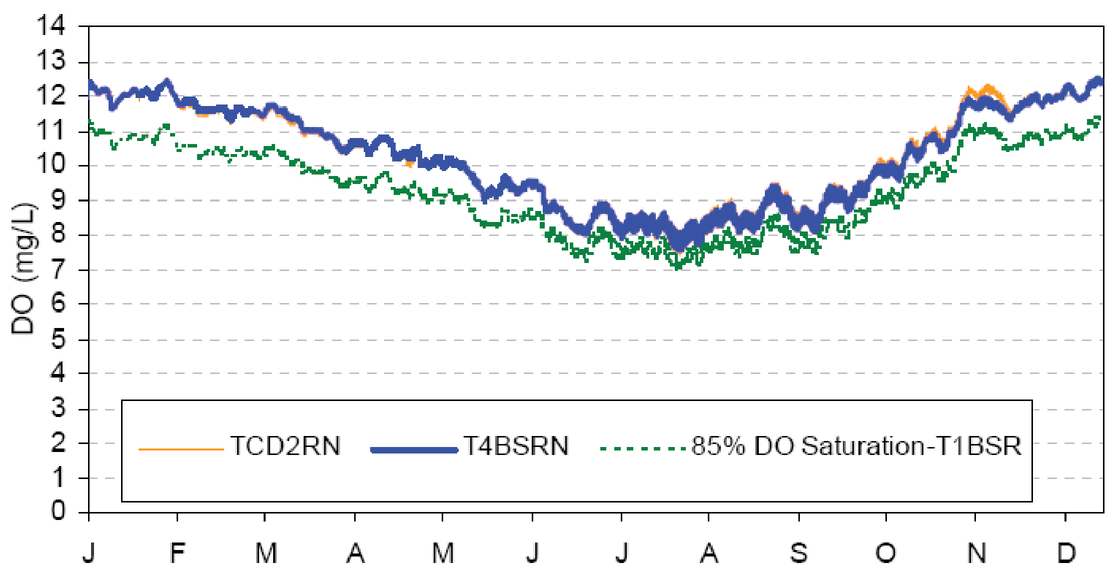

Figure 3.2-21. Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 42.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

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. 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.

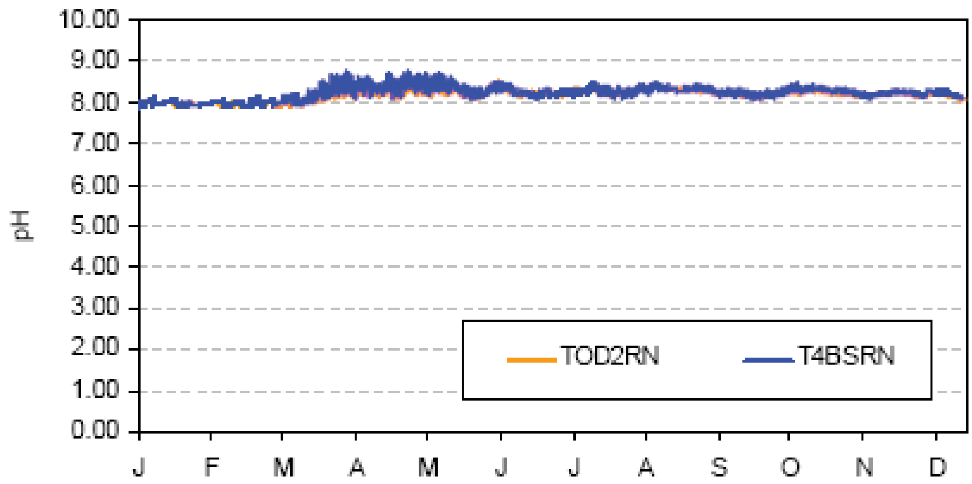

Figure 3.2-22. Predicted pH Downstream from J.C. Boyle Reservoir (RM 224.7) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

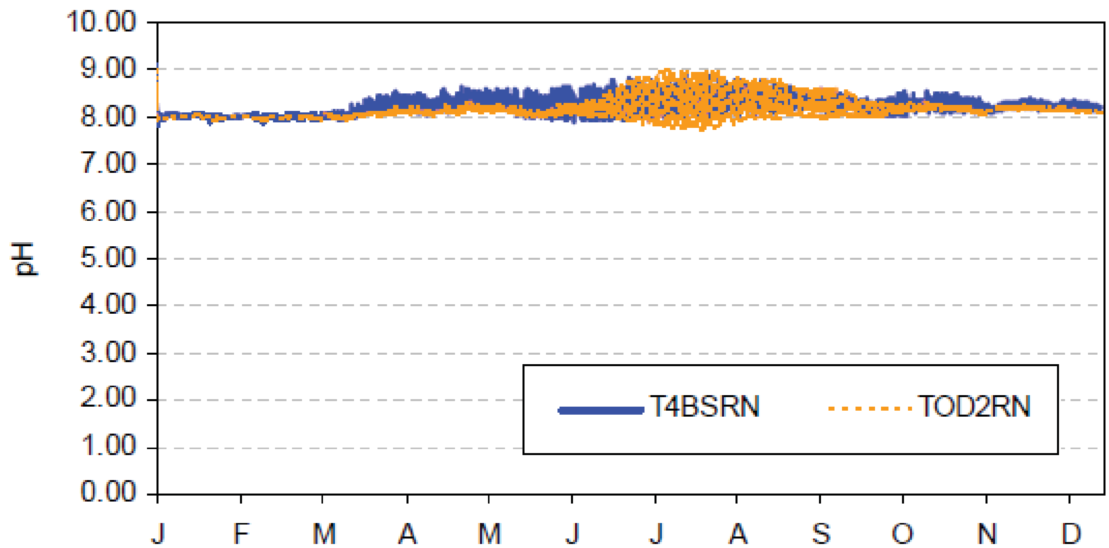

Figure 3.2-23. Predicted pH at the Oregon-California State line (RM 208.5) for the Klamath TMDL Scenarios Similar to the Proposed Action (TOD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario). Source: NCRWQCB 2010a.

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.

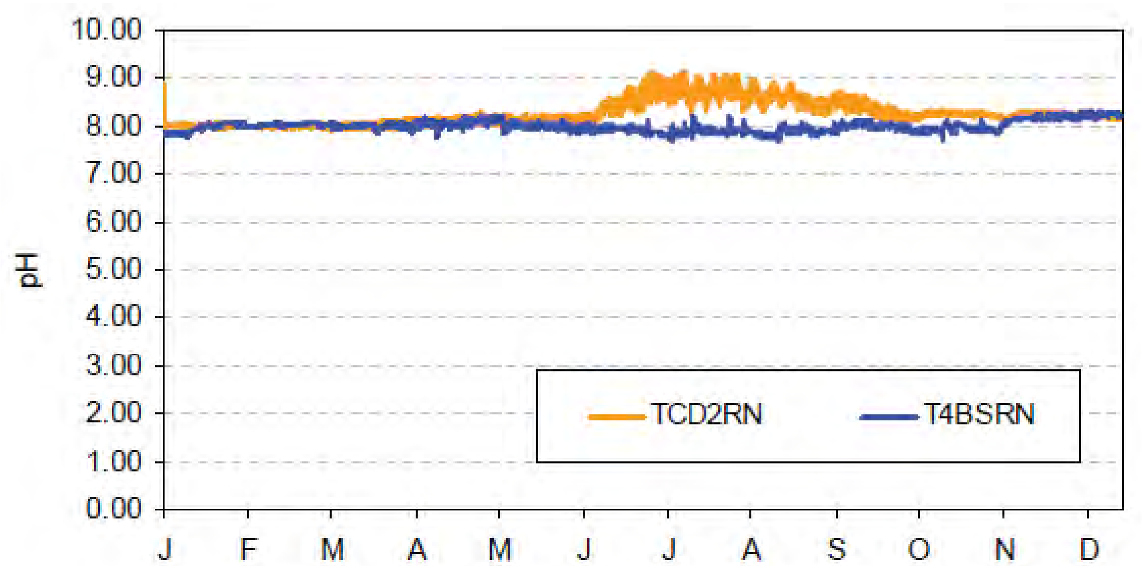

Figure 3.2-24. Predicted Klamath River pH Immediately Downstream from Iron Gate Dam for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).
Source: NCRWQCB 2010a.

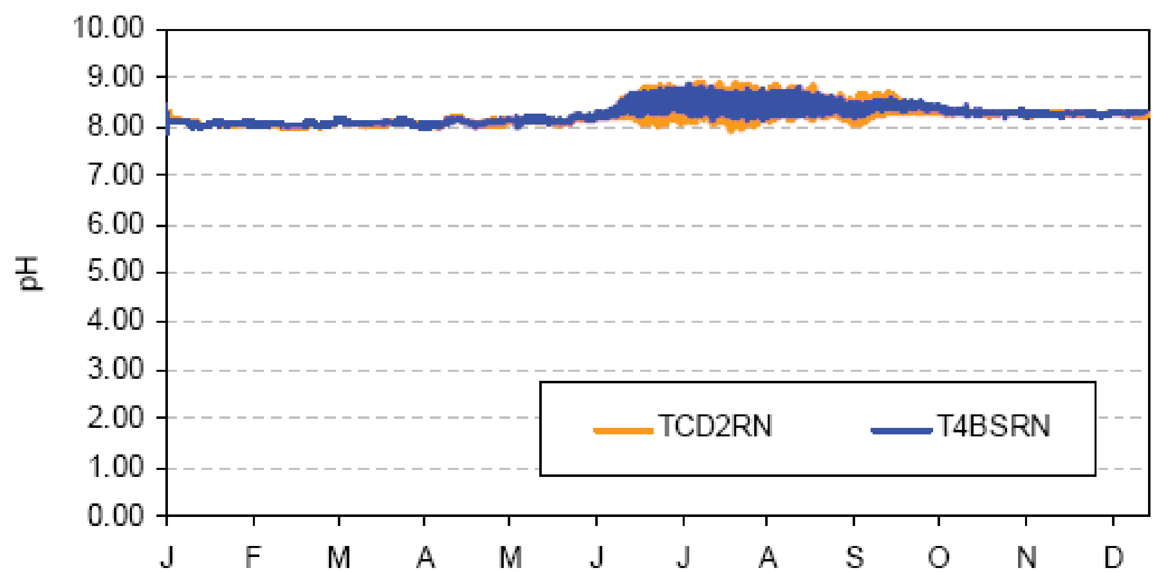

Figure 3.2.25. Predicted Klamath River pH upstream of the Scott River (RM 143.0) for the Klamath TMDL Scenarios Similar to the Proposed Action (TCD2RN Scenario) and the No Action/No Project Alternative (T4BSRN Scenario).
Source: NCRWQCB 2010a.

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.

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 chlorophyll-*a* and substantial decrease or elimination of algal toxins and 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 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 transported into the 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 from Iron Gate Dam would 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 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 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 Klamath River and the potentially the Klamath Estuary would be beneficial.

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 from J.C. Boyle Reservoir would be considerably less than those anticipated to occur downstream 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 from J.C. Boyle Dam would be the same as those for the 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 Pathway 3" in CDM [2011]). No samples exceeded the total non-carcinogenic screening levels.

Forty-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. 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 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 the range of available soil concentrations for the Klamath Basin (arsenic may be naturally elevated in the Upper Klamath Basin [see Appendix C, Section 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 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 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 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 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 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 versus 95 percent) and somewhat lower survival for the off-thalweg sample (83 percent versus 95 percent) (CDM 2011).

Although this result suggests potential for toxicity to freshwater benthic organisms downstream 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 (7.4 million yd^3 and 4.7 million yd^3, respectively; see Section 2.5.1) is considerably greater than that of J.C. Boyle Reservoir (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 (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 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 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 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 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 Klamath River (i.e., through ingestion of contaminants from drinking water withdrawals or dermal contact with water) is likely 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) cannot 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 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 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 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 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.**

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, 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.**

East and Westside Facilities – Programmatic Measure

Decommissioning the East and Westside Facilities could result in slight decreases in ammonia levels in the Keno Impoundment/Lake Ewauna). Decommissioning of the East and 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 into Link River. Redirection of water flows under the Proposed Action could potentially result in additional nitrification of Upper Klamath Lake 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.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Construction of the City of 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 City of 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). 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 City 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 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.

<u>Phase I Fisheries Restoration Plan</u>

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 and 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 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 (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. Fallowing of crop land would decrease fertilizer (nutrient) and pesticide/herbicide (inorganic and organic contaminants) inputs.

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, 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 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 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 in the 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 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 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 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 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 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 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 and Lower Klamath Basin as the Proposed Action. **Long-term increases in suspended sediments and nutrients in the Hydroelectric Reach, the Lower**

Klamath River, the Klamath Estuary, and the marine nearshore environment as 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 diel temperature variation in the J.C. Boyle 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 diel temperature variation in the J.C. Boyle Peaking Reach would be beneficial. Downstream from Copco 1 and Iron Gate Dams, the long-term increase in spring water temperatures would be less than significant, and the decrease in late summer/fall water temperatures would be beneficial for the Hydroelectric Reach and the 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 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 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 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. The summertime increases in pH in the Lower Klamath River from Iron Gate Dam to the Scott River would be less than significant. There would be no change from existing conditions on pH for Klamath River just downstream from Seiad Valley, the Klamath Estuary, and the marine nearshore environment. The long-term decrease in chlorophyll-*a* and substantial decrease or elimination of algal toxins and in the Hydroelectric Reach and subsequent transport into the Lower Klamath River and the Klamath Estuary would be beneficial.**
- **Long-term effects on inorganic and organic contaminants in the Hydroelectric Reach, the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.**

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 Reclamation. This transfer would not result in the generation of new impacts on water quality compared with existing facility operations. Following transfer of title, 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.**

East and Westside Facilities – Programmatic Measure

Decommissioning the East and Westside Facilities could result in slight decreases in ammonia levels in the Keno Impoundment/Lake Ewauna. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would have the same effect as described under the Proposed Action. **Therefore, implementation of the East and Westside Facility Decommissioning action would be potentially beneficial due to slight decreases in ammonia levels.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Construction activities for the City of 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 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 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 increases in SSCs and potential inorganic and organic contaminants in the Hydroelectric Reach, the 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 overall higher flow releases would result in more reservoir water entering the 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; 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 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 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.

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 in the J.C. Boyle Bypass Reach, due to the higher overall flow releases would be a less than significant impact. 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 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 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 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).**

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 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.

Water Temperature

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 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 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.

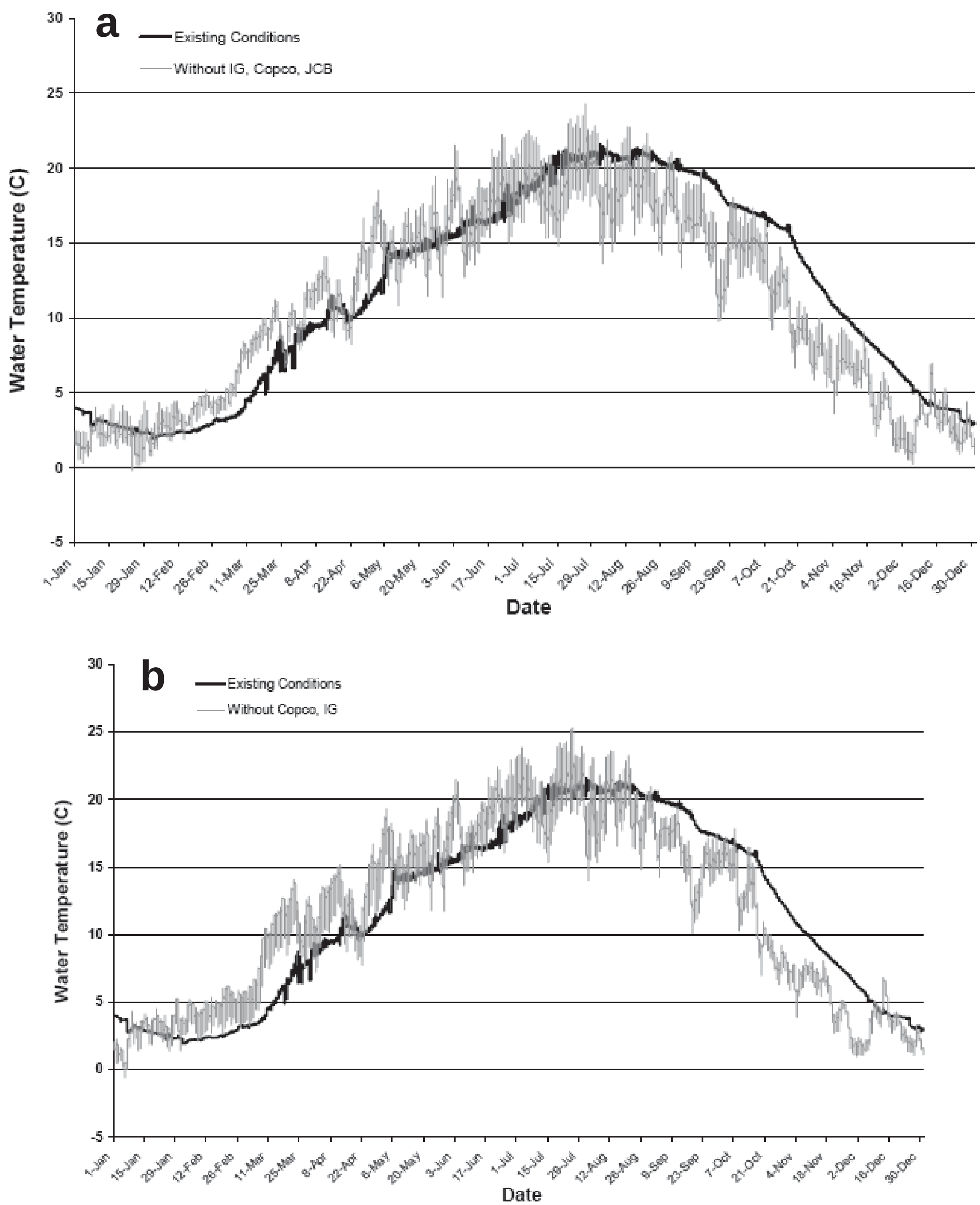

Figure 3.2-26. Simulated Hourly Water Temperature Downstream from Iron Gate Dam (RM 190.1) Based on Year 2004 for Current Conditions Compared to Hypothetical Conditions: (a) without Iron Gate (IG), Copco 1 and 2, and J.C. Boyle (JCB) Dams and (b) without Iron Gate (IG) and Copco 1 and 2 Dams. Source: 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 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*, 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 in the 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 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 in the 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 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 Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

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 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*, 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.

<u>Lower Klamath Basin</u>

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 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 Klamath River, the Klamath Estuary, and the marine nearshore environment would be a less-than-significant impact.

Dissolved Oxygen

<u>Upper Klamath Basin</u>

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 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*, 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 from the dam (see Figure 3.2-22.) having this dam in place would not affect pH downstream 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 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) summertime increases in pH would be less than significant for the 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 from Seiad Valley, the Klamath Estuary, and the marine nearshore environment.

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 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 ODEQ 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 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.

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 City of 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 (<2 years) and Long-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				
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	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 overall water temperatures and diel temperature variation in the J.C. Boyle Bypass and Peaking Reaches.	2, 3, 4, 5	LTS for J.C. Boyle Bypass Reach in summer/fall B for J.C. Boyle Peaking Reach in summer/fall	None	LTS for J.C. Boyle Bypass Reach in summer/fall B for J.C. Boyle 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 from Copco 1 Reservoir.	2, 3, 5	LTS for springtime B for late summer/fall	None	LTS for springtime B for late summer/fall

Table 3.2-14. Summary of Short-term (<2 years) and Long-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 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, 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 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 from Salmon River, the Klamath Estuary, and marine near shore environment

Table 3.2-14. Summary of Short-term (<2 years) and Long-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				
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 from J.C. Boyle Dam.	2, 3, 5	S	None	S
Construction/deconstruction activities could cause short-term increases in suspended material in the Hydroelectric Reach due to stormwater runoff from	2, 3, 4, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-term (<2 years) and Long-term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
construction/deconstruction areas.				
Removal of Iron Gate Dam would require relocation of the City of 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 Klamath River and the Klamath Estuary.	2, 3, 5	S	None	S

Table 3.2-14. Summary of Short-term (<2 years) and Long-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 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 from Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Construction/deconstruction activities could cause short-term increases in suspended material in the 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 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 suspended material in the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-term (<2 years) and Long-term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
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 Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS
Nutrients				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could result in long-term interception and retention of TN and TP in the Hydroelectric Reach on an annual basis but release 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				
Continued impoundment of water in the reservoirs could cause long-term interception and retention of TP and TN on an annual basis and release (export) of TP on a seasonal basis	1, 4	NCFEC	None	NCFEC

Table 3.2-14. Summary of Short-term (<2 years) and Long-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 Klamath River could cause short-term increases in sediment-associated nutrients in the river, 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 Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	LTS	None	LTS
Dissolved Oxygen				
Upper Klamath Basin				
Continued impoundment of water in the reservoirs could cause long-term[1] 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.	1, 4	NCFEC	None	NCFEC
Draining the reservoirs and release of sediment could cause short-term[2] increases in oxygen demand (Immediate Oxygen Demand [IOD] and Biological Oxygen Demand [BOD]) and reductions in dissolved oxygen in the Hydroelectric Reach downstream from J.C. Boyle Reservoir.	2, 3, 5	S	None	S
Dam removal and conversion of reservoir areas to 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.	2, 3	B	None	B

Table 3.2-14. Summary of Short-term (<2 years) and Long-term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
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
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.	1, 4	NCFEC	None	NCFEC
Dam removal and sediment release could cause short-term increases in oxygen demand (IOD and BOD) and reductions in dissolved oxygen in the Lower Klamath River, the Klamath Estuary, and the marine nearshore environment.	2, 3, 5	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 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
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.	1, 4	NCFEC	None	NCFEC

Table 3.2-14. Summary of Short-term (<2 years) and Long-term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
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 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.	2, 3, 5	B	None	B
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 Klamath River immediately downstream 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 long-term summertime increases in pH in the Lower Klamath River immediately downstream from Iron Gate Dam.	2, 3, 5	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	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

Table 3.2-14. Summary of Short-term (<2 years) and Long-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 from Iron Gate Dam to the Klamath Estuary, and 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 Klamath River and the Klamath Estuary.	2, 3, 5	B	None	B

Table 3.2-14. Summary of Short-term (<2 years) and Long-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 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 (<2 years) and Long-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				
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 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 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 operations would affect water quality during construction.	4, 5	LTS	None	LTS

Table 3.2-14. Summary of Short-term (<2 years) and Long-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 result in slight decreases in ammonia levels in the Keno Impoundment/Lake Ewauna.	2, 3	B	None	B
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 sediment and nutrient inputs to Upper Klamath Lake.	2, 3	LTS (short term) B (long term)	None	LTS (short term) B (long term)

Table 3.2-14. Summary of Short-term (<2 years) and Long-term (2–50 years) Water Quality Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
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

[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

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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). The five study reaches 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 (Sprague, Wood, and Williamson 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, 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. Copco 2 Bypass Channel
3. Lower Klamath River: downstream 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

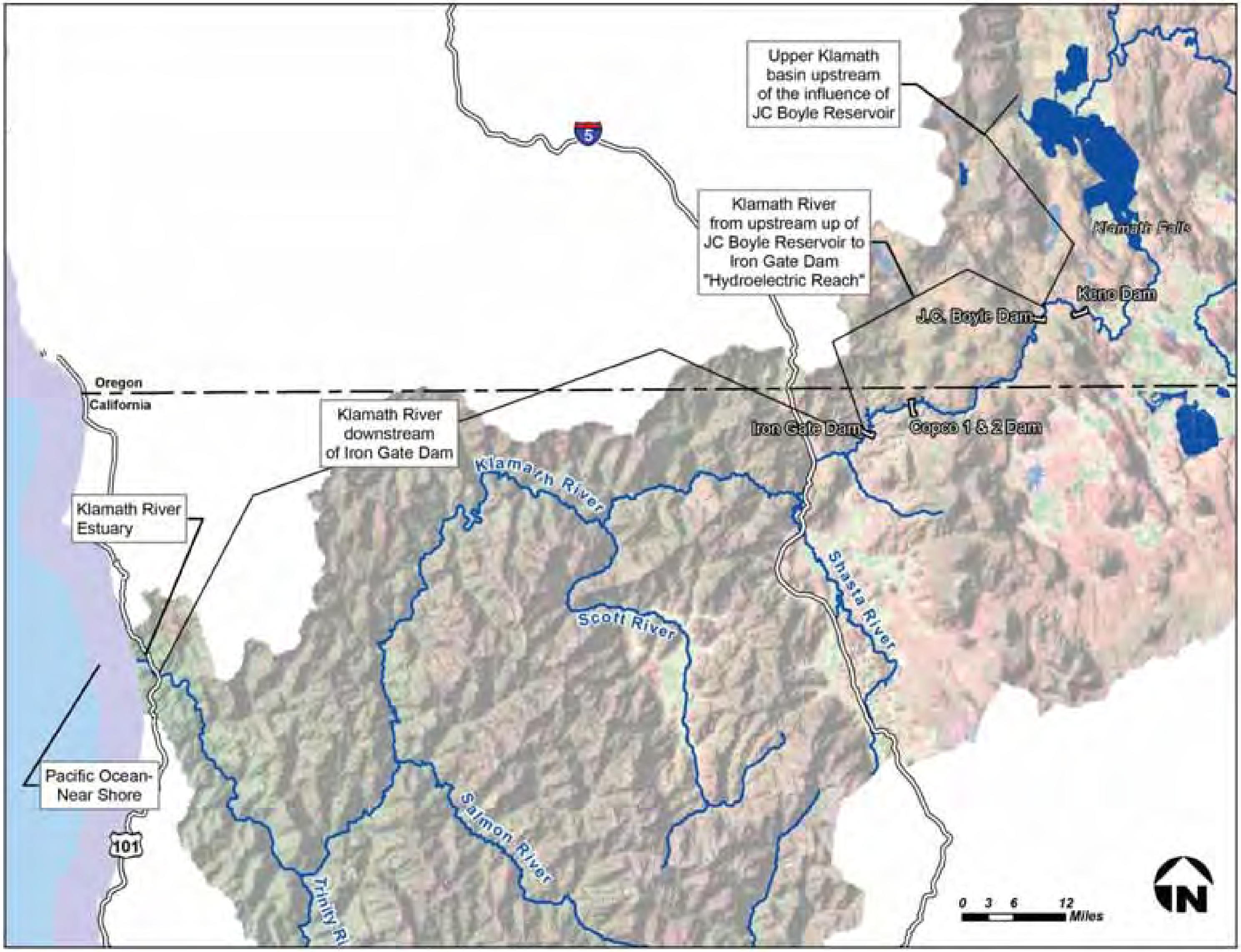

Figure 3.3-1. Five Study Reaches within the Area of Analysis for the Aquatic Resources Analysis.

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 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 and 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 including beneficial uses for 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, *Habitat 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 Basin 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 Federal or State 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 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. Anadromous fish numbers were already in decline in the early 1900s (Snyder 1931)
[2] Includes Klamath River and Trinity River Chinook salmon
[3] Excludes hatchery-influenced escapement
[4] Shasta River is a subset of the overall 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 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 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 millimeters (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 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).

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 review as to whether Chinook salmon within the Upper Klamath and Trinity River ESU should be listed as threatened or endangered (http://www.noaanews.noaa.gov/stories2011/20110411_chinook.html). 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). 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 comprises 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 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 tributaries of the Upper Klamath Basin, including Jenny, Fall, and Shovel Creeks, as well as the Sprague, Williamson, and Wood rivers (Administrative Law Judge 2006).

Adult upstream migration through the estuary and Lower Klamath River peaks in early September and continues through late October (Moyle 2002; FERC 2007; Strange 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 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*.

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 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). 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 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 Klamath Basin (Moyle 2002; Hamilton et al. 2005 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

[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.

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 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 from Iron Gate Dam and in its tributaries, and 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 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 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 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 from Iron Gate Dam, and historically used habitat upstream of Upper Klamath Lake (Hamilton et al. 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, 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, 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 (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. 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 (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 from Iron Gate Dam and its major tributaries: the Trinity, Salmon, Shasta, and Scott River Basins (Stillwater Sciences 2009a). Although the evidence is inconclusive as to whether Pacific lamprey were historically present above Iron Gate Dam, the 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).

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'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 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, 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 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 RM 13 to 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 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 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 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, supports populations of redband trout. These fish support a substantial recreational fishery.

The Upper Klamath 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 from Iron Gate Dam, from Spencer Creek downstream, and are common in the 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 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

The Klamath smallscale sucker (*Catostomus rimiculus*) is common and widely distributed in the Klamath River and its tributaries 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 (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 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.).

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, 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 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 (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 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 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 (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 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 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 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; 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 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 Klamath River, Shasta River, Scott River, Salmon River, Mid-Klamath River, 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 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 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. 2008; Hillemeier et al. 2009). Juvenile coho salmon have been observed to move into non-natal rearing streams, off-channel ponds, the Lower Klamath River, and the estuary for overwintering (Soto et al. 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); 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 (McAllister 1963; Scott and Crossman 1973; Willson et al. 2006, as cited in 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). Final critical habitat was designated in October of 2011 (NOAA Fisheries Service 2011).

Historically, the Klamath River was described as the southern limit of the range of eulachon (Gustafson et al. 2010). Other accounts have described large spawning aggregations of eulachon 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 (Moyle et al. 1995). In addition, small numbers of eulachon have been reported from the Smith River (Moyle 2002). The only reported commercial catch of eulachon in northern California occurred in 1963 when a combined total of 25 metric tons (56,000 lbs) was landed from the Klamath River, 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 on the Klamath River. Another seven were captured between January and April of 2011 at the mouth of the 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 Green Sturgeon DPS

The Southern Green Sturgeon DPS is listed as threatened under the 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 has not been documented. No sturgeon tagged by the Yurok Tribe within the Klamath River 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 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 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 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 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 and revised in 2011 (USFWS 2011a). Critical habitat was proposed 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 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, but the USFWS denied the petition for 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 ºC. Embryos hatch in 40 days in 7 ºC water temperature (25 days in 10.6 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 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 the Upper Klamath Basin.

Upper Klamath Lake is the most prominent feature in this part of the 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. 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. During the summer months these water bodies exhibit episodic high pH, broad daily shifts in dissolved oxygen, and 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 (Perkins et al. 2000, Banish et al. 2009). Instances of pH levels above 10 and extended periods of pH levels greater than 9 lasting for several weeks 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 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). Important flow contributions from springs into these tributaries provide cool summer baseflows with water temperatures and dissolved oxygen 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 generally quite poor due to warm surface waters and annual blooms of the *Aphanizomenon flow-aquae, Anabaena flos-aquae*, and *M. aeruginosa* (see Section 3.4). *M. aeruginosa,* and to an unknown extent *Anabaena flos-aquae*, produce toxins that could be harmful to fish and other animals and humans. Routine sampling from areas frequented by recreational users of the reservoirs has documented cell counts up to 4,000 times greater than what the World Health Organization considers a moderate health risk (see Section 3.4). This has resulted in 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, 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). In the peaking reach, this flow is added to flows from the powerhouse, which can range from 0 to over 3,000 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 1.4 mile long Copco 2 Bypass Reach, has flows of about 5 cfs provided below Copco 2 Dam. 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 small numbers of native shortnose and Lost River suckers 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 Klamath River flows unobstructed for 190 miles downstream from Iron Gate Dam before entering the Pacific Ocean. Downstream 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 Klamath Basin downstream 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 from Iron Gate Dam. Green sturgeon (belonging to the Northern Green Sturgeon DPS) spawn and rear in the Klamath River downstream 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. Anadromous fish stocks have declined substantially from historical 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 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 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 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.

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 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 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.

3.3.3.3.1 Lower Klamath River: Downstream 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. 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 from Iron Gate Dam are summarized in Section 3.2.3.3. In general, the data indicate that SSCs downstream from Iron Gate Dam range from less than 5 mg/L during summer low flows to greater than 5,000 mg/L during winter high flows. 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 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:** SSCs and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream 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) SSC and duration from these results was estimated (Figure 3.3-2).

- **Extreme conditions:** 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 with high SSCs, such as a flood (Figure 3.3-3).

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.

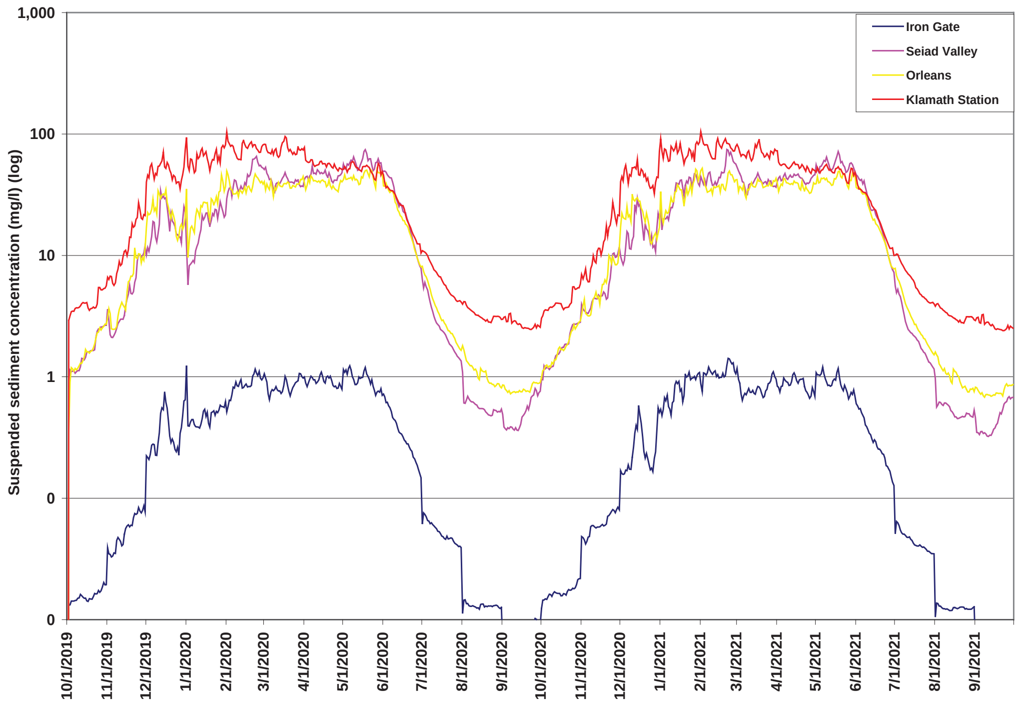

Figure 3.3-2. Normal conditions (50 Percent Exceedance Probability) SSCs for Three Locations Downstream from Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.

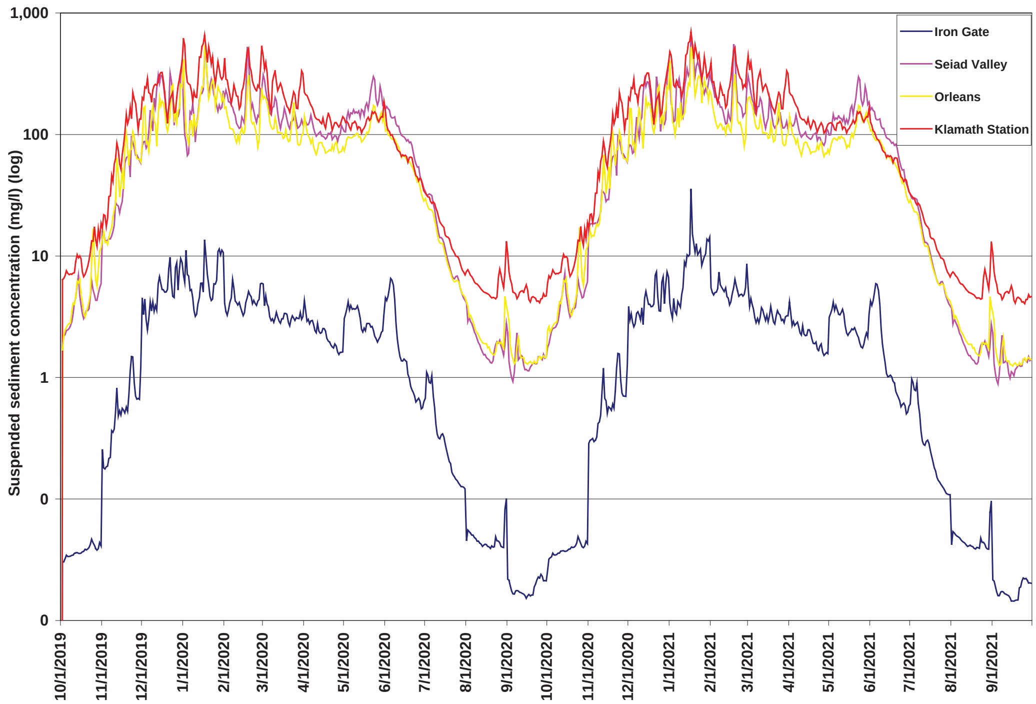

Figure 3.3-3. Extreme conditions (10 Percent Exceedance Probability) SSCs for Three Locations Downstream from Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.

Klamath River Estuary

Under existing conditions SSCs within the Klamath River Estuary 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 Klamath River downstream 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 SSCs are relatively high during winter (typically 50 to 100 mg/L), and lower (< 10 mg/L) during summer. Under extreme conditions the SSC is generally 10 to 100 mg/L in summer and fall, with peaks between 100 and 1,000 mg/L during winter and spring (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. 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.

As described in detail in Section 3.2.4.3.2, 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). 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 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.

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 1.4-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 reservoirs currently store 13.1 million cubic yards (yd^3) of sediment (Reclamation 2012), with Copco 1 Reservoir storing the largest amount of sediment (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 2012).

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 from Iron Gate Dam

Downstream 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 2012). The reach from Iron Gate Dam to Cottonwood Creek (RM 182.1) is characterized by coarse, cobble-boulder bars immediately downstream 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 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.

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 from the dams until tributaries resupply the channel with finer sediment. Most (≈98 percent) of the sediment supplied to the mainstem Klamath River (Stillwater Sciences 2010a) currently is delivered from tributaries downstream from Cottonwood Creek, limiting the effects of interrupting upstream sediment supply 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 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 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 years, on average (Figure 3.3-4).

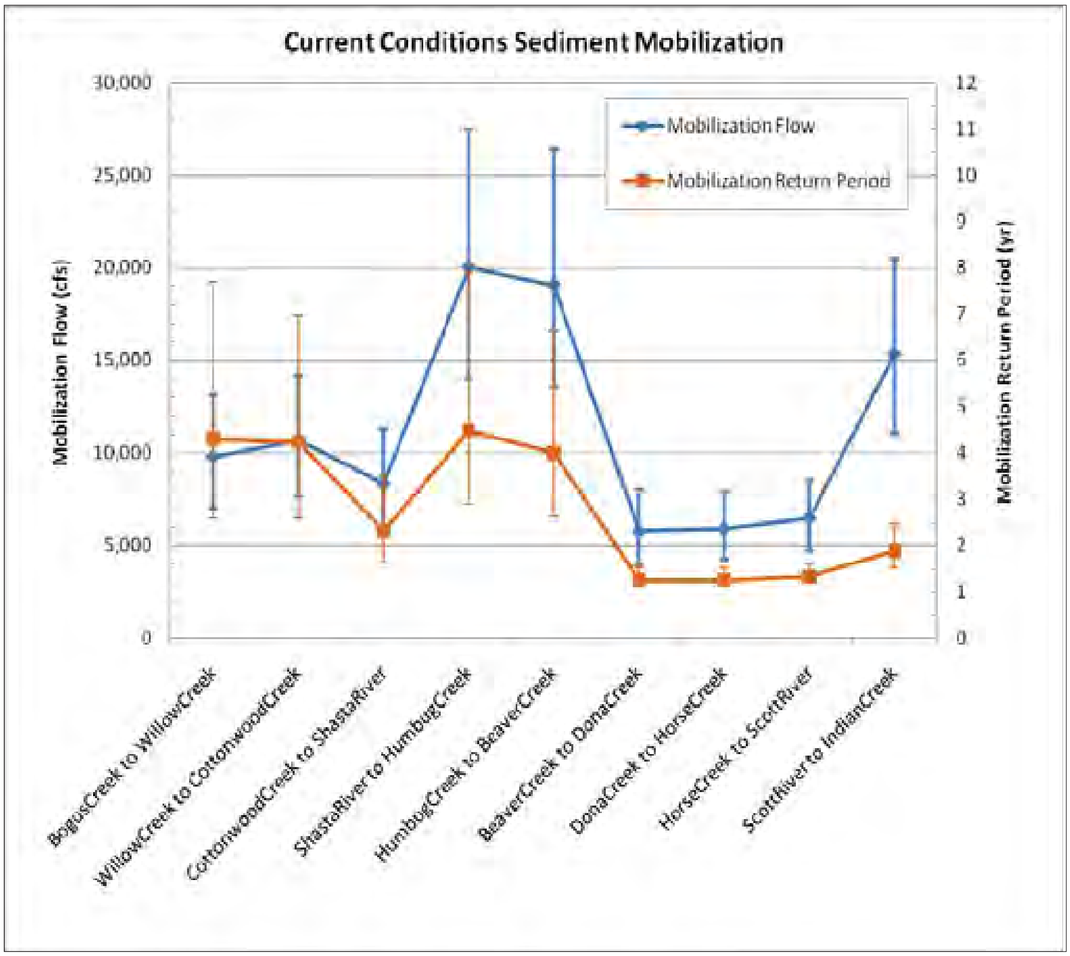

Figure 3.3-4. Mobilization Flow and Return Period at which Sediment Mobilization Occurs (Reclamation 2012).

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 from the Klamath Estuary to Keno Dam has been listed as impaired for water temperature (Table 3.2-8 in Section 3.2, Water Quality). 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 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 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 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

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). 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 al. 2011). 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. Temperatures in Upper Klamath Lake are actually cooler than those downstream 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).

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 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).

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. 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 the retention of cold water in Copco 1 and Iron Gate reservoirs during the winter, and the relatively shallow outlets of both reservoirs (PacifiCorp 2004a). Summertime thermal stratification in Copco1 and Iron Gate reservoirs is typically accompanied by hypoxia (Appendix C, Section C.4.1.4). Although water temperatures increase in the summer months (see Section 3.2.3.2), temperatures documented in the Hydroelectric Reach are within the tolerance ranges of the species observed there, but would be considered seasonally stressful for cold water species.

Lower Klamath River: Downstream from Iron Gate Dam

Water temperatures in spring in the Lower Klamath Basin downstream 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 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 temperatures can lead to increased water temperatures (Hamilton et al. 2011). Downstream 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 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 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). However, this effect is reduced by input of cool ocean water and a high prevalence of coastal fog.

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 salmon, (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 occasionally result in substantial mortality (e.g., the 2002 fish kill of 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 within the river, and thus the higher the risk of exposure for salmon (Bjork and Bartholomew 2010). Actinospore abundance, a primary determinant of infectious dose, is controlled by the number of 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 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.

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 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 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. 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 II and Type III (Table 3.3-3):

Table 3.3-3. Ceratomyxa shasta 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. 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* densities have been reported to be as high in the Williamson River (Hurst et al. 2012) as in the area downstream from Iron Gate Dam (Hallett and Bartholomew 2006). In 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 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. The current infectious zone and high parasite loads below Iron Gate Dam are the result of a 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 (Bartholomew and Foott 2010). . 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), and within all four

Project reservoirs. However, these polychaete populations are most abundant at reservoir inflow areas with densities decreasing with distance from reservoir/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 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 from Iron Gate Dam

In the Lower Klamath River, the polychaete host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations. 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 filamentous green periphytic algae), sand-silt, and fine benthic organic material in the substrate (Stocking 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 Klamath River is considered to be a combined effect of high spore input from heavily infected, spawned adult salmon that congregate downstream 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 Klamath River downstream 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, salmon (particularly juvenile salmon, 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 salmon 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 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 (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*, 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 through 2012, years with lower river temperatures and conditions less conducive to juvenile disease, prevalence of *C. shasta* in emigrant Chinook salmon during the peak migration period was less than 35 percent.

For adult salmon disease risk have been less frequent and of a different nature. Ich and columnaris have occasionally had a substantial impact, 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). 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 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 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 are not be as frequent as the annual exposure of juvenile salmon 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 bioaccumulate in 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 reconnaissance study was conducted to evaluate the presence, concentration, and dynamics of microcystin exposure by Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). 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 hypothesized that the 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 from Iron Gate Dam, 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 (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 from Iron Gate Reservoir and transported downstream to areas where Chinook salmon were migrating upstream.

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 (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 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 from Iron Gate Dam). These changes are described in 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 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 depending on water availability and power demand. Flows through the reach downstream 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 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), 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 from Iron Gate Dam

A universal feature of the historical hydrographs of the Klamath River and its tributaries is a season of 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 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

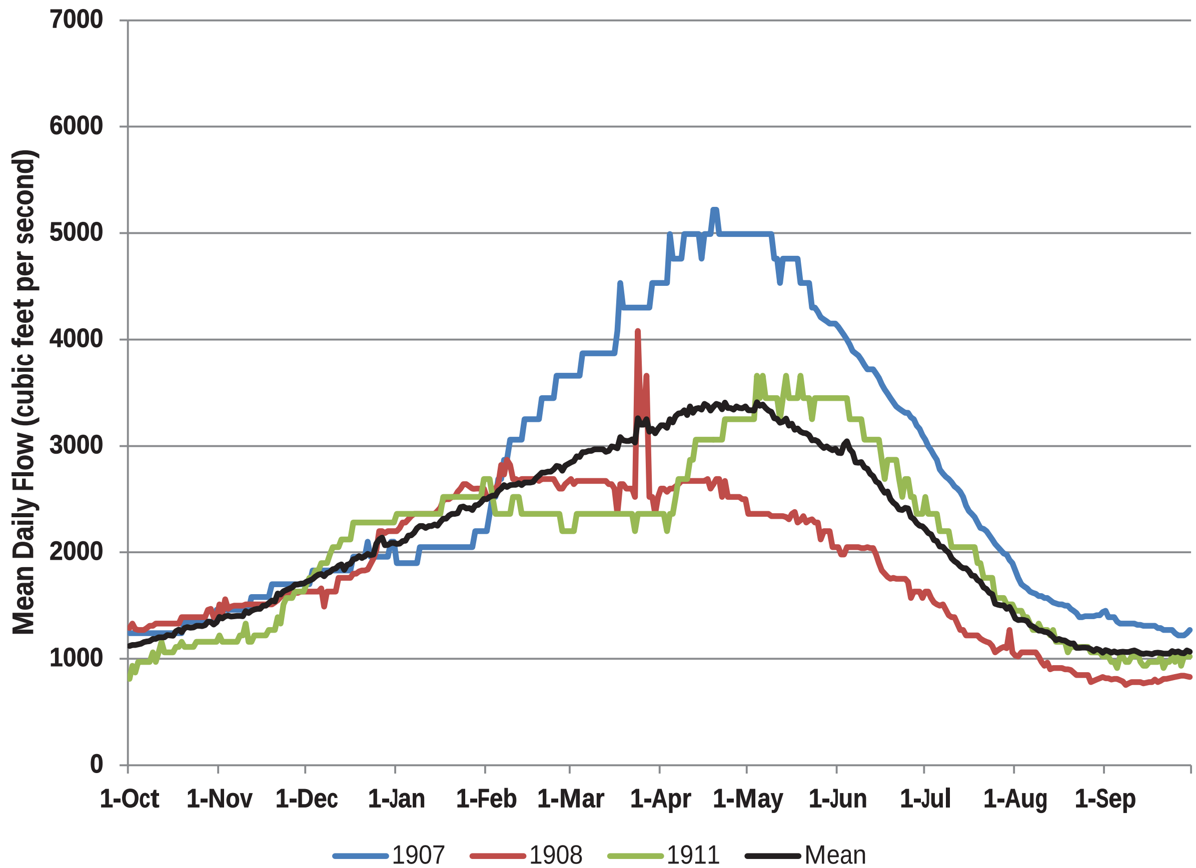

Figure 3.3-5. Mean daily flows (cubic feet per second) for the Klamath River at the USGS Gage at Keno for three different water years, generally representing drier (1908), more normal (1911) and wetter (1907) conditions. Mean daily flows for water years 1905 through 1912 are also displayed to illustrate 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 or spring when water temperatures are cool and flows are either increasing or are high 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, winter and spring. In the middle and lower portions of the Klamath River, discharge responds rapidly to rainfall 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).

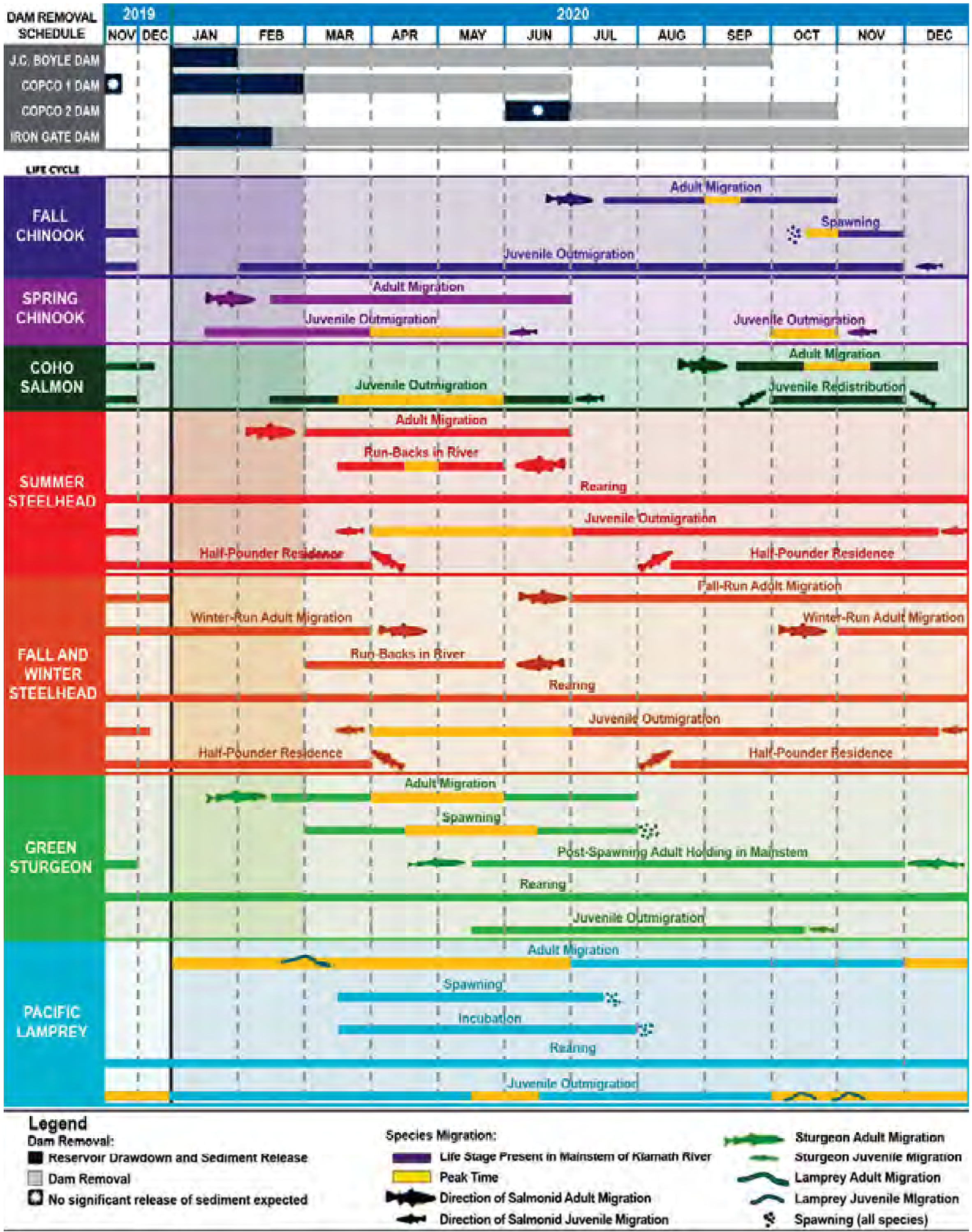

Figure 3.3-6. Timeline Depicting the Timing of Salmon Lifecycles in the Mainstem of the Klamath River Coinciding with Dam Removal Plans.

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, 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 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 to 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.

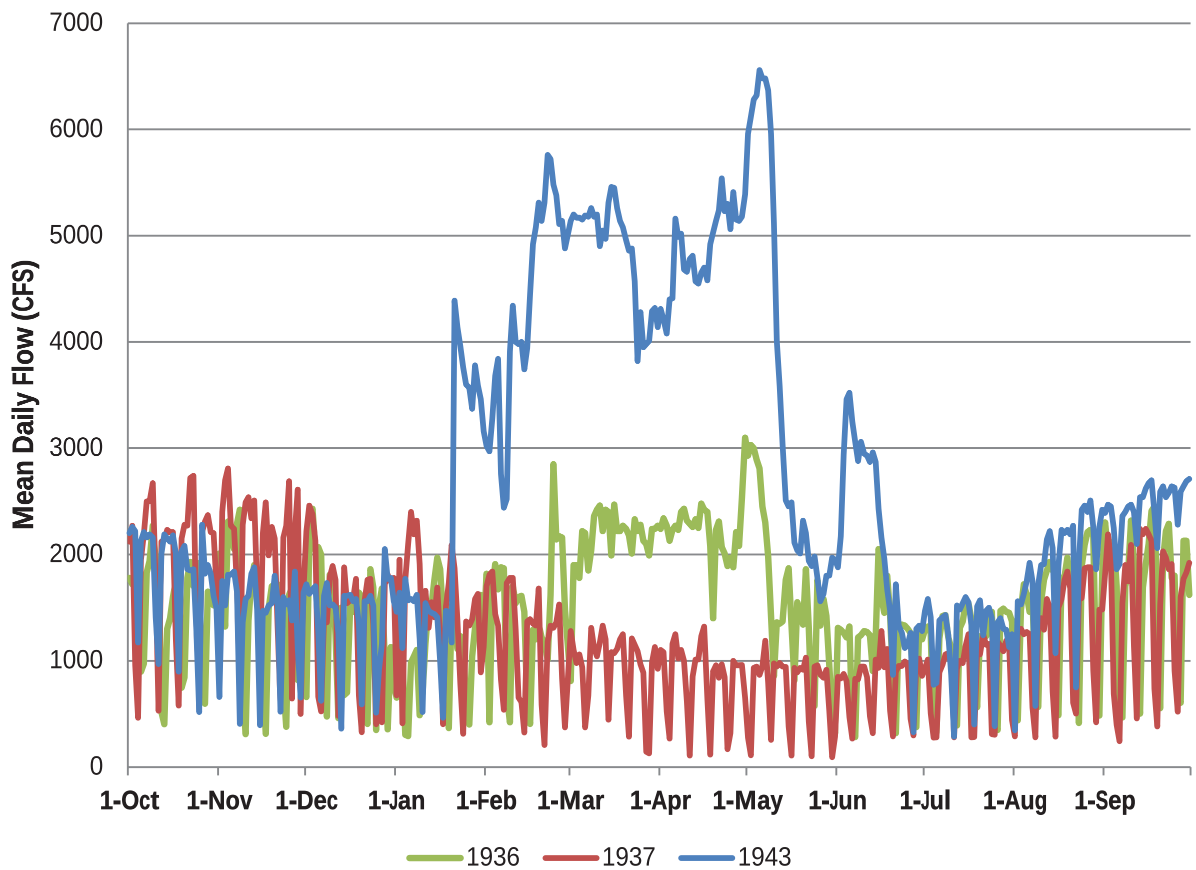

Figure 3.3-7. Mean daily flows (cubic feet per second) for the Klamath River at the USGS Gage near Fall Creek (Gage #11512500) for three different water years, generally representing drier (1937), normal (1936) and wetter (1943) conditions.

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).

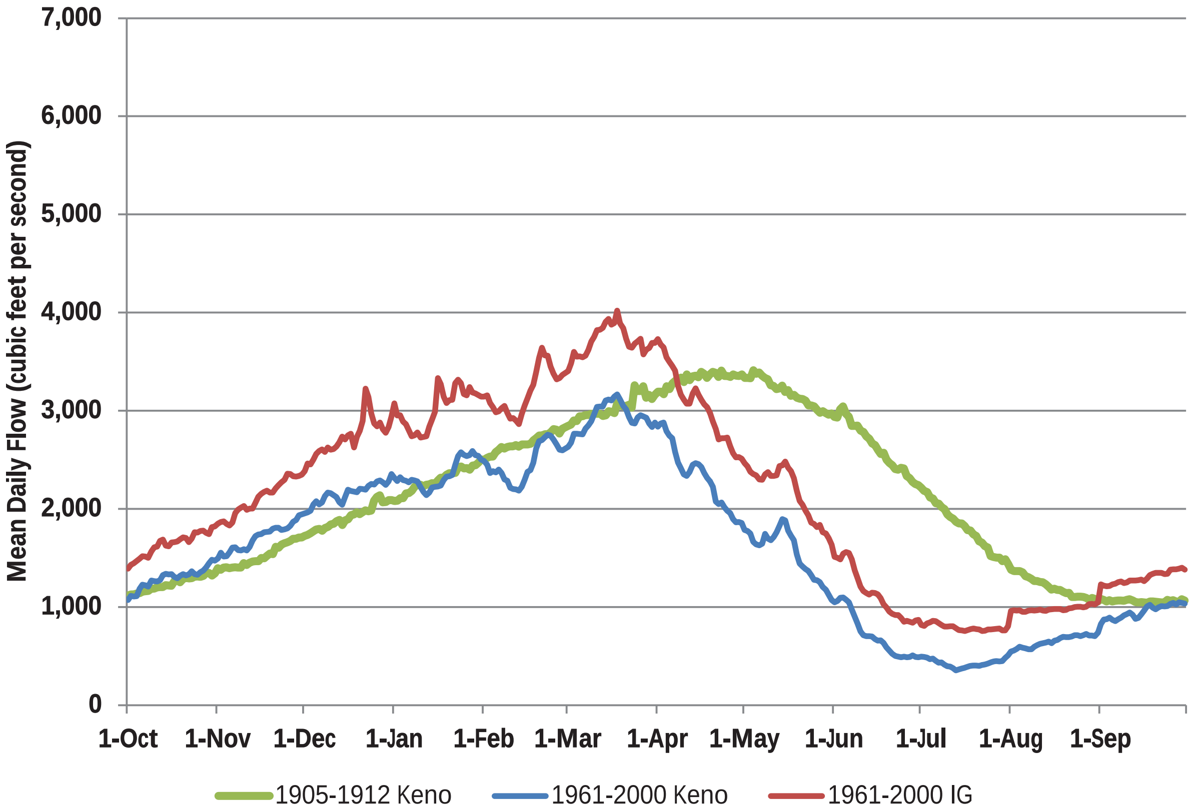

Figure 3.3-8. Comparison of mean daily flows recorded at Keno (USGS Gage # 11509500) historically (1905-1912) with more recent conditions (1961-2000). Mean daily flows recorded at Iron Gate (USGS Gage #11516530) are shown to depict both the mean daily accretions and similarities that exist in the hydrograph 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, would 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 (2002) 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).

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

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 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 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 available using the 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 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 with 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 from Iron Gate Dam on the Klamath River and Lewiston Dam on the Trinity River are designated as critical habitat (NOAA Fisheries Service 1999b).

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, NOAA Fisheries Service also focuses on the known physical and biological features (PCEs) within the designated area that are

[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.”

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

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 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

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 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 fishery management plans, developed by NOAA Fisheries Service and the 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 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. 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.

Groundfish

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 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 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:** SSCs and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream 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) 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:** 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). "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:** SSCs and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream 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 from Iron Gate Dam in all water years observed since 1961 with facility removal. To predict the "most likely scenario" that will occur under the Proposed Action, the median (50 percent exposure concentration) was estimated.

- **Worst-case scenario:** 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 years are representative and would persist through time, allowing for mild fluctuations as a function of hydrology (Reclamation 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 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 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 3.2.4.1.7.

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 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 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 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.

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 and KBRA hydrology are incorporated into the RBM10 model (Perry et al. 2011) (see Section 3.2.4.1.1 and Appendix D for additional detail). Neither implementation of total maximum daily loads (TMDLs) nor climate change was incorporated into the existing models, including the Chinook salmon life cycle model (EDRRA) developed by Hendrix (2011). For purposes of the water quality and aquatics analyses it is assumed that TMDL water temperature objectives can be met; 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 1.0 to 3.0°C warming of median air temperature by the end of the analysis period (Snyder et al. 2004; Bartholow 2005; 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 mortality and have periodically contributed to substantial mortality for Klamath River salmon. 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 Basinsalmon. 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 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
- 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, 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. 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 (BMI) populations 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 BMIs were evaluated for both short- and long-term changes in SSCs and bedload sediment. Suspended sediment impacts on 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 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 years) and the long term (more than 2 years), but either short- or long-term impacts could be significant.

For the analysis of Aquatic Resources in this EIS/EIR, the following determinations were considered:

- No 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 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.

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

<u>Suspended Sediment</u>

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 Lower Klamath River downstream from the Trinity River confluence (RM 40.0) to the estuary mouth is listed as sediment impaired under Section 303(d) of the CWA (see Table 3.2-8). 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 Jensen (1996) Severity Index predicted to be higher than 8 for most of the winter (see Appendix E for detailed analysis).

<u>Bedload Sediment</u>

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. 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 from Iron Gate Dam Under the No Action/No Project Alternative, the 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 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).

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. Dissolved oxygen levels 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 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.

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 would meet the 6.5 mg/L objective year round, including the warm summer and fall months (see subsection to Section 3.2.4.3.1, Upper Klamath Basin). Full attainment could require decades to achieve and it is highly dependent on improvements in dissolved oxygen in Upper Klamath Lake.

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 dissolved oxygen in the Upper Klamath Basin. These restoration actions and implementation of water quality improvement measures under Oregon TMDLs to address water quality impairments are also expected to improve pH during the period of analysis (50 years) 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 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 Hydroelectric Reach (Copco 1 and Iron Gate) would also continue to provide 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. 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 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 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 Klamath River downstream 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 from Iron Gate Dam, 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 August–September and the 90 percent saturation objective 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). 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 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 Klamath River downstream 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 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 from Iron Gate Dam, and so would not consistently meet California Basin Plan and Hoopa Valley Tribe water quality objectives for dissolved oxygen. The No Action/No Project Alternative would continue to periodically result in dissolved oxygen levels that may be deleterious to aquatic resources downstream from Iron Gate Dam, but this effect would be similar to or less than that which currently occurs.

<u>Water Temperature</u>

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the No Action/No Project Alternative, 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. However, climate change 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 1.0 to 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 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 provide favorable springtime water temperatures for rearing fish in the 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 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.

Lower Klamath River: Downstream from Iron Gate Dam The Lower Klamath River downstream from Iron Gate Dam would continue to have elevated water temperatures in the summer and fall in the near term. 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 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 temps in spring likely delay emergence, and reduce growth rates of juveniles (Hardy et al. 2006). In addition, juveniles and adults migrating in late summer and fall would continue to experience warm temperatures 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, 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 conditions conducive to disease (Bartholomew and Foott 2010). These effects would 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, 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.

<u>Fish Disease and Parasites</u>

The ongoing presence of the dams under the No Action/No Project Alternative would continue to contribute to the static flows, immobile substrate, seasonally warm water temperatures, and planktonic food sources that are favorable for polychaetes and for *C. shasta* and *P. minibicornis* (Hetrick et al. 2009) Salmon carcasses would continue to concentrate 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.

<u>Algal Toxins</u>

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 3.2.4.3.1.6 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 be expected.

Hydroelectric Reach: 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 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 be expected.

Lower Klamath River: Downstream from Iron Gate Dam Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would continue to support growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in Copco 1 and Iron Gate Reservoirs and subsequent transport of high seasonal concentrations of algal toxins to the Klamath River downstream from Iron Gate Dam. This would also support continued bioaccumulation of microcystin in fish and mussel tissue for species downstream from the 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 from Iron Gate Dam would be expected.

<u>Aquatic Habitat</u>

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 resident fish habitat in the 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 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

<u>Critical Habitat</u>

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 initially would be reduced and remain poor similar to that under existing conditions. Also, full attainment of the water temperature TMDLs would be partially offset by climate change. **The effect of the No Action/No Project Alternative 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 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 is expected to improve water quality conditions over time 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 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 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 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 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 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.

[3] Page 69 of Appendix C of the July 20, 2011 Addendum to Goodman et al. 2011.

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 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 hundreds of miles of 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 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 from Iron Gate Dam, especially where adults (and carcasses) tend to congregate in high numbers, just downstream from Iron Gate Dam (Stocking and Bartholomew 2007, Bartholomew and Foott 2010), but also in other locations further downstream. Additional factors related to the project would continue to exacerbate the situation downstream 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

[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.

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 from Orleans, and even more so downstream 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 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 they have limited effects on fish, although physiological stress and reduced growth rates are possible. In general, fall-run Chinook salmon appear relatively unaffected by current SSCs because smolt outmigration primarily occurs when 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 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. 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. Lack of sediment transport is also likely to be contributing to the high densities of polychaetes downstream 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 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 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 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 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 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

[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.

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 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 from Orleans, and especially downstream 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.

One of the main spawning streams for spring-run Chinook salmon, the Salmon River has dramatically increased sediment production 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; 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 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 historical habitat which used to extend upstream 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 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 temperatures are reduced, whether these temperatures are a result of short- or long-term 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.

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, 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. 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 2010a). During a 2008 PIT-tag study of juvenile coho salmon in the Shasta River, Chesney et al. (2009) found

[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.

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. 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 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 (2010a) *BO on operation of the Klamath Project between 2010 and 2018*.

The effect of the No Action/No 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 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 Project Alternative, summer steelhead spawning and rearing habitat availability and distribution would continue to be restricted during summer and fall to reaches downstream from Seiad Valley by high water temperatures farther upstream. 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 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 from Iron Gate Dam. Under the No Action/No Project Alternative, they would continue to be restricted from 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, 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.

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 from Orleans, and especially downstream 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 spawning and larval rearing habitat reduces the Basin’s population viability through contracting their distribution within the watershed and reducing abundance.

Under the No Action/No Project Alternative, the dams would continue to reduce sediment supply to the mainstem Klamath River downstream 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 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 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 SSCs are high, especially since they remain within the sublethal range.

The effects of dams and reservoirs would continue to affect water quality downstream 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 years, and spawning every 4 years on average (Klimley et al. 2007). In the Klamath River mainstem, green sturgeon spawn and rear in the lower 67 miles, downstream 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 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 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 green sturgeon.

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.

Shortnose and Lost River suckers would continue to be subject to poor water quality within reservoirs. However, with little or no successful reproduction (Buettner et al. 2006), populations downstream 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 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 from J.C. Boyle Dam would continue to be hindered or obstructed from migrating to spawning grounds in Spencer Creek by requiring them to ascend a fish ladder at J.C. Boyle Dam (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 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 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 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 J.C. Boyle facility 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 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 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 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 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 (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). Historically, the Klamath River was described as the southern limit of the range of eulachon (Gustafson et al. 2010). 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 moderately abundant 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. 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-listed threatened species throughout their range in California, but the USFWS denied the petition for 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 from Iron Gate Dam. Under the No Action/No 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 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 ridged mussel 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 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 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 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 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. 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. 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)

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

<u>Suspended Sediment</u>
Suspended sediment effects under Proposed Action are described in detail in Appendix E, and summarized here.

Lower Klamath River: 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 from Iron Gate Dam (Reclamation 2012), resulting in higher SSCs than would normally occur under existing conditions (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 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. 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 3.3-10), where 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 SSCs from the Proposed Action are predicted to decrease. Under a worst case scenario SSCs are projected to remain somewhat elevated above existing conditions until October.

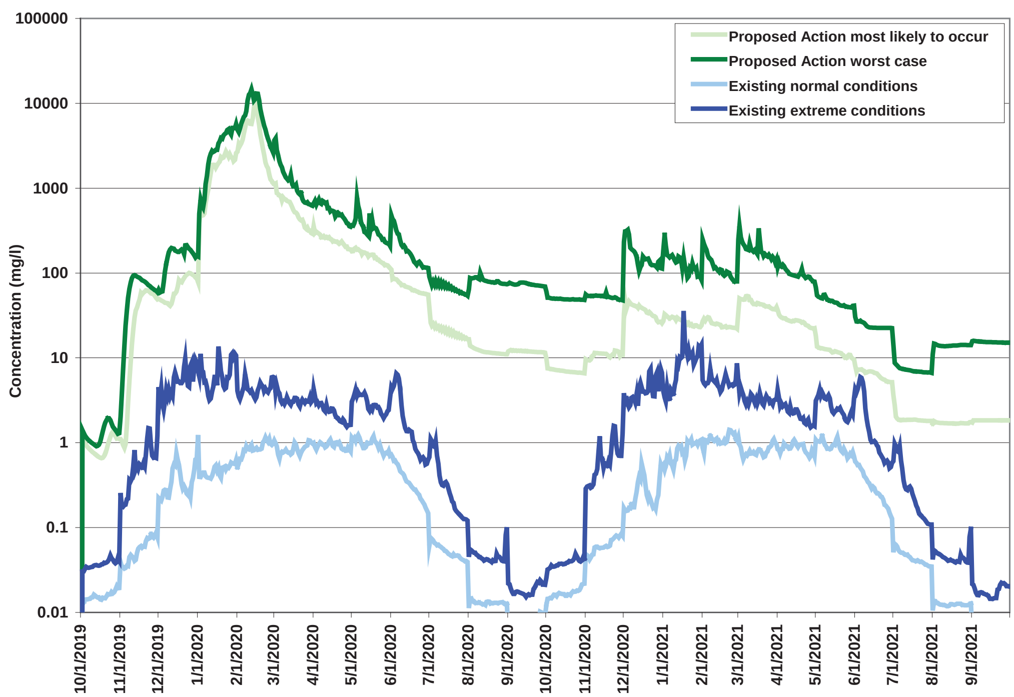

Figure 3.3-9. Comparison of SSCs under Proposed Action and Existing Conditions at Iron Gate Dam, as Predicted Using SRH-1D Model.

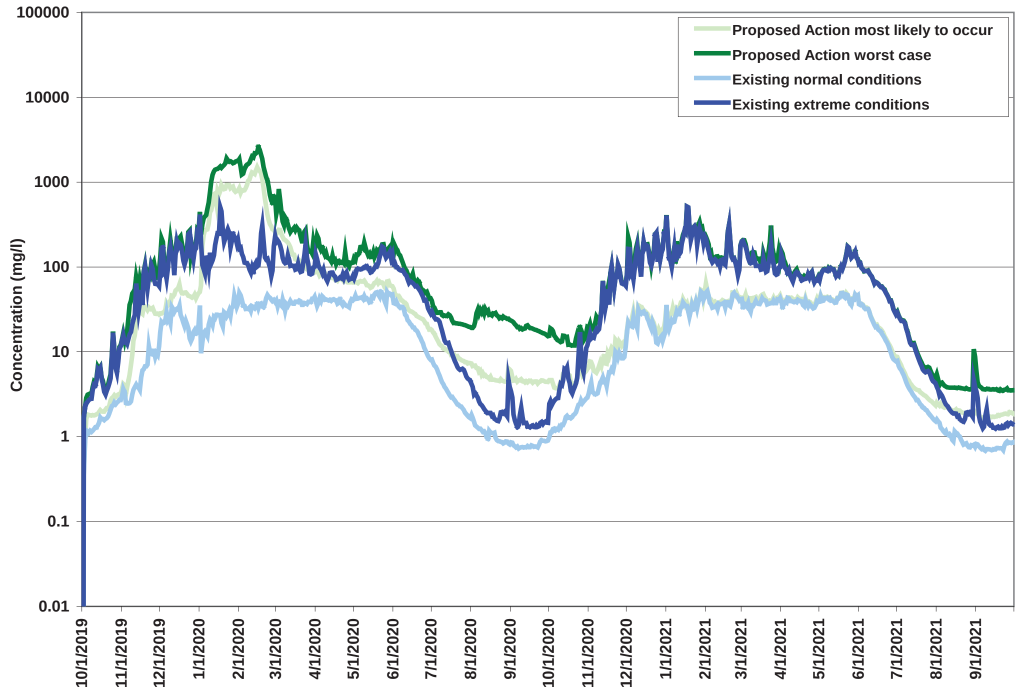

Figure 3.3-10. Comparison of SSCs under Proposed Action and Existing Conditions at Orleans, as Predicted Using SRH-1D Model.

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 3.3-11). 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.

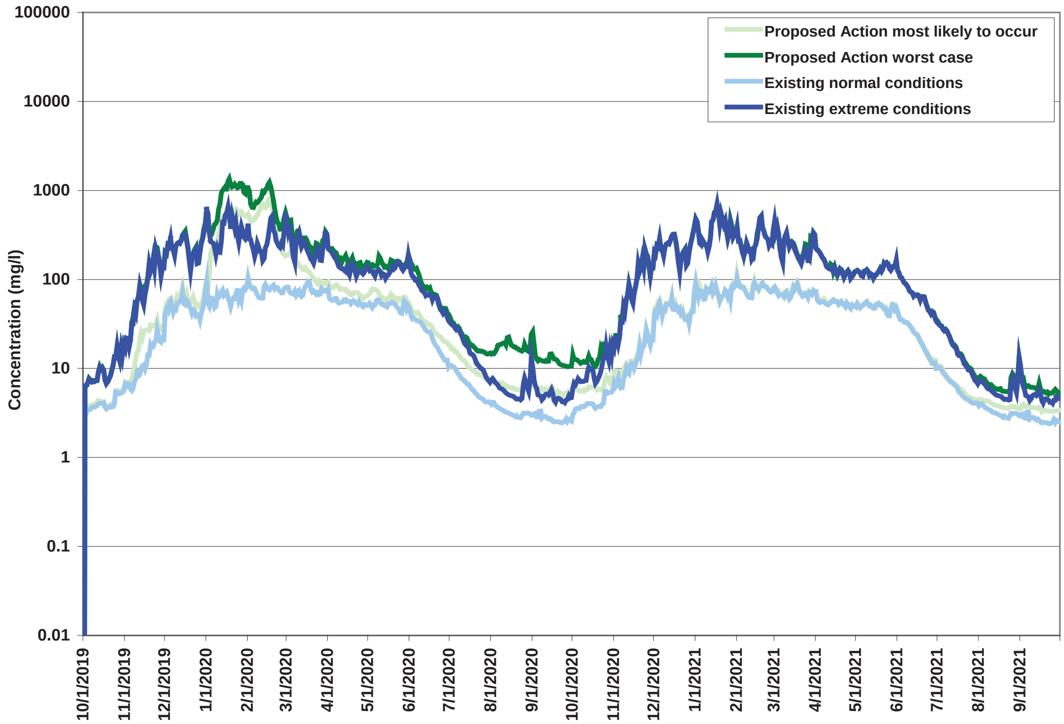

Figure 3.3-11. Comparison of SSCs under Proposed Action and Existing Conditions at Klamath Station, as Predicted Using SRH-1D Model.

Pacific Ocean Nearshore Environment In contrast to the Lower 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. 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 2012). No sediment is stored within the Copco 2 Reservoir, Copco 1 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 36 to 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 3.3-12). 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. 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).

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 3.3-13). 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 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 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 3.3-13) (Reclamation 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 F).

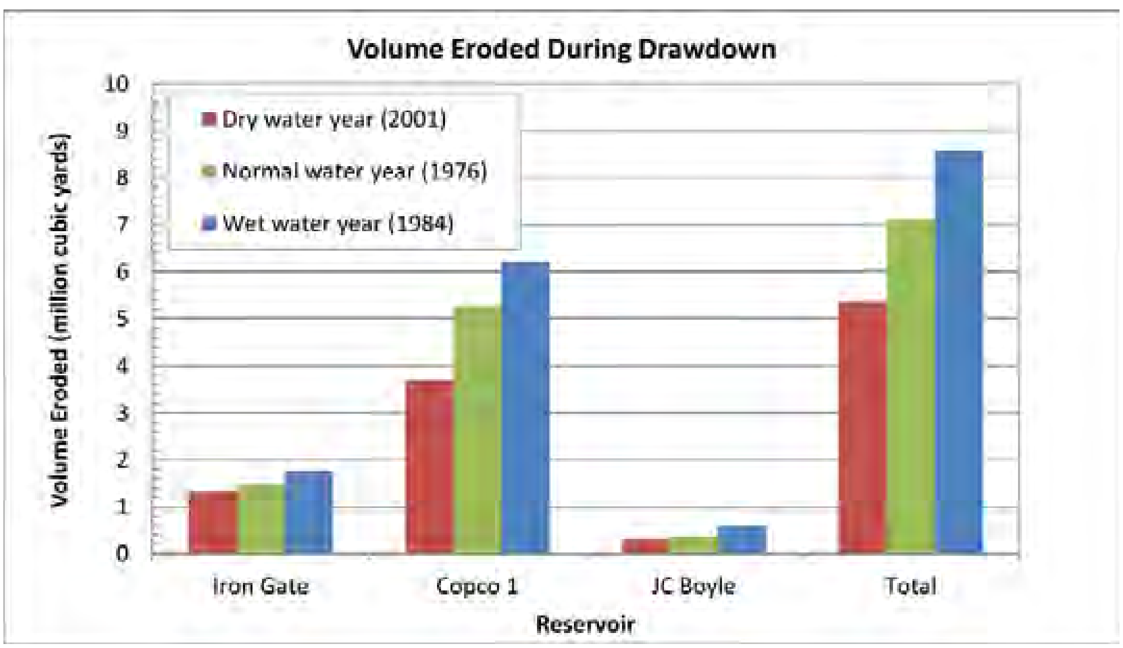

Figure 3.3-12. Sediment Erosion from Dams in the Hydroelectric Reach During 2020 Drawdown Beginning in January (Reclamation 2012).

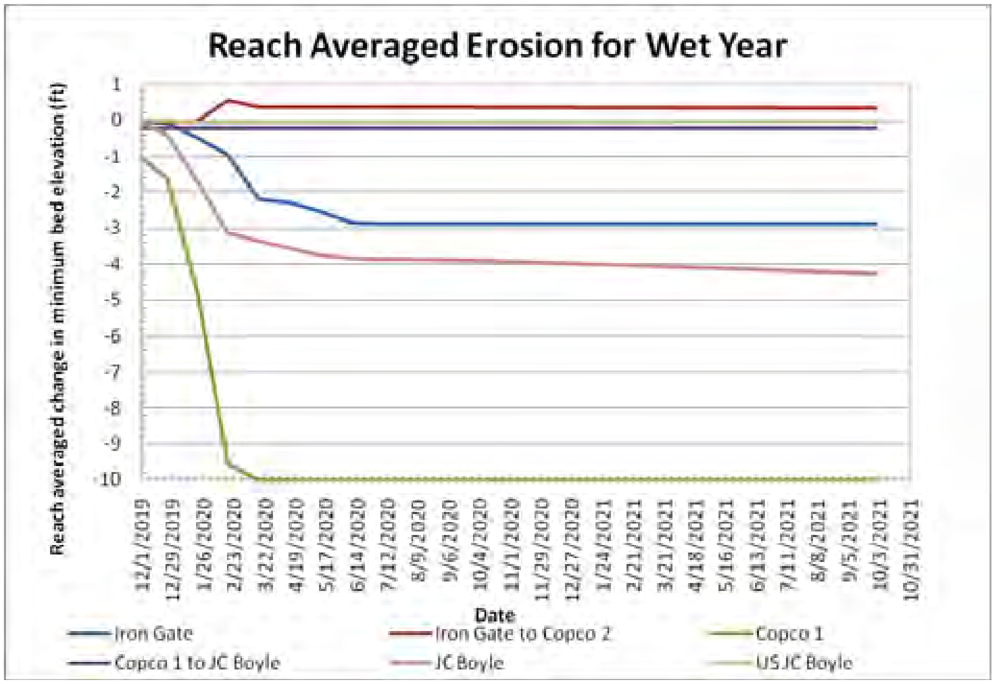

Figure 3.3-13. Reach-Averaged Erosion in the Hydroelectric Reach during Wet Year (Reclamation 2012).

The Copco 2 Dam to Iron Gate Reservoir reach shows 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).

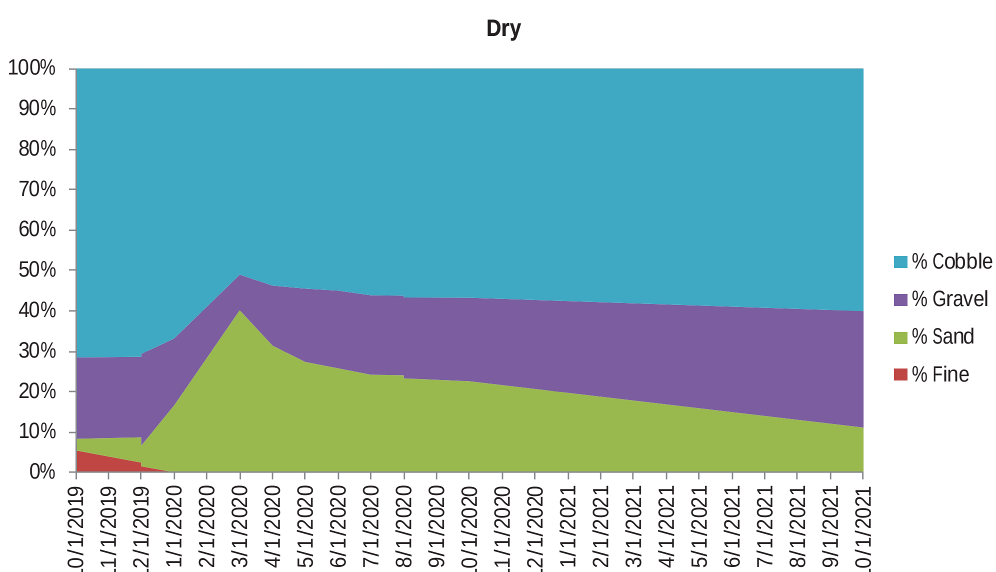

Figure 3.3-14. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years during and after Drawdown (Based on simulation results provided by Reclamation, March 2012).

Lower Klamath River: Downstream from Iron Gate Dam 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 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 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 to 256 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences 2010a; Reclamation 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 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.

Short-term (2-year) SRH-1D model simulations estimate up to 1 ft of reach-averaged deposition of fine and coarse sediment between Iron Gate Dam and Bogus Creek (RM 189.8) (0.3 to 1 feet and up to 0.8 ft of deposition between Bogus Creek and Willow Creek (RM 185.2) (0.4 to 0.8 ft). Reaches farther downstream showed no apparent change (<0.5 ft) Figure 3.3-15, Reclamation 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 2012). Reclamation (2011a) expects 2 to 3 feet of aggradation between Iron Gate Dam and Cottonwood Creek over the next 50 years.

Under the Proposed Action, the flow magnitude required to mobilize sediment would likely decrease from existing conditions. Reclamation (2011a) estimated the magnitude and return period of flows required to mobilize sediment downstream 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. 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).

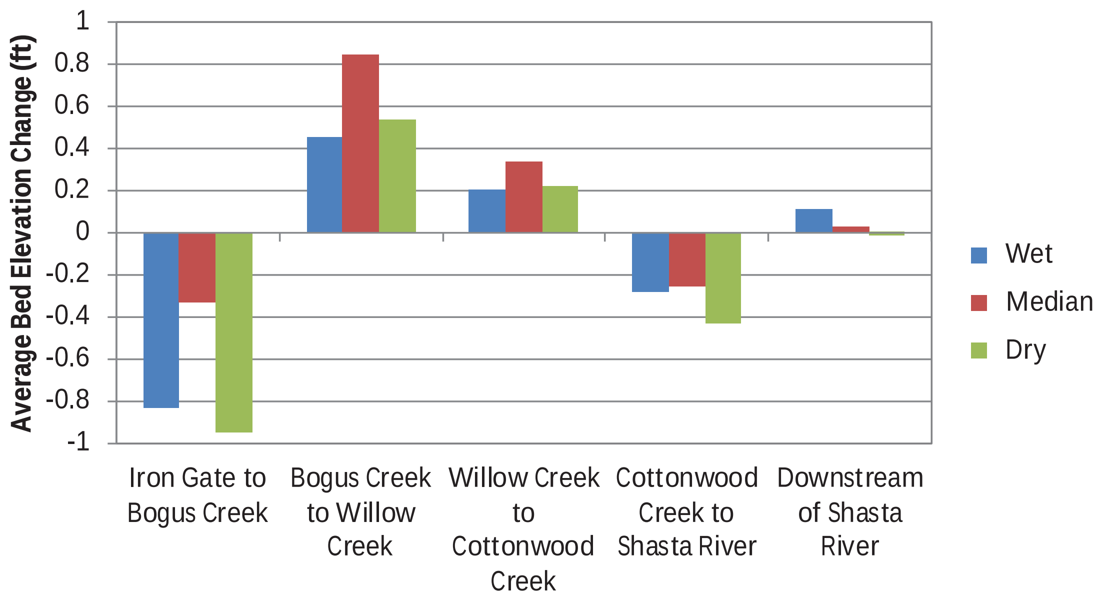

Figure 3.3-15. Reach Averaged Bed Elevation Change for Two Successive Wet, Median, or Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012).

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 F) 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.

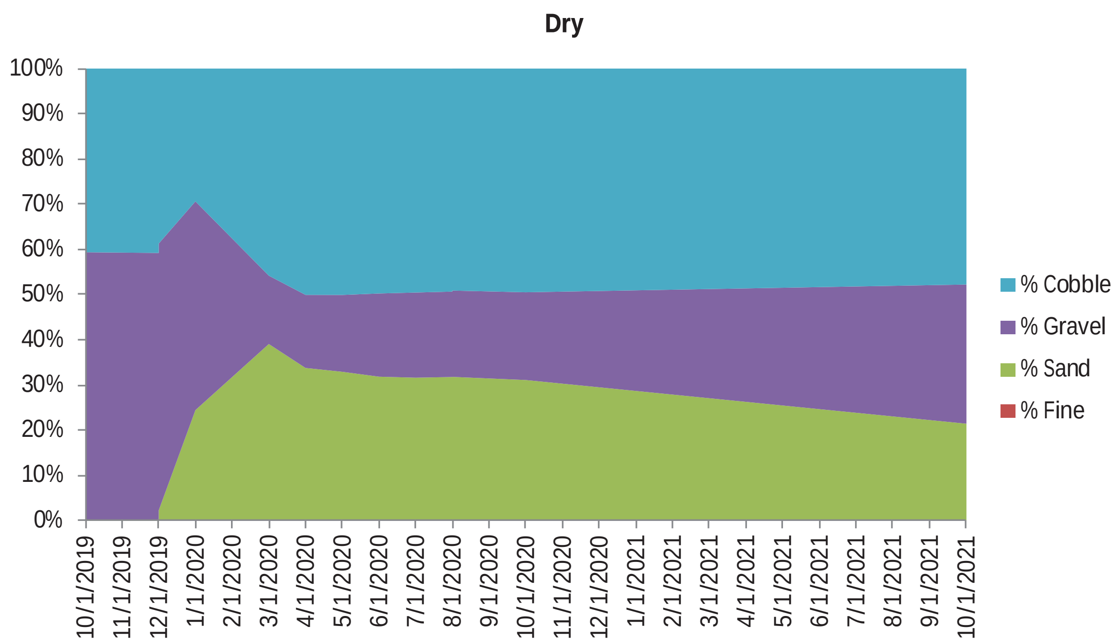

Figure 3.3-16. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012).

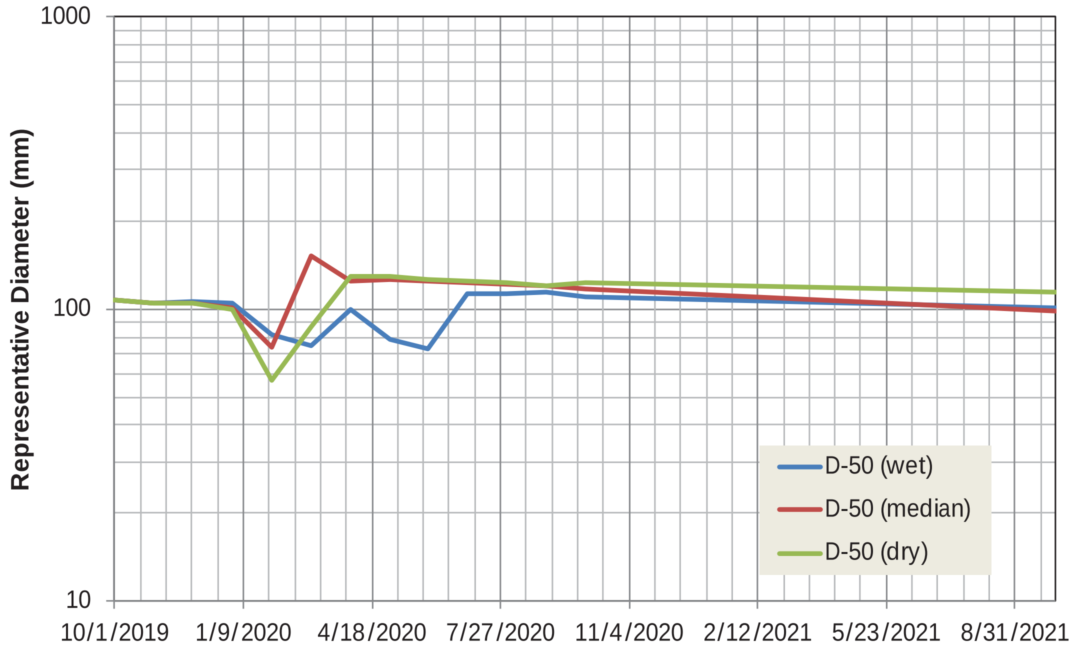

Figure 3.3-17. Simulated D50 (mm) from Iron Gate Dam to Bogus Creek during Successive Wet, Median, and Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by Reclamation, March 2012).

Water Quality

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Dam removal activities under the Proposed Action 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 primarily adult 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 of the Klamath River (Link River Dam to Keno Dam) exhibits dissolved oxygen concentrations greater than 6 mg/L from mid-November through mid-June. These measurements are generally acceptable for migrating adult anadromous salmonids (USEPA 1986) for these months 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 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 would cause long-term increases in dissolved oxygen 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.

As described in the subsection of Section 3.2.4.3.2, Water Quality, under the Proposed Action, pH in the Hydroelectric Reach would no longer experience daily variation 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 from Iron Gate Dam Sediment release associated with the Proposed Action could cause short-term increases in oxygen demand and reductions in dissolved oxygen. As described in the subsection of Section 3.2.4.3.2, Water Quality, predicted short-term increases in oxygen demand under the Proposed Action generally result in dissolved oxygen 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 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 water quality objective of 90 percent saturation (i.e., 10–11 mg/L) would occur in the reach 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 Klamath River, particularly for the reach immediately downstream from Iron Gate Dam. Effects would diminish with distance downstream 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 Dam removal activities under the Proposed Action would not affect water temperature 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. 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.

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 (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/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^{o}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, Perry et al. 2011; see also 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 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 from Iron Gate Dam would reflect natural temperature regimes (Hamilton et al. 2011). The conversion of an additional 22 miles 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 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 Klamath River (subsection of Section 3.2.4.3.2). This elimination would cause water temperatures to become more in sync with historical migration and spawning periods for the Klamath River, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions (Hamilton et al. 2011).

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 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).

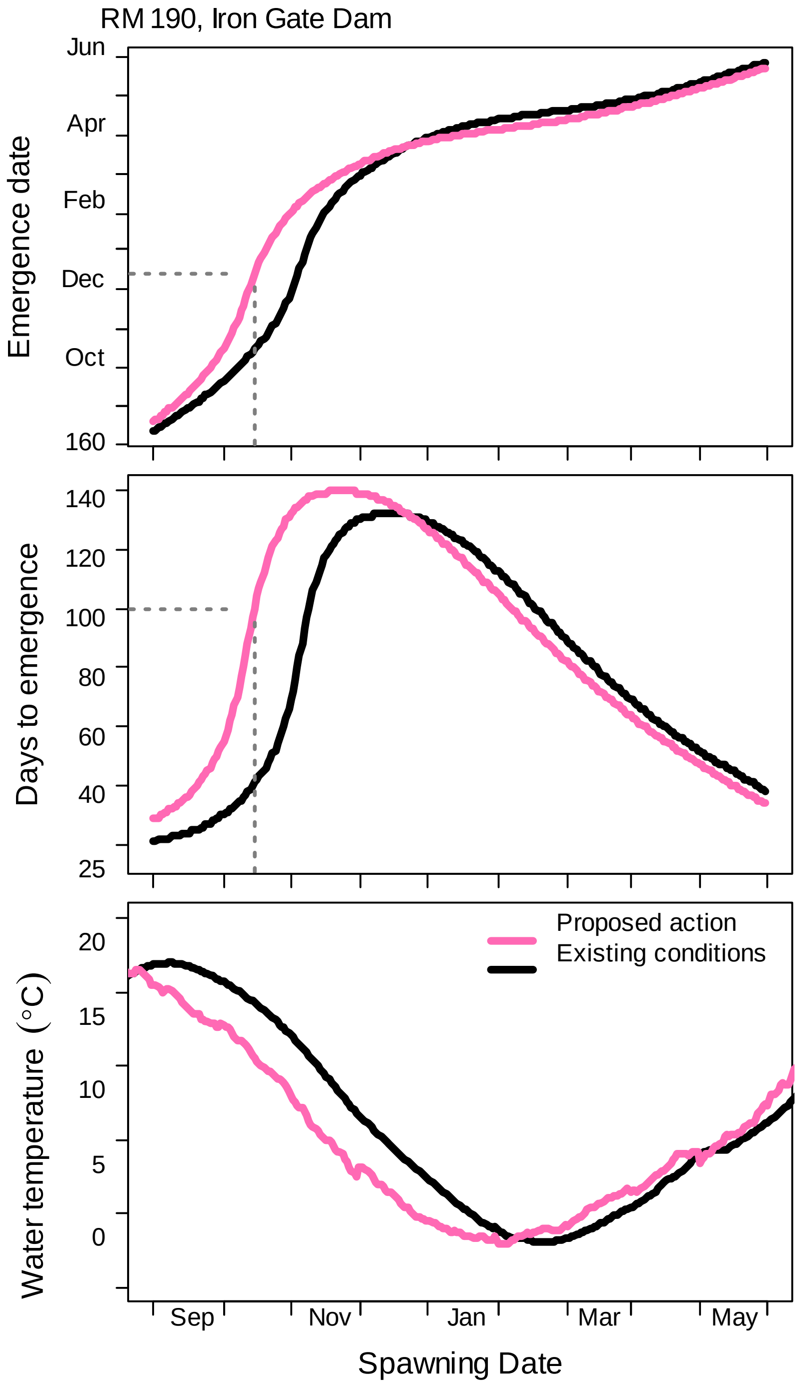

Figure 3.3-18. Time series of average daily mean water temperature (lower panel) forecasted at Iron Gate Dam (RM 190) for the Index Sequential climate scenario spanning years 2020 to 2061, for Proposed Action and Existing Conditions. Days to emergence (middle panel) and date of emergence (upper panel) 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)

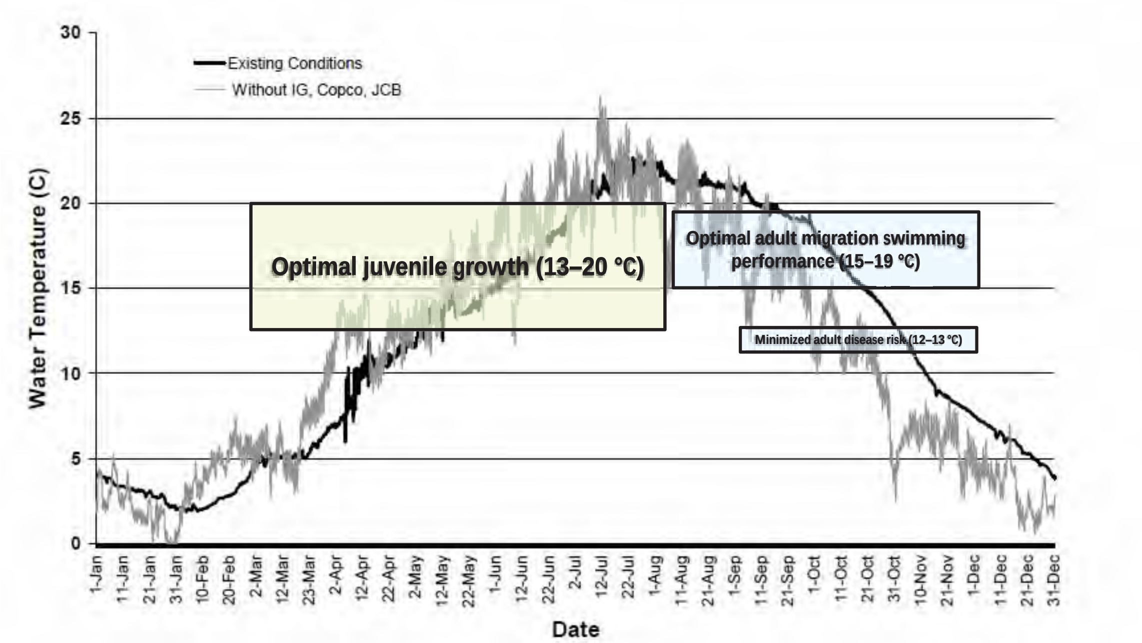

Figure 3.3-19. PacifiCorp (2005) Simulated hourly water temperatures below Iron Gate Dam based on a dry water year (WY 2002) for existing conditions compared to the Proposed Action (without Project dams), and USEPA (2003) water temperature criteria for salmonid growth and migration.

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 from Iron Gate Dam, but could extend an additional 120 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 subsection of Section 3.2.4.3.2., Water Quality).

Klamath River Estuary and Pacific Ocean Nearshore Environment The influence of the Proposed Action would likely decrease with distance downstream 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 salmon from fish disease. The greatest disease related mortality is due to *C. shasta* and *P. minibicornis* in the Lower Klamath River downstream from Iron Gate Dam. Among all of the 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). 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 and carcasses 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. 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 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. Because polychaete populations are located outside of the main flow along the margins of the riverbanks (Bartholomew and Foott 2010), variable flows disrupt this habitat. 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; Bartholomew and Foott 2010) 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 to move upstream in the mainstem Klamath River and tributaries. However, available information 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 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*.

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). 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 introduction 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)).

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 infections nidus (reach with highest infectivity) for *C. shasta* and *P. minibicornis* may be recreated upstream where salmon spawning congregations occur, and there is associated uncertainty (Foott et al. 2011), the likelihood of this happening appears to be remote for the following reasons. 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 Klamath River in the reach from the Shasta River downstream to Seiad Valley (FERC (2007; Bartholomew and Foott 2010). Here, flows in that reach that mimic natural conditions, combined with reestablishment of natural sediment transport rates, would restore natural geomorphic channel forming processes (Hetrick et al. 2009) necessary to create diverse habitat and reduce the influence of those synergistic factors that currently create conditions favorable for disease. Under a dams out alternative, those conditions that are believed to result in development of an infectious nidus below Iron Gate Dam, or a could result in development of a potential infectious nidus above Iron Gate Dam, are unlikely to occur.

Further, the likelihood of those synergistic factors in the Williamson River would be reduced as carcasses would likely be more dispersed in the watershed (Foott et al. 2011), and flow variability will act to reduce polychaete habitat stability above the Williamson River mouth. *C. shasta* in the Williamson River is currently maintained by planting of susceptible rainbow trout that become infected, likely produce myxospores, and die within a restricted reach in the lower Williamson River.

In addition, under a scenario of potential 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; p. 40), thus missing the time of year when water temperatures in the Williamson River might possibly be conducive to disease. In some years, maximum temperatures in the Williamson River do not exceed the disease threshold of 15 C (Bartholomew and Foott 2010; Hamilton et al. 2010). The risk of a juvenile salmon disease response here would be lower than the current zone but not negligible in all water years (Scott Foott, USFWS, 2012, pers. comm.).

Historically, it appears spawning concentrations of upper basin Chinook salmon took place primarily in the Sprague River (Lane and Lane Associates 1981). There is no information indicating that high densities of polychaetes occur in the Sprague River (Foott et al. 2011). Thus, the synergistic factors that contribute to an infectious nidus for emigrants below Iron Gate Dam and near the Iron Gate Hatchery are unlikely to occur here either. There is some concern regarding a disease zone in the lower Williamson River downstream from the confluence with the Sprague River (Hurst et al. 2012). However, some Chinook emigrants from both these tributaries may very well emerge from groundwater areas early, then rear in Upper Klamath Lake, with growth opportunities that allow them to migrate when they can minimize exposure to *C. shasta*.

The 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 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 from Iron Gate Dam. This would also decrease the associated bioaccumulation of microcystin in fish tissue for species downstream 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 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 2012), increasing flows downstream 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 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 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 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; Reclamation 2012), flow variability would increase.

Restoration of the hydrologic function of the river system is paramount to creating habitat diversity and maintaining biophysical attributes of a river system (Stanford et al. 1996; Poff et al. 1997). Although implementation of Alternative 2 or 3 will not fully restore the natural hydrologic regime of the Klamath River, it would result in a flow pattern that mimics pre dam conditions, having greater intra- and inter-annual variability than exists today with the Klamath Dams in place (Hetrick et al. 2009). Implementation of the KBRA will provide flexibility to manage flows that respond to real-time climatic and biological conditions, thereby 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 we expect will reduce polychaete populations (Stocking and Bartholomew 2007) and presumably, reduce infection rates within polychaete populations (Hetrick et al. 2009).

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, http://www.nap.edu/openbook.php?record_id=10838&page=144). These hydrologic effects would likely be more important in upstream areas (directly downstream from Iron Gate Dam) than downstream areas (downstream from the confluence of the Scott River) due to the substantial flow contribution of tributaries to the Klamath River (Reclamation 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 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, 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 increase supply of gravel 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 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). 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, 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 from the J.C. Boyle Powerhouse. As discussed in detail above, the thermal lag formerly caused by water storage in reservoirs and the associated increased thermal mass would be eliminated in the Lower Klamath River. This elimination would cause water temperatures 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 temperature more favorable for salmonids in the 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 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, reservoir drawdown associated with dam removal under the Proposed Action could alter the quality of 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 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 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 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 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 3.3.4.3.2). 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 near-shore environment and estuary, the Proposed Action would have a less-than-significant effect on EFH for groundfish in the short and long term.**

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 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 Quantitative modeling of fall-run Chinook salmon populations suggests that the Proposed Action would increase population abundance. Modeling of dam removal and existing conditions by Oosterhout (2005) suggests that dam removal would substantially increase numbers of spawners over a 50-year period relative to other management scenarios. Additional 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, and ocean conditions; and presented variance estimates of uncertainty. Hendrix (2011) applied a life-cycle model (EDRRA) to forecast the abundance of Chinook salmon (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. Neither implementation of total maximum daily loads (TMDLs) nor climate change was incorporated into the existing models, including the Chinook salmon life cycle model (EDRRA) developed by Hendrix (2011).

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. The 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.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> 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 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 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, 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) related to implementation of TMDLs and that would help meet beneficial uses such as anadromous fish (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 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 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 six months, and revert to and maintain pool-riffle morphology due to restoration of riverine processes, creating holding and rearing habitat for anadromous salmonids.

Modeling (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 percent) of sand immediately following reservoir drawdown until a 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. 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). 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 from Iron Gate Dam

The Proposed Action would decrease dissolved oxygen and release dam-stored sediment downstream to the 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 3.3-5). 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 mortality from suspended sediment is anticipated to include the following:

- Under the most-likely-to-occur or worst-case scenario complete loss of eggs from the 2019 brood year deposited in the mainstem in fall 2019 is predicted. Based on redd surveys from 1999 through 2009 (Magneson and Wright 2010), an average of around 2,100 redds could be affected. 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 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 percent mortality is predicted, or around 0 to 189 smolts (around 0.02 percent

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 2,100 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 2,100 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 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 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 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 from Iron Gate Dam), as sediment deposition would lessen downstream 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 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 Klamath River. Flows under the Proposed Action are intended to benefit fall-run Chinook salmon, and are anticipated to have positive consequences for Chinook salmon given their life cycle in the Klamath River.

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 synchronized with historical migration and spawning periods (Hamilton et al. 2011). 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 temperatures more favorable for 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).

<u>Estuary</u>
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. 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. 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 Klamath River, where SSCs resulting from the Proposed Action are expected to be lower due to dilution from tributaries. **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 hundreds of miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach. 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. 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. 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.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u>
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 significant tributaries in the Upper Klamath Basin, comprising 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 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 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, 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 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 (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).

<u>Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>

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), 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 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 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 the incidence of disease and algal toxins.

Lower Klamath River: Downstream from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the 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 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, 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 percent of all production). Type I and Type II juvenile outmigrants are expected to experience sublethal effects.

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

	Life History Stage: Spring-run Chinook Salmon			
Scenario	**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.

<u>Estuary</u>

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. Flow and water temperature effects would likely not extend downstream to the estuary.

<u>Summary: Spring-Run Chinook Salmon</u>

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 some Type III smolts (< 1 percent of production). **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, fish disease incidence, and algal toxins which could affect spring-run Chinook salmon in the long term. Dam removal would restore connectivity to 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. 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: "Although Current Conditions will likely continue to be detrimental to coho, 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, and the potential risk for disease and low ocean survival to offset gains in production in the new habitat."

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u>
There is no historical evidence that coho salmon occurred upstream of J.C. Boyle Reservoir. However, in historical interviews Snyder (1931) noted that while, "silver salmon are said to migrate to the headwaters of the Klamath to spawn, the interviews were not conclusive since most people at the time did not distinguish between the various anadromous salmonid species. Overall, historical evidence of coho salmon occurrence upstream of Spencer Creek and J.C. Boyle reservoir is uncertain.

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>
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 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 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 result in more favorable water temperature for salmonids, as well as improve water quality and reduce 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 from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the 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 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

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 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 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 (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 from Iron Gate Dam could improve over existing conditions. Within six months the river is predicted to revert to and maintain a pool-riffle morphology, providing a benefit to coho salmon.

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

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. 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 redds and smolts 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 Klamath River populations under the most likely or worst-case scenarios. All population units would be expected to recover from these losses within one or two generations, given the benefits described below. **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, 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 Klamath River, Mid-Klamath River, Shasta River, Scott River, Salmon River, and 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. 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 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). This would be a potential increase 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).

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 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 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 from Iron Gate Dam

The Proposed Action would release dam-stored sediment downstream to the 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)**
Most likely	**Existing Conditions (normal)**					
	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

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 (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 Klamath River. 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. 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. All of these long-term changes would benefit steelhead using the Lower Klamath River Reach.

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 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. 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 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 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 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 hundreds of miles of historical habitat in the Upper Klamath Basin and would create additional habitat within the Hydroelectric Reach. 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. 2011b). 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 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 lamprey (Close et al. 2010). The conclusion was that the Proposed Action could increase Pacific lamprey 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 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.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u>
Pacific lamprey occurred historically at 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).

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>
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 six 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. 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 that occur within the Hydroelectric Reach.

Lower Klamath River: Downstream from Iron Gate Dam

The Proposed Action would release dam-stored sediment and reduce dissolved oxygen downstream to the 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 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 bed material within the reservoirs and between Iron Gate to Cottonwood Creek is expected to have a high content (30 to 50 percent) of sand immediately following reservoir drawdown until a 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 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 Klamath River.

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 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 Sections 3.3.4.4.2 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 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.

<u>Lower Klamath River: Downstream from Iron Gate Dam</u>
The Proposed Action would release dam-stored sediment downstream to the 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 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 Klamath River and would improve water quality and reduce instances of algal toxins. These long-term effects would benefit green sturgeon using the Lower Klamath River reach.

<u>Estuary</u>
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. Flow and water temperature effects resulting from the Proposed Action would likely not extend downstream to the estuary.

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

<u>Summary: Green Sturgeon</u>

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 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 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 concurrence by the State of California, CDFG will provide draft legislation to the other KHSA/KBRA parties which would authorize limited take of 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 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 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.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u>
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 from Keno Dam would eliminate the stranding of redband trout caused by flow reductions at Klamath Hydroelectric Project facilities.

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). Furthermore, anadromous steelhead trout and resident rainbow/redband trout 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 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.

<u>Summary: Redband Trout</u>
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 restore connectivity among the Lower Klamath Basin, the Hydroelectric Reach and 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 improved habitat quality, the effect of the Proposed Action would be beneficial for redband trout in the long term.**

Bull Trout
<u>Upper Klamath River Upstream of the Influence of J.C. Boyle Reservoir</u>
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).

<u>Summary: Bull Trout</u>
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
<u>Lower Klamath River: Downstream from Iron Gate Dam and Estuary</u>
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 from Iron Gate Dam
A few introduced resident species occur in the 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

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 mg/L for 2 to 3 months would occur as far downstream as Klamath Station (at RM 5.0; see Figure 3.3-14); 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 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 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 from Cottonwood Creek are not predicted to have any substantial aggradation.

Of the freshwater mussel species found on the mainstem Klamath River, the western 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 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 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 6 months (see 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 colonized or 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.

<u>Summary: Freshwater Mussels</u>
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 restore connectivity among the Lower Klamath Basin, the Hydroelectric Reach and 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
<u>Peaking Effects</u>
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).

<u>Suspended Sediment Concentrations</u>
Under the Proposed Action, increased SSCs would be expected to affect filter-feeding BMI populations 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 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 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 restore connectivity among the Lower Klamath Basin, the Hydroelectric Reach and 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 improved habitat quality, the effect of the Proposed Action on macroinvertebrates would be beneficial in the long term.**

<u>Deconstruction</u>
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 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 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, 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. 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.). 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.

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 Westside Facilities – Programmatic Measure

Decommissioning the East and Westside Facilities could cause adverse aquatic resource effects. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would no longer divert water flows at Link River Dam into the two canals. 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. **Implementation of the East and Westside Facility Decommissioning action would be beneficial for suckers and redband, and no change from existing conditions for other aquatic species.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

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 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 City of Yreka Water Supply Pipeline would have less-than-significant impacts to aquatic resources.**

KBRA – Programmatic Measures

The KBRA, which is a 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 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 and establish a monitoring and adaptive management program to evaluate and optimize the success of restoration actions.

Measures that are ongoing in the 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. 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 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 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.

As specified in the KHSA, volitional upstream and downstream passage facilities (screens and ladders) would be developed for passage around 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 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[7]. 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 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/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/Lake Ewauna.
3. For fall-run Chinook salmon emigrants, the seasonally 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 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.

[7] 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.).

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.

A plan would be developed for monitoring groundwater in order to restrict pumping to no more than 6 percent of the output of springs listed in the KBRA Section 15.2.4.A.i. This measure would protect an important resource that provides 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 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 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 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 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. 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 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 BMIs would be no change from existing conditions.**

<u>Fish Entrainment Reduction</u>

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 BMIs would be no change from existing conditions.**

Klamath Tribes Interim Fishing Site

Implementation of the Klamath Tribes Interim Fishing Site could result in alterations to managed harvest mortality of fish species that are culturally important to the Klamath 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 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 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 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

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.

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 therefore have no long-term effect on aquatic resources. These IMs would 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 Westside Facilities – Programmatic Measure

Decommissioning the East and Westside Facilities could cause adverse aquatic resource effects. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would no longer divert water flows at Link River Dam into the two canals. 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. **Implementation of the East and Westside Facility Decommissioning action would be beneficial for suckers and redband, and no change from existing conditions for other aquatic species.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

The Proposed Action would require the relocation of the City of Yreka Water Supply Pipeline. Under the Partial Facilities Removal Alternative, the relocation of the City of 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 DOI and DOC 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 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 CFR 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 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 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. 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 this EIS/EIR would need to comply with the Section 18 prescriptions for the construction, operation, and maintenance of upstream and downstream passage (DOI 2007). General prescriptions cover anadromous (fall- and spring-run Chinook salmon, coho salmon, steelhead, and Pacific lamprey) and resident (rainbow and redband trout, shortnose and Lost River suckers) fish passage at all Klamath Hydroelectric Project dams, and include implementing operation and maintenance 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 water quality certification conditions to allow year-round volitional passage.

Under the Fish Passage at Four Dams Alternative, Iron Gate Hatchery will continue to 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. 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 high from June to September (see Section 3.2.3.2) and surface layers may seasonally exceed thermal tolerances for 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 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 will persist, including current warm temperatures in late summer and fall (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 would be reduced under the 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 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 post spawn salmon carcasses downstream from Iron Gate Dam may still be elevated associated with the continued operation of Iron Gate Hatchery. Provision of fish passage would allow anadromous salmonid migration to move upstream in the mainstem Klamath River and tributaries. Available information 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 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*.

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). 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 introduction 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)).

Available information also indicates that risks associated with movement of 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 infections nidus (reach with highest infectivity) for *C. shasta* and *P. minibicornis* may be recreated upstream where salmon spawning congregations occur, and there is associated uncertainty (Foott et al. 2011), the likelihood of this happening appears to be remote for the following reasons. 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 Klamath River in the reach from the Shasta River downstream to Seiad Valley (FERC (2007; Bartholomew and Foott 2010). Here, flows in that reach that mimic natural conditions, combined with reestablishment of natural sediment transport rates, would restore natural geomorphic channel forming processes (Hetrick et al. 2009) necessary to create diverse habitat and reduce the influence of those synergistic factors that currently create conditions favorable for disease. Under a dams out alternative, those conditions that are believed to result in development of an infectious nidus below Iron Gate Dam, or a could result in development of a potential infectious nidus above Iron Gate Dam, are unlikely to occur.

Further, the likelihood of those synergistic factors in the Williamson River would be reduced as carcasses would likely be more dispersed in the watershed (Foott et al. 2011), and flow variability will act to reduce polychaete habitat stability above the Williamson River mouth. *C. shasta* in the Williamson River is currently maintained by planting of susceptible rainbow trout that become infected, likely produce myxospores, and die within a restricted reach in the lower Williamson River.

In addition, under a scenario of 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; p. 40), thus missing the time of year when water temperatures in the Williamson River might possibly be conducive to disease. Although their research was focused on dam removal, access to the habitat above Iron Gate Dam through other means, such as fishways under Alternative 4, would likely have a similar outcome. In some years, maximum temperatures in the Williamson River do not exceed the disease threshold of 15 C (Bartholomew and Foott 2010; Hamilton et al. 2010). The risk of a juvenile salmon disease response here would be lower than the current zone but not negligible in all water years (Foott 2012).

Historically, it appears spawning concentrations of upper basin Chinook salmon took place primarily in the Sprague River (Lane and Lane Associates 1981). There is no information indicating that high densities of polychaetes occur in the Sprague River (Foott et al. 2011). Thus, the synergistic factors that contribute to an infectious nidus for emigrants below Iron Gate Dam and near the Iron Gate Hatchery are unlikely to occur here either. There is some concern regarding a disease zone in the lower Williamson River downstream from the confluence with the Sprague River (Hurst et al. 2012). However, some Chinook emigrants from both these tributaries may very well emerge from groundwater areas early, then rear in Upper Klamath Lake, with growth opportunities that allow them to migrate when they can minimize exposure to *C. shasta*.

<u>Algal Toxins</u>

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 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 Upper Klamath Lake would occur.

Hydroelectric Reach: 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 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 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 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 (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 from Iron Gate Dam would occur.

<u>Aquatic Habitat</u>
Under the Fish Passage at Four Dams Alternative 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 water temperatures.

Fish 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 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. Similar to existing conditions, they would be warmer in the summer and fall when adults are migrating upstream and may pose a degree of seasonal risk to adult migrants downstream from Iron Gate Dam, upon entry into the reservoirs, and in bypass reaches. The incidence of fish disease in salmon would be reduced under the 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 post spawn salmon carcasses downstream from Iron Gate Dam may still be elevated associated with the continued operation of Iron Gate Hatchery.

In terms of 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 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. Fish Passage at Four Dams Alternative would not affect critical habitat for this species. Implementation of this alternative is expected to increase production of wild Chinook salmon by providing anadromous salmonids with access to habitat upstream of Iron Gate Dam. 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 stocks (Hanson et al. 2010); therefore, any increase in salmon production from 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 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, fishways at Four Dams could alter the availability of habitat resulting in effects on aquatic species.

Fall-Run Chinook Salmon

Upper Klamath Basin 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 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). 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 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 of 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 (Buchanan et al. 2011b). 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 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 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)[8], 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. 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, and algal toxins would be the same as under existing conditions.

Under this alternative fish migrating through reservoirs would be seasonally exposed to some degree to stressful water quality conditions including high temperatures in reservoir

[8] 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.

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 stressful in June through September, contributing to lower resistance to disease seasonally. 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 fact that anadromous fish currently complete life cycles through eight dams and reservoirs on the Columbia and Snake rivers, and historically completed life cycles through Upper Klamath Lake, provides strong evidence that anadromous salmonids could also migrate through the reservoirs created by Project facilities (Administrative Law Judge 2006).

Lower Klamath River: Downstream 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. 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). Coarsening of the bed could reduce spawning habitat for fall-run Chinook salmon 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 Klamath River downstream 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 continuation of warm water releases from Iron Gate Dam will contribute to the delay in adult upstream migration of fall-run Chinook salmon (Dunsmoor and Huntington 2006), and increase the risk of prespawn mortality (Hamilton et al. 2011).

As described above, the incidence of fish disease for fall-run Chinook salmon would be reduced under the Fish Passage at Four Dams Alternative relative to existing conditions. Dissolved oxygen concentrations during August-October immediately downstream from Iron Gate Dam would continue to be low (less than 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 from Iron Gate Dam.

<u>Estuary</u>
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, 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 could 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 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 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 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). 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). Overall, the Fish Passage at Four Dams Alternative would provide access to 49 significant tributaries in the Upper Klamath Basin, comprising 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 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).

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 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 to November 15). 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 would provide approximately 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),[9] 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

[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.

Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. 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 of access to cooler water from tributaries, 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 this alternative, suspended and bedload sediment, water quality, and the occurrence of fish disease and algal toxins would be the same as under existing conditions.

This alternative would result in continuation of 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 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 in the fall, as flows increase. Therefore water quality in reservoirs is expected to have minor effects on this species.

Lower Klamath River: Downstream 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. 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 Klamath River downstream 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). 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, including increased risk of disease, and high rates of delayed spawning and prespawn mortality (Hetrick et al. 2009).

As described above, the incidence of fish disease for spring-run Chinook salmon would be reduced under the Fish Passage at Four Dams Alternative relative to existing conditions. Dissolved oxygen concentrations during August-October immediately downstream from Iron Gate Dam would continue to be low (less than 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 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, 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. As described below, predation could result in 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 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 from Iron Gate Dam would experience a continuation of existing 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 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 Upstream End of J.C. Boyle Reservoir to Iron Gate Dam 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). 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 and all tributaries upstream at least as far as Spencer Creek, including Jenny, Shovel, and Fall creeks (Hamilton et al. 2005). Passage through the reach would provide approximately 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 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. 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

[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.

provide fish with some refuge from high temperatures because of access to cooler water from tributaries, 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).

Under this alternative, suspended and bedload sediment, water quality, and the occurrence of algal toxins would be the same as under existing conditions.

This alternative would result in continuation of 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 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 available information 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 effect on this species.

Lower Klamath River: Downstream 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. 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 Klamath River downstream 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).

As described above, the incidence of fish disease for coho salmon would be reduced under the Fish Passage at Four Dams Alternative relative to existing conditions. Dissolved oxygen concentrations during August-October immediately downstream from Iron Gate Dam would continue to be low (less than 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 from Iron Gate Dam.

Estuary

The Fish Passage at Four Dams Alternative is not expected to substantially change or affect coho salmon estuarine habitat relative to existing conditions.

Summary: Coho Salmon

Under this alternative, 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).

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 effects, and the three Trinity River population units, and the 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 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,). This would be a potential increase 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. 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 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).

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.

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, consistent with mandatory conditions (DOI 2007). 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.

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 stressful to fish from

June through September (Dunsmoor and Huntington 2006; FERC 2007). 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.

Lower Klamath River: Downstream 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 would continue to trap fine and coarse sediment. 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 Klamath River up to Iron Gate Dam (Stillwater 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 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 Klamath River downstream 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 et al. 2005). Dissolved oxygen concentrations during August-October immediately downstream from Iron Gate Dam would continue to be low (less than 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 from Iron Gate Dam.

<u>Estuary</u>
The Fish Passage at Four Dams Alternative is not expected to substantially change or affect steelhead estuarine habitat relative to existing conditions.

<u>Summary: Steelhead</u>
Under this alternative, 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 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. 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 occurred historically 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 (Administrative Law Judge 2006), and may not 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 habitat upstream 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 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. 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 from Iron Gate Dam Under the Fish Passage at Four Dams Alternative, Klamath Hydroelectric Project Dams would continue to trap fine and coarse sediment. 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 from Iron Gate Dam would continue to be starved of fine sediment. Coarsening of the bed could reduce spawning habitat for lamprey downstream 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 Klamath River downstream 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, 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 Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. 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 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 from Iron Gate Dam would experience a continuation of existing 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, fishways at Four Dams could result in alterations in habitat availability which could affect 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 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 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 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. 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.

Redband could be affected by the reintroduction of anadromous fish, including the potential for competition, predation, and exposure 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 fish passage criteria and the ladder impairs upstream migration (Administrative 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 through time, benefiting this species. Climate change would result in warmer conditions, which would reduce the suitability of habitat.

<u>Summary: Redband Trout</u>
Under this alternative, 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 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.

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, 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. **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 primarily 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.[11] 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 Keno Impoundment/Lake Ewauna could result in limited, seasonal mortality as follows:

[11] 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. 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/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/Lake Ewauna.
3. For fall-run Chinook salmon emigrants, the seasonally 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 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 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 described 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 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 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, 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.

In the Hydroelectric Reach, 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 (i.e., long-term increases in spring water temperatures and decreases in late summer/fall water temperatures) (see Section 3.2.4.3.5).

Fish Disease and Parasites

Under this alternative, there would be fewer deleterious effects in terms of fish disease as compared to 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 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 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 from Iron Gate Dam will be increased as described for the Proposed Action, with the exception of downstream 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 existing conditions. Fish passage upstream by anadromous salmonids would increase under this alternative, 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 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 (FERC 2007).

Provision of fish passage would allow anadromous salmonid migration to move upstream in the mainstem Klamath River and tributaries. Available information 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 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*.

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). 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 introduction 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)).

Available information also indicates that risks associated with movement of 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 infections nidus (reach with highest infectivity) for *C. shasta* and *P. minibicornis* may be recreated upstream where salmon spawning congregations occur, and there is associated uncertainty (Foott et al. 2011), the likelihood of this happening appears to be remote for the following reasons. 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 Klamath River in the reach from the Shasta River downstream to Seiad Valley (FERC (2007; Bartholomew and Foott 2010). Here, flows in that reach that mimic natural conditions, combined with reestablishment of natural sediment transport rates, would restore natural geomorphic channel forming processes (Hetrick et al. 2009) necessary to create diverse habitat and reduce the influence of those synergistic factors that currently create conditions favorable for disease. Under a dams out alternative, those conditions that are believed to result in development of an infectious nidus below Iron Gate Dam, or a could result in development of a potential infectious nidus above Iron Gate Dam, are unlikely to occur.

Further, the likelihood of those synergistic factors in the Williamson River would be reduced as carcasses would likely be more dispersed in the watershed (Foott et al. 2011), and flow variability will act to reduce polychaete habitat stability above the Williamson River mouth. *C. shasta* in the Williamson River is currently maintained by planting of susceptible rainbow trout that become infected, likely produce myxospores, and die within a restricted reach in the lower Williamson River.

In addition, under a scenario of potential 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; p. 40), thus missing the time of year when water temperatures in the Williamson River might possibly be conducive to disease. Although their research was focused on dam removal, access to the habitat above Iron Gate Dam through other means, such as fishways under Alternative 4, would likely have a similar outcome. In some years, maximum temperatures in the Williamson River do not exceed the disease threshold of 15 C (Bartholomew and Foott 2010; Hamilton et al. 2010). The risk of a juvenile salmon disease response here would be lower than the current zone but not negligible in all water years (Foott 2012).

Historically, it appears spawning concentrations of upper basin Chinook salmon took place primarily in the Sprague River (Lane and Lane Associates 1981). There is no information indicating that high densities of polychaetes occur in the Sprague River (Foott et al. 2011). Thus, the synergistic factors that contribute to an infectious nidus for emigrants below Iron Gate Dam and near the Iron Gate Hatchery are unlikely to occur here either. There is some concern regarding a disease zone in the lower Williamson River downstream from the confluence with the Sprague River (Hurst et al. 2012). However, some Chinook emigrants from both these tributaries may very well emerge from groundwater areas early, then rear in Upper Klamath Lake, with growth opportunities that allow them to migrate when they can minimize exposure to *C. shasta*.

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 from 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*, alleviating the transport of high seasonal concentrations of algal toxins to the Klamath River downstream from Iron Gate Dam. This would also decrease the associated bioaccumulation of microcystin in fish and mussel tissue for species downstream 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 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 would restore 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. 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 from Iron Gate Dam would increase over 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 would likely be improved from restored riparian vegetation in the long term.

Aquatic Resources Effects

Critical Habitat

As described below, 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. Fish passage would be provided past the two remaining dams.

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.

Copco 1 and Iron Gate Reservoirs also cause the majority of the water temperature and water quality issues in the Hydroelectric Reach, so water quality conditions would be improved relative to existing conditions within the Hydroelectric Reach and to areas downstream from Iron Gate Dam as well.

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 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 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, reservoir drawdown associated with dam removal under this alternative could alter the quality of 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 improved over existing conditions by providing passage past the remaining two dams.

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 improved relative to existing conditions. These water quality improvements would accrue to areas downstream 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, 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 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). Poor water quality (e.g., severe hypoxia, temperatures exceeding 25 °C, high pH) in the reach from Keno Dam to 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. The potential habitat under the two remaining reservoirs for the production of anadromous 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 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 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 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 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 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).

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. 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 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). 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 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.

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. As with conditions for fall-run Chinook salmon, disease conditions would be reduced under this alternative.

Lower Klamath River: Downstream 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 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 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

Under the Fish Passage at J.C. 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 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 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 the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative.

Hydroelectric Reach: 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 access would be restored for the 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. 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.

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. As described for fall-run and spring-run Chinook salmon above, disease conditions would be reduced under this alternative.

Lower Klamath River: Downstream 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 Klamath River. Suspended and bedload sediment conditions and effects on coho salmon in the 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 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 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). This would be 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. 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 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 salmonids for at least the October through May period (Maule et al. 2009).

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 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.

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.

Lower Klamath River: Downstream 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 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 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 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 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 hundreds of miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach, 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 occurred historically 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).

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. 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. Removal of the two dams would likely result in more favorable water temperature for lamprey and other native fishes, and would improve water quality.

Lower Klamath River: Downstream 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

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 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 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 among the Lower Klamath Basin, the Hydroelectric Reach and its tributaries among the Lower Klamath Basin, the Hydroelectric Reach and its tributaries, 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 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 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 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 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 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 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. As described for the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would 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 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 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, if there is an Affirmative Determination by the Secretary, and a concurrence by the State of California, CDFG will provide draft legislation to the other KHSA/KBRA parties which would authorize limited take of 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 from Keno Dam; therefore, the increases in stream habitat upstream of J.C. Boyle Dam might not be realized under this alternative.

Redband could be affected by the reintroduction of anadromous fish, including the potential for competition, predation, and exposure to disease, as described for the Proposed Action above.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam 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 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 restore connectivity among the Lower Klamath Basin, the Hydroelectric Reach and 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 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 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 from Iron Gate Dam Under this alternative, suspended sediment conditions and effects on eulachon in the 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 Based on the lower magnitude of SCC, the 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 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 Klamath River, but would not be expected to reach the area potentially used by longfin smelt. Longfin smelt using the 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

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 Upstream End of J.C. Boyle Reservoir to Iron Gate Dam 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 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 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 2,100 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 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 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 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 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 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 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 from 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 from 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 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 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 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 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 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 from J.C. Boyle Dam and terminating approximately 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 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 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 Klamath River, downstream 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 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 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. 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	**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**
	Proposed Action					
Summer and Winter Steelhead	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**
	Proposed Action with Mitigation Measure AR-2					
Summer and Winter Steelhead	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	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

	Life History Stage				
Species	**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.

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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 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 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, and peaking reaches and including tributaries to the Klamath River (examples include Jenny, Spencer, Slate, Shovel, and Fall creeks).
3. Lower Klamath River: downstream 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 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 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). 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 mg of chlorophyll-a/m^2. The Hoopa Valley Tribe also uses 150 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)
- 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 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 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 form the base of the food web in the reservoirs. Phytoplankton 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 biomass 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 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), dissolved oxygen crashes due to the decomposition of decaying algal biomass, and in extreme conditions, disruption of food webs. 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, 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) where they can out-compete other algal species such as diatoms. 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.

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, dissolved oxygen, and pH cycles. Within the Klamath Basin, blue-green algal productivity is locally and seasonally associated with extreme daily fluctuations in dissolved oxygen levels (high during the day and low at night), 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 from the Oregon-California State line to the Klamath Estuary are included on the CWA Section 303(d) list of water bodies with water quality impairments

[1] Pertaining to a lake or other calm water types.

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 concentrations as described above. *M. aeruginosa* requires an aquatic source of dissolved inorganic nitrogen 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* 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. In contrast to *M. aeruginosa*, toxin 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, 2009; CH2M Hill 2009; Teh et al. 2010), including potential adverse effects to endangered juvenile suckers in Upper Klamath Lake (VanderKooi et al. 2010; see Section 3.3.3.2 Physical Habitat Descriptions - Water Quality - Algal Toxins). The World Health Organization (WHO) guidelines for exposure to microcystin were exceeded in 2007–2008 in Upper Klamath Lake (VanderKooi et al. 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, 2007, 2008; Kann 2008; Kann and Corum 2009), the Klamath River from Copco 1 Reservoir (RM 203.1) to 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).

3.4.3.2 Periphyton

Periphyton are generally dominated by diatoms and green algae. Blue-green algae can also occur in the periphyton community, but they are typically a small component of the community and do not reach nuisance levels. Like phytoplankton in lakes and reservoirs, periphyton are important components in the base of the food web in riverine systems. Periphyton can also play an important role in riverine water quality, affecting nutrient cycling and resulting in diel (24-hour cycle) fluctuations in dissolved oxygen and pH (Anderson and Carpenter 1998, Kuwabara 1992, Tanner and Anderson 1996). Excessive swings in dissolved oxygen and pH can be stressful to aquatic biota, such that too much periphyton can adversely affect 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.

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 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*. The factors influencing periphyton abundance and community composition are complex and include abiotic factors such as nutrients, substrate, flow velocity, shading, light availability, 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

Multiple peer-reviewed sediment core studies indicate that Upper Klamath Lake was historically a biologically productive lake (i.e., the lake produced abundant fish and algae blooms) as indicated by high nutrient concentrations (particularly phosphorus) in the sediments and algal cell remains, including remains of blue-green algae species (Eilers et al. 2001, 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 hypereutrophic[2] 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 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[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, 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

[2] 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) 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 as described further in Section 3.4.3.4.

The reach from Link River to Keno Dam has extremely poor water quality, especially during summer months, with water temperatures exceeding 25ºC, pH approaching 10 units, dense algal blooms, and 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 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 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 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 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 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 with distance downstream (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, the decreasing riverine trend is interrupted by large summer and fall blooms 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 spring to early summer, followed by a period of low chlorophyll-*a* concentrations (FERC 2007; 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, dominated by *Aphanizomenon flos-aquae* and *M. aeruginosa* (Asarian and Kann 2011; Kann 2006; FERC 2007; 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.

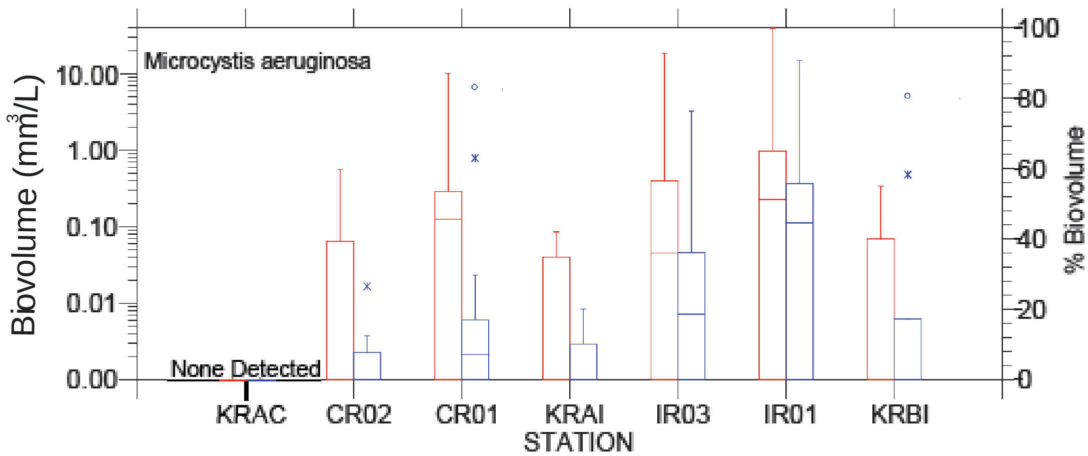

Figure 3.4-1. Biovolume (in red) and percent biovolume (in blue) of Microcystis aeruginosa above, within, and downstream from Copco 1 and Iron Gate Reservoirs during 2005. Station definitions: KRAC, Klamath River above Copco Reservoir; CR01, Copco Reservoir Station 1; CR02, Copco Reservoir Station 2; 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 the reach. Recent data indicate that while microcystin 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. This pattern reverses, however, as water is impounded in 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 2005, high levels of microcystin have prompted the posting of public health advisories around the Copco and Iron Gate

Reservoirs, and during certain years, along 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 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 can result in bioaccumulation of microcystin 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 in fish and mussel tissue.

3.4.3.4.2 Periphyton

Nuisance blooms of periphyton have not been documented in the riverine portions of this reach. In the J.C. Boyle 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 from Iron Gate Dam

3.4.3.5.1 Phytoplankton

Although both *Aphanizomenon flos-aquae* and *M. aeruginosa* have been observed just downstream from Iron Gate Dam, and as far downstream as the Klamath Estuary, this reach of the river is more suitable for the growth of periphytic algae, and does not provide optimal habitat for phytoplankton species that typically thrive in reservoir and lake environments. 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 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). 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 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).

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 from Iron Gate Dam revealed a shift in community composition, where nitrogen-fixing species are not present directly downstream 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 from Iron Gate Dam, Eilers (2005) 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 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 from the Collier Rest Area, both periphyton coverage and chlorophyll content increased gradually to peak levels near the confluence with the Salmon River (RM 67). While periphyton biomass was generally found to be low to moderate 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 approximately 600 cfs around August 15 to approximately 1,200 cfs near the end of August, and decreasing to approximately 800 cfs by September 1, the start of the 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 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 is dominated by phytoplankton, but has more periphyton in the upstream areas where the estuary has more riverine characteristics. The presence of brackish water influences the types of algae present in different areas of the estuary. Like the Lower Klamath River, the Klamath Estuary has an algal community composed primarily of diatoms and blue-green algae (Fetcho 2007, 2008, 2009). Phytoplankton densities are generally lower in this area than those measured concurrently in the 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, 2008). These instances of elevated levels of *M. aeruginosa* corresponded with elevated levels measured at upstream locations in the Lower Klamath River.

Although periphyton data for the estuary 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 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. 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 Methods

Existing information regarding blue-green algal blooms in the Klamath Basin suggests that several critical factors 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. In addition to Upper Klamath Lake and Copco 1 and Iron Gate Reservoirs, riverine reaches in close proximity to the reservoirs generally experience high abundance of *M. aeruginosa* (Kann 2006, Kann and Corum 2009), and with the highest cell densities and microcystin toxin concentrations 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 assessment of the effects of the Proposed Action and 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 nutrient availability. Existing model output and empirical data describing the expected effects of dam removal on water quality (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 optimal habitat for blue-green algae or periphyton in the area of analysis.

The following specific metrics are evaluated:

- The extent to which monthly mean and maximum water temperatures would be within the range of 18 to 25 °C or exceed 28 °C;
- Total suspended sediment and nutrient concentrations; and,
- The presence or absence of lacustrine (i.e., lake-like) conditions.

The water temperature thresholds are selected based on information regarding required temperatures for growth and toxicity of blue-green algae provided in the Blue-Green Algae Work Group assessment (SWRCB et al. 2010) and Van Der Westhuizen and Eloff (1985). 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, 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 are also used 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., *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. 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 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 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 caused by these intense blue-green algae blooms (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

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 in the Klamath River downstream from Iron Gate Dam. Periphyton growth could continue to be relatively high downstream 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. However, 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 in Total Nitrogen (TN) may not result in significant biostimulatory effects on periphyton growth 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 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 algal biomass in these reaches because it will be accompanied by only relatively minor increases in TP. In addition, overall TN and TP increases 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. Potential increases in periphyton growth could be counteracted by more frequent river bed turnover (see Section 3.3.3.6.2.1.2 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, Appendix 2). The magnitude of the effect of bed turnover and scouring on periphyton would 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, 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 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. **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.**

Klamath Estuary

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 indicates that 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 in the Lower Klamath River (see prior section), levels in the Klamath Estuary are also likely to be reduced or eliminated.

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 Klamath River downstream from Iron Gate Dam, periphyton growth under the Proposed Action could be affected by increased nutrient availability following dam removal. However, the long-term increase in nutrients in the Klamath Estuary would be 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, 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

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*) therefore effects on these species under the Proposed Action 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 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.**

East and Westside Facilities – Programmatic Measure

Decommissioning the East and Westside Facilities could cause adverse effects to algae. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would eliminate water diversions at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there would be no change in algae conditions in the Klamath River. **Therefore, implementation of the East and 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 City of Yreka Water Supply Pipeline required as part of the removal of Iron Gate Dam would not affect algae. The water supply pipeline for City of 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 City of Yreka Water Supply Pipeline relocation.**

KBRA – Programmatic Measures

The KBRA, which is a 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 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 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 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 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 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/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 from Iron Gate Dam, and the Klamath Estuary. 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 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 from Iron Gate Dam and in the Klamath Estuary could also occur and 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[3]. Long-term increases in the growth of nuisance periphyton in the Klamath River downstream from Iron Gate Dam, and the Klamath Estuary would be a less than significant impact.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measure

Removal of Iron Gate Dam would require relocation of the City of 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 City of 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. **There would be no impact to algae in the Hydroelectric Reach or the Klamath River downstream from Iron Gate Dam as a result of the City of Yreka 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

[3] 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

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 would not affect phytoplankton in the Klamath River upstream of J.C. Boyle Reservoir	2, 3, 5	NCFEC	None	NCFEC
Dam removal activities would not affect periphyton in the Klamath River upstream of J.C. Boyle Reservoir	2, 3, 5	NCFEC	None	NCFEC
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
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	NCFEC	None	NCFEC
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	2, 3, 5 [2]	S	None	S

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
Dam.				
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.	4	LTS	None	LTS
Implementation of IM 7, J.C. Boyle Gravel Placement and/or Habitat Enhancement, could result in increased bedload mobility and the potential for increased scour of nuisance periphyton in the Hydroelectric Reach.	2 ,3	B	None	B
Klamath River Downstream from Iron Gate Dam				
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 from Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Continued impoundment of water at the Four Facilities could support long-term growth of nuisance periphyton such as *Cladophora spp.* downstream from Iron Gate Dam.	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 River downstream from Iron Gate Dam.	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 biomass of nuisance periphyton in the Klamath River downstream from Iron Gate Dam.	2, 3, 5	LTS	None	LTT

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
Keno Transfer				
Implementation of the Keno Transfer could cause adverse algae effects.	2, 3	NCFEC	None	NCFEC
***East and Westside Facilities* - Programmatic Measure**				
Decommissioning the East and Westside Facilities could cause adverse effects to algae.	2, 3	NCFEC	None	NCFEC
***City of Yreka Water Supply Pipeline Relocation* - Programmatic Measure**				
Under the Proposed Action, relocation of the City of Yreka Water Supply Pipeline required as part of the removal of Iron Gate Dam would not affect algae.	2, 3, 5	NCFEC	None	NCFEC

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

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

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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, 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[1]
- Noxious Weed Act (7 USC § 2801 et seq.) and Executive Order 13112 Invasive Species (64 FR 6183)

[1] The Northwest Forest Plan, Record of Decision (ROD) for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl, was signed April 14, 1994. The BLM Klamath Falls Resource Area incorporates direction from the Northwest Forest Plan ROD into the 1995 Klamath Falls Resource Area Record of Decision and Resource Management Plan and Rangeland Program Summary.

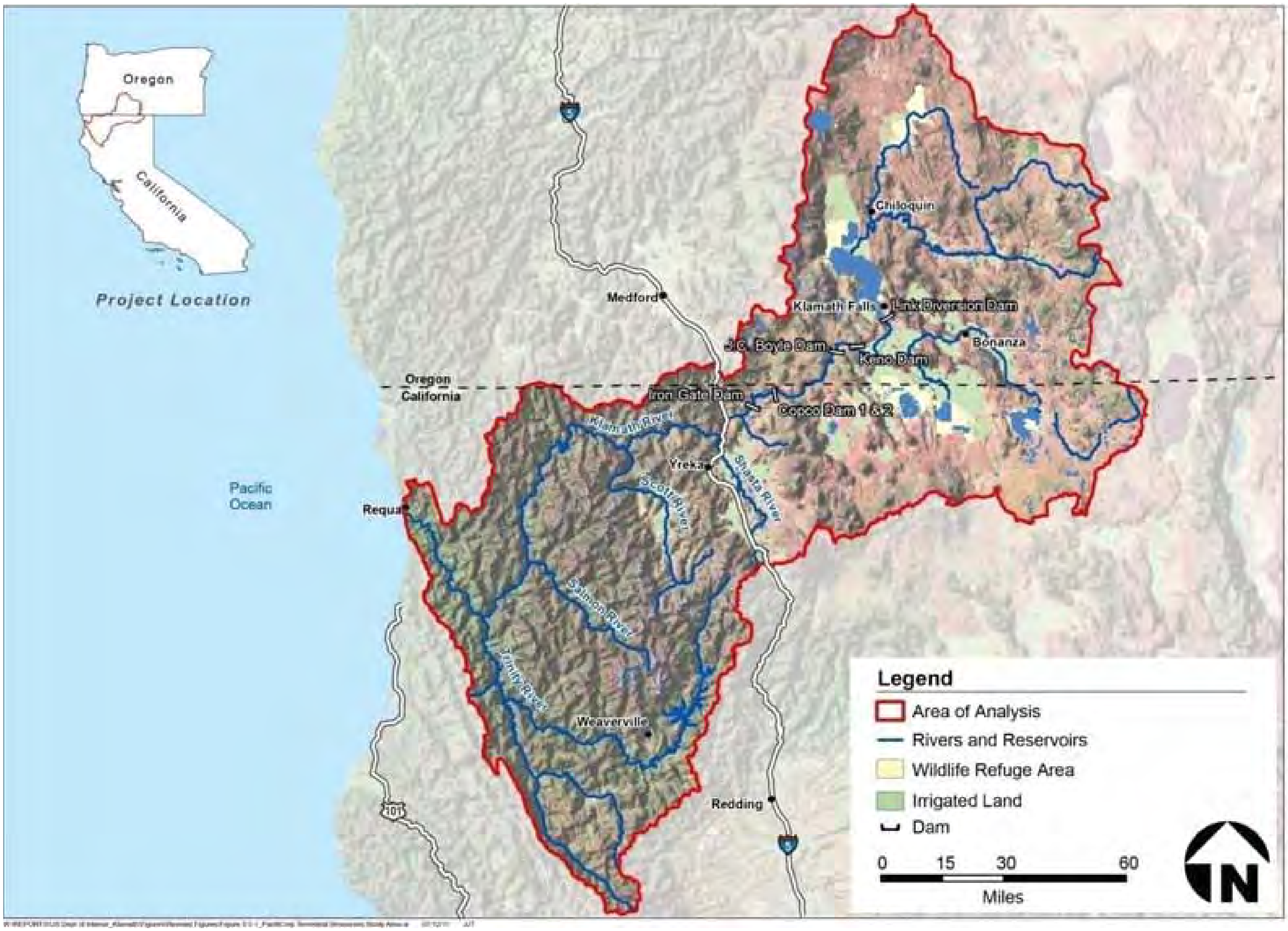

Figure 3.5-1. PacifiCorp Terrestrial Resources Study Area.

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 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 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 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 tributaries of the Lower Klamath River;
- *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 of the Shasta River, as listed in Table 3.5-1.

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

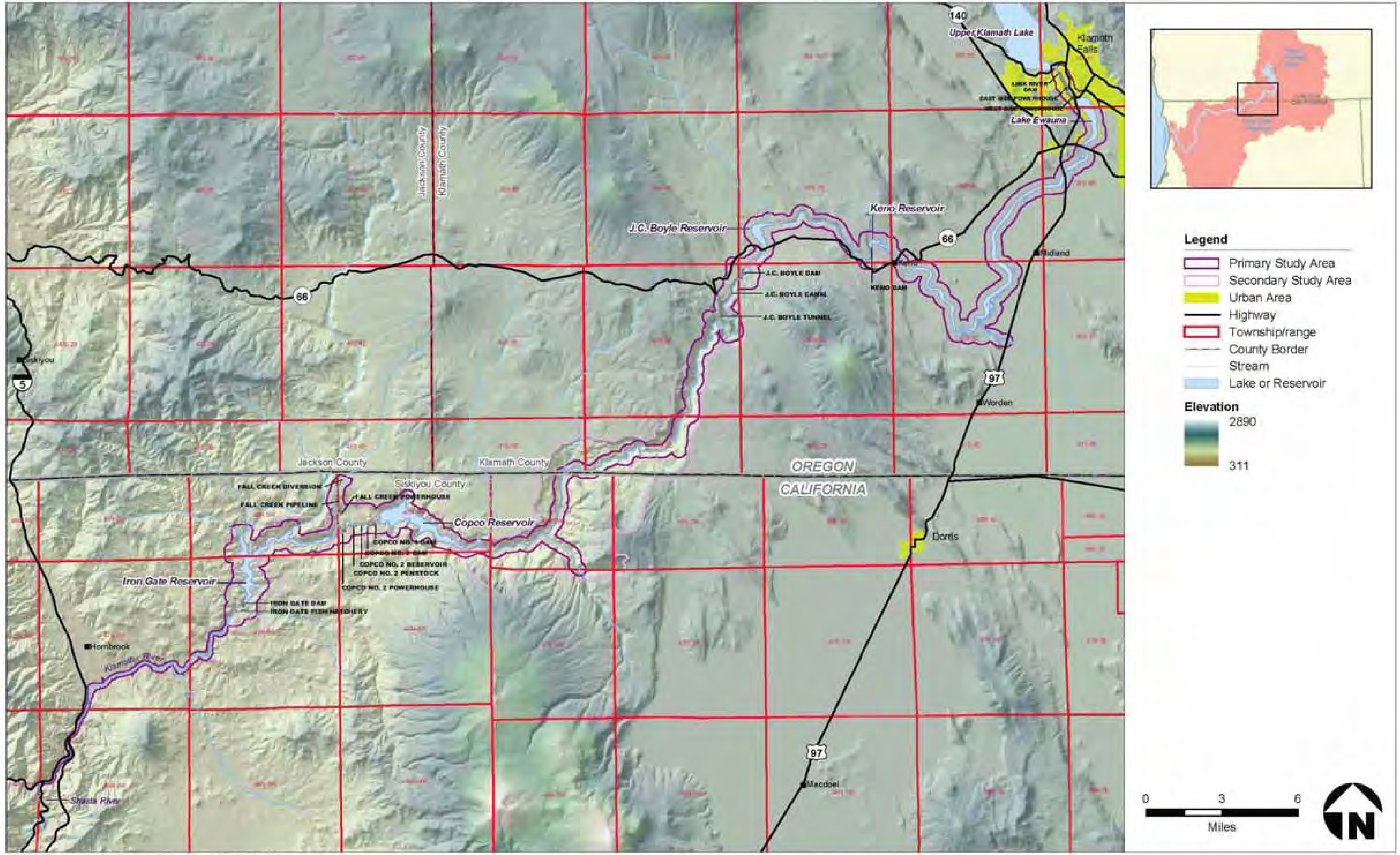

Figure 3.5-2. PacifiCorp Terrestrial Resources Study Area (PacifiCorp 2004a).

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 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												
Palustrine Aquatic Bed		0.9		0.6		0.1		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**	**2,076.1**	**1,924.5**	**2,050.6**	**9,532.9**	**562.1**	**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

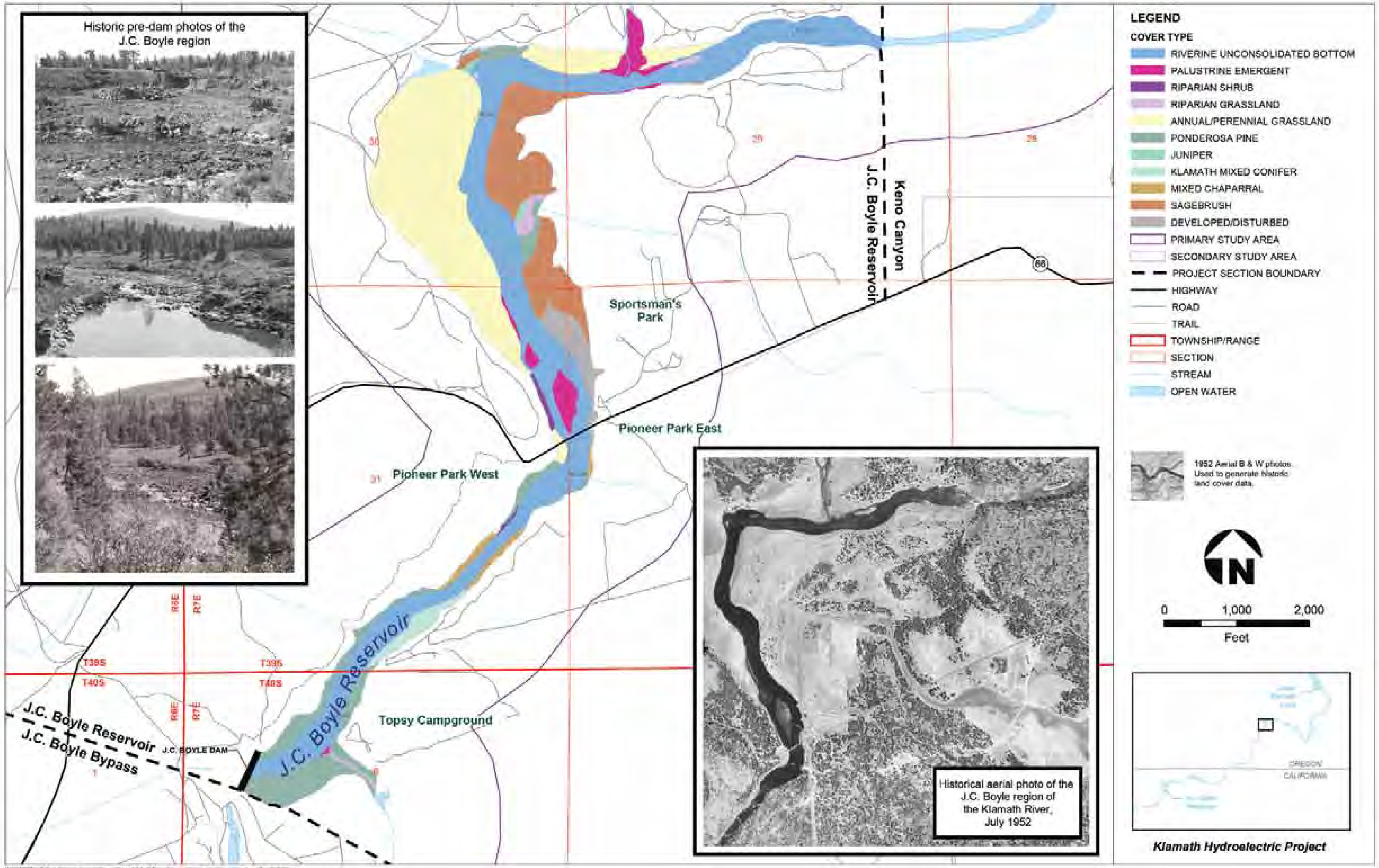

Figure 3.5-3. J.C. Boyle Reservoir Historic Vegetation Types.

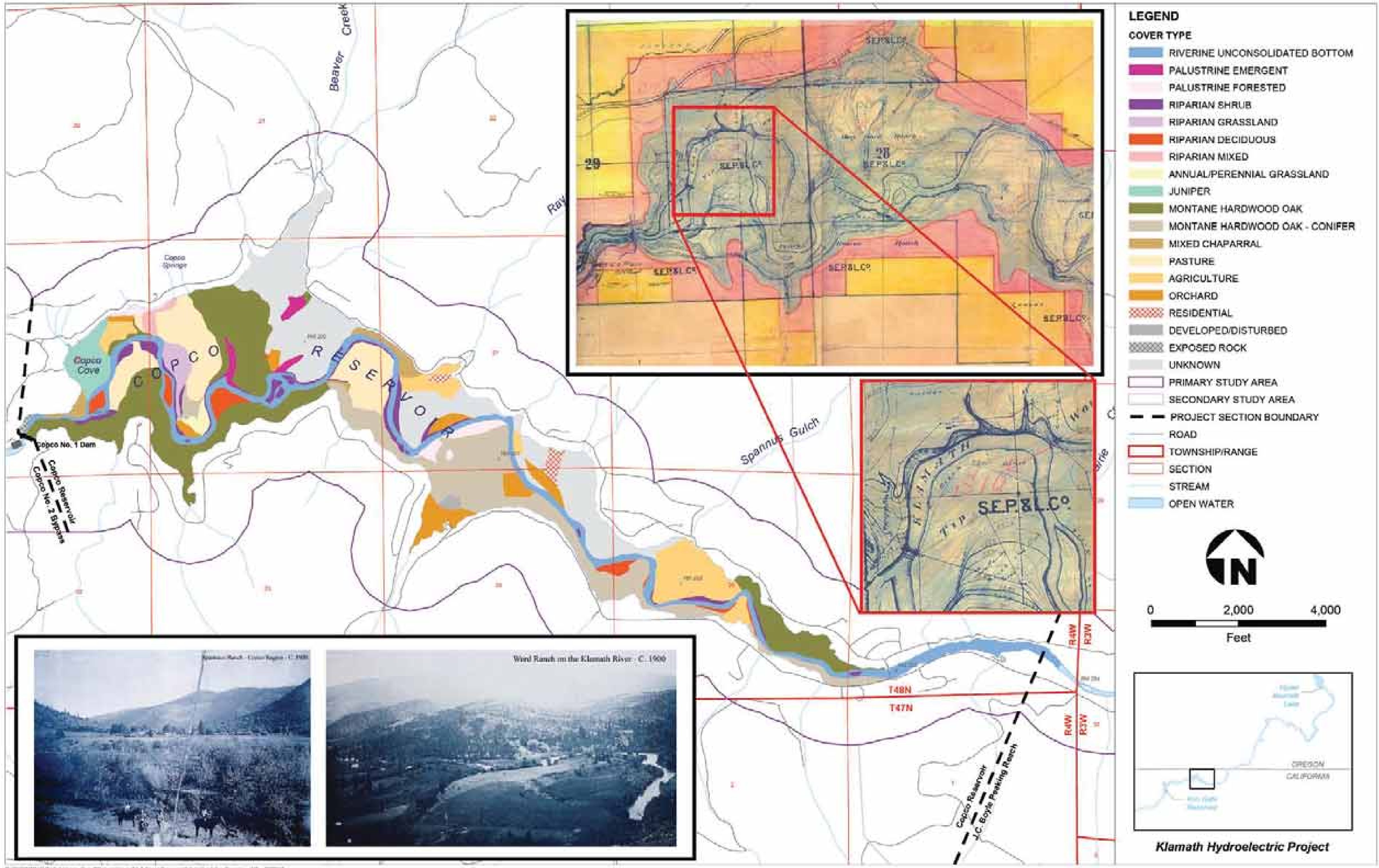

Figure 3.5-4. Copco Reservoir Historic Vegetation Types.

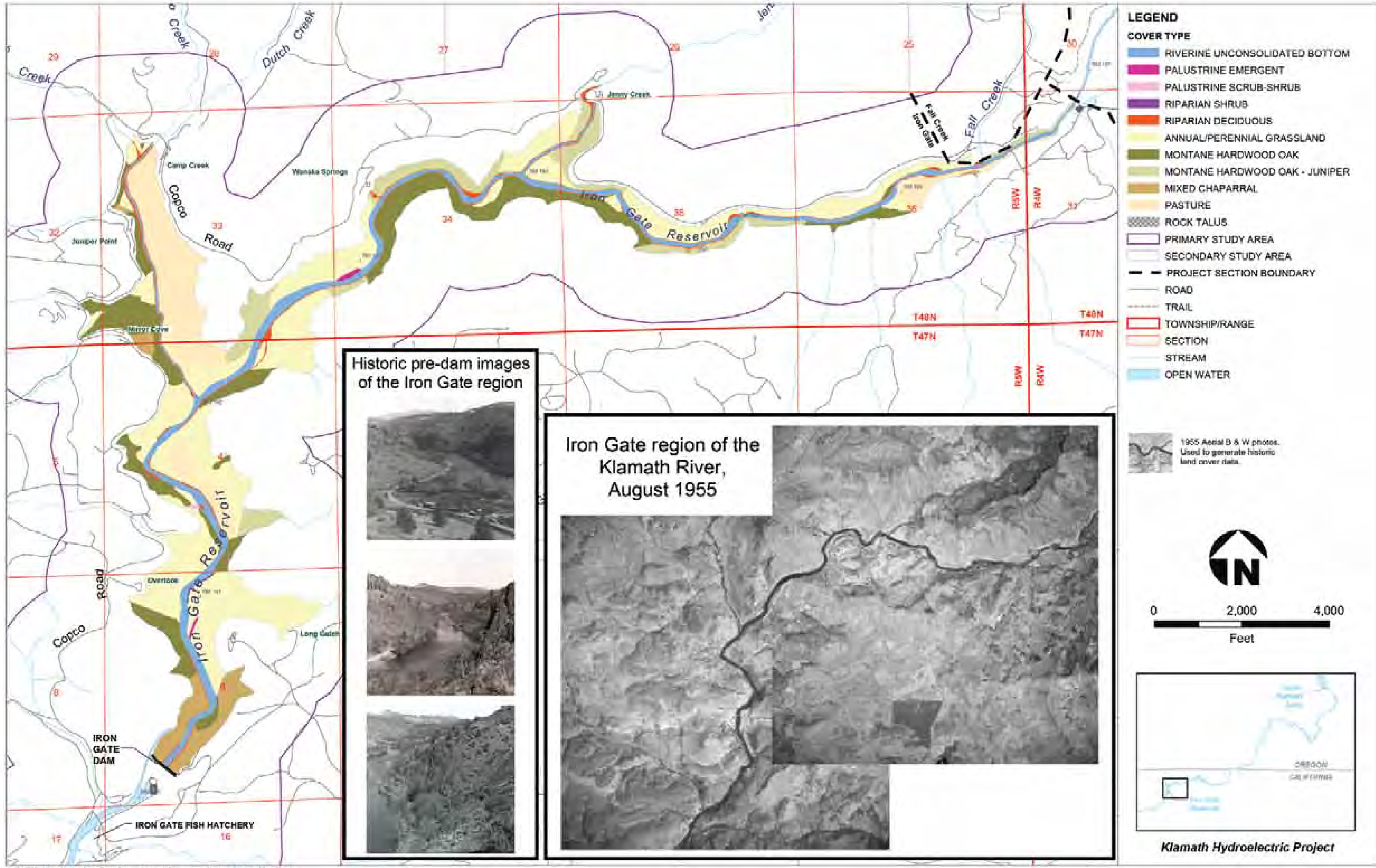

Figure 3.5-5. Iron Gate Reservoir Historic Vegetation Types.

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 Klamath River reaches. These species include reed canarygrass, Japanese and Himalayan knotweed, and Himalayan blackberry (Hamilton 2011). In addition, poison hemlock (*Conium maculatum*) is a common noxious weed present along the shores of Keno Impoundment (Larson 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.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 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 (Larson 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. 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 (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 (Reclamation 2011).

Fall Creek Reach

Fall Creek is a tributary to the Klamath River just upstream 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 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 (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 (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 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 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. 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 tributary streams of the Lower Klamath River and found these two amphibian species to be widespread in the tributaries (Green Diamond Resource Company 2006). 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 prey, including six species of hawk, two eagle species, three falcon species, seven owl species, and one species of vulture; eight species of woodpeckers, including acorn woodpecker, white-headed woodpecker, Lewis' woodpecker, red-shafted flicker, red-breasted sapsucker, downy woodpecker, hairy woodpecker, and 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 plant species of concern. Wildlife species include one Federal threatened species, the northern spotted owl, 15 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 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.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 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 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 tributaries of the Lower Klamath River (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 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 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).
Northern red-legged frog	*Rana aurora*	CSSC USFS:S	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).	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 substrate, springs, headwater seeps, waterfalls, and moss covered rock rubble with flowing water.	Widespread in tributary streams in the Lower Klamath River (Green Diamond Resource Company 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 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 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 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 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 Klamath River (CNDDB 2010). Has been documented in the Upper Klamath Basin within the last two years (Collom 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*	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*	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 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 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 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-B = Survey and Manage Species, as designated in the Northwest Forest Plan; category 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-C: Survey and Manage Species, as designated in the Northwest Forest Plan; category C - pre-disturbance surveys practical

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 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 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 are more than one mile away from the dams and associated facilities (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 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 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 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 (Leppig 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 (Larson 2011). One species that may occur based on known occurrences near the project area is the Siskiyou (Chace) sideband (*Monadenia chaceana*). Although USFWS has determined that the Siskiyou sideband does not warrant Federal listing (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 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 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 (Larson 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 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 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 (Reclamation 2011).

In contrast, active restoration would be needed for upland and riparian areas. In accordance with the Reservoir Area Management Plan (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 (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 (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 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 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 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. 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 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 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. **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 were evaluated in a Biological Assessment (BA) under Section 7 of the Federal ESA. Avoidance measures and project design standards 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 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 (Roberts 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:

- 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.

<u>Bald Eagle</u>

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 [2]. 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

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[2] 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.

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[3]. 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 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 conducted within 5 miles of construction areas, including along 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 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

[3] 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 3.5-6).

- If an active nest is located, a restriction buffer in accordance with **Mitigation Measure *TER-2*** (Section 3.5.4.4, Table 3.5-6) 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.[4] **Therefore, impacts on birds, including special-status bird species, during construction would be less than significant.**

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

[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.

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 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 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] **Therefore, impacts on special-status plants during construction would be less than significant.**

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.**

[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.

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.

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 (Larson 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 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 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 (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 (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, benefiting deer by expanding winter range habitat (Hamilton 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.

<u>Modification of Riparian Habitat</u>

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). 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.**

<u>Long-term Impacts on Wetlands</u>

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 (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.

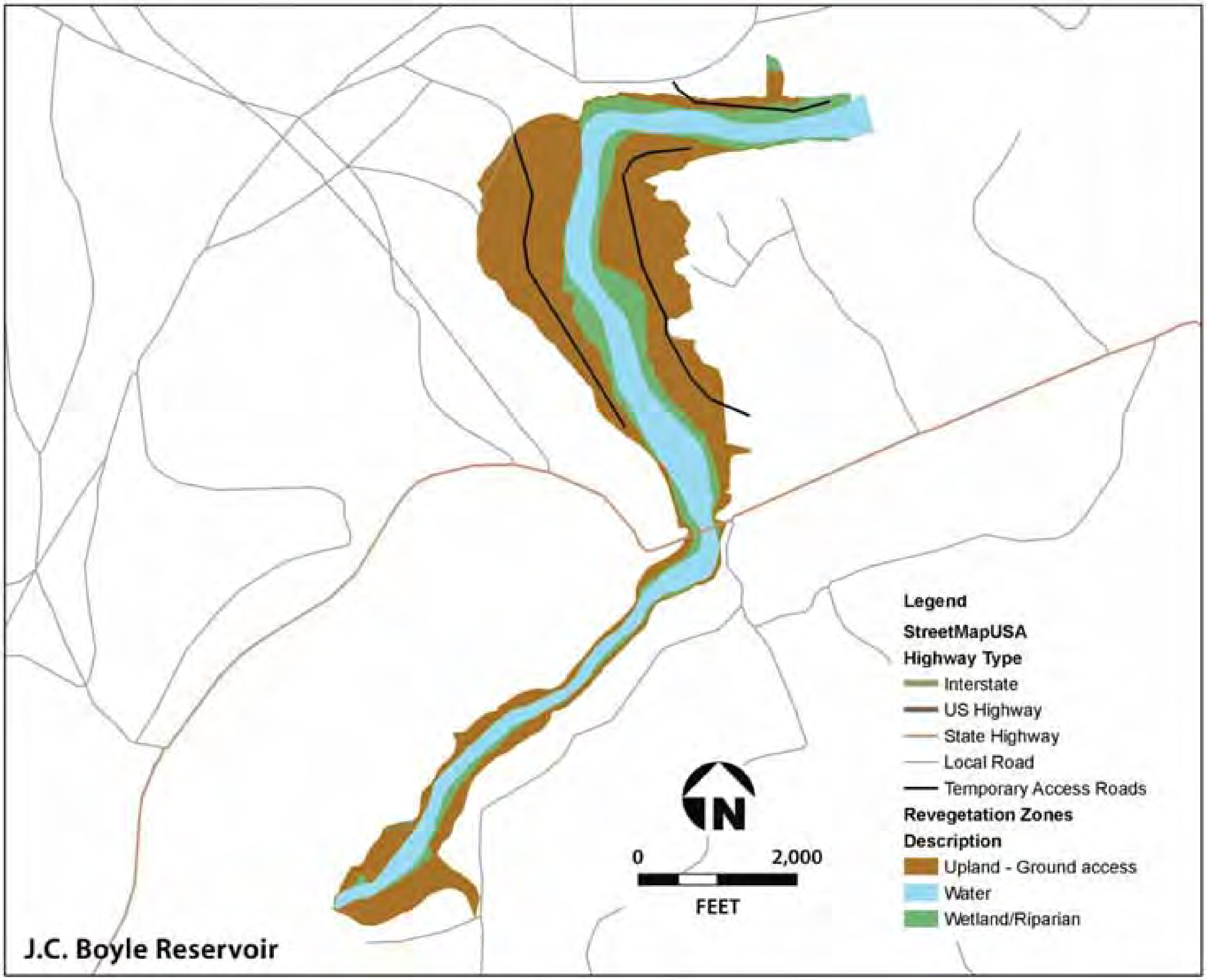

Figure 3.5-6. J.C. Boyle Reservoir Revegetation.

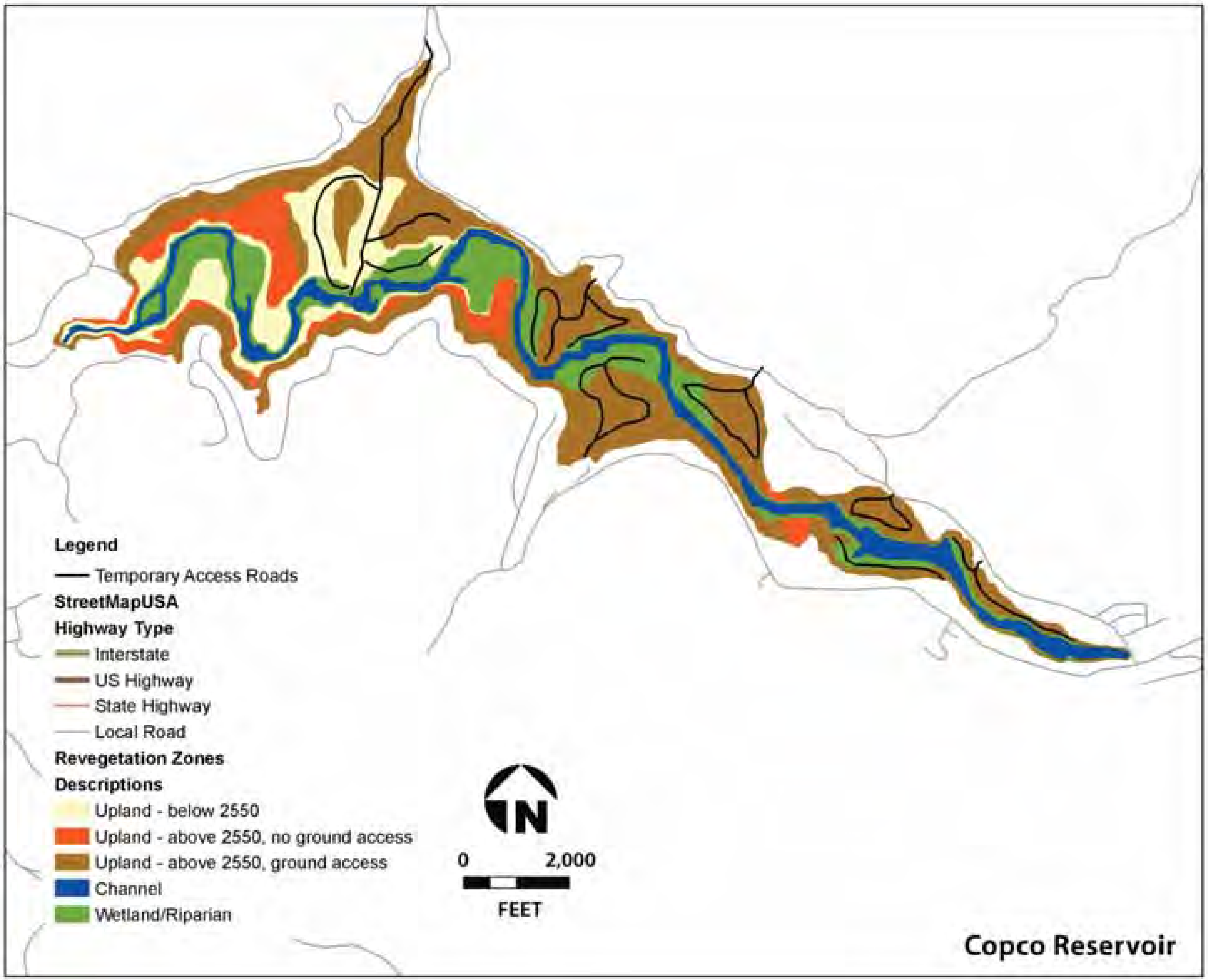

Figure 3.5-7. Copco Reservoir Revegetation.

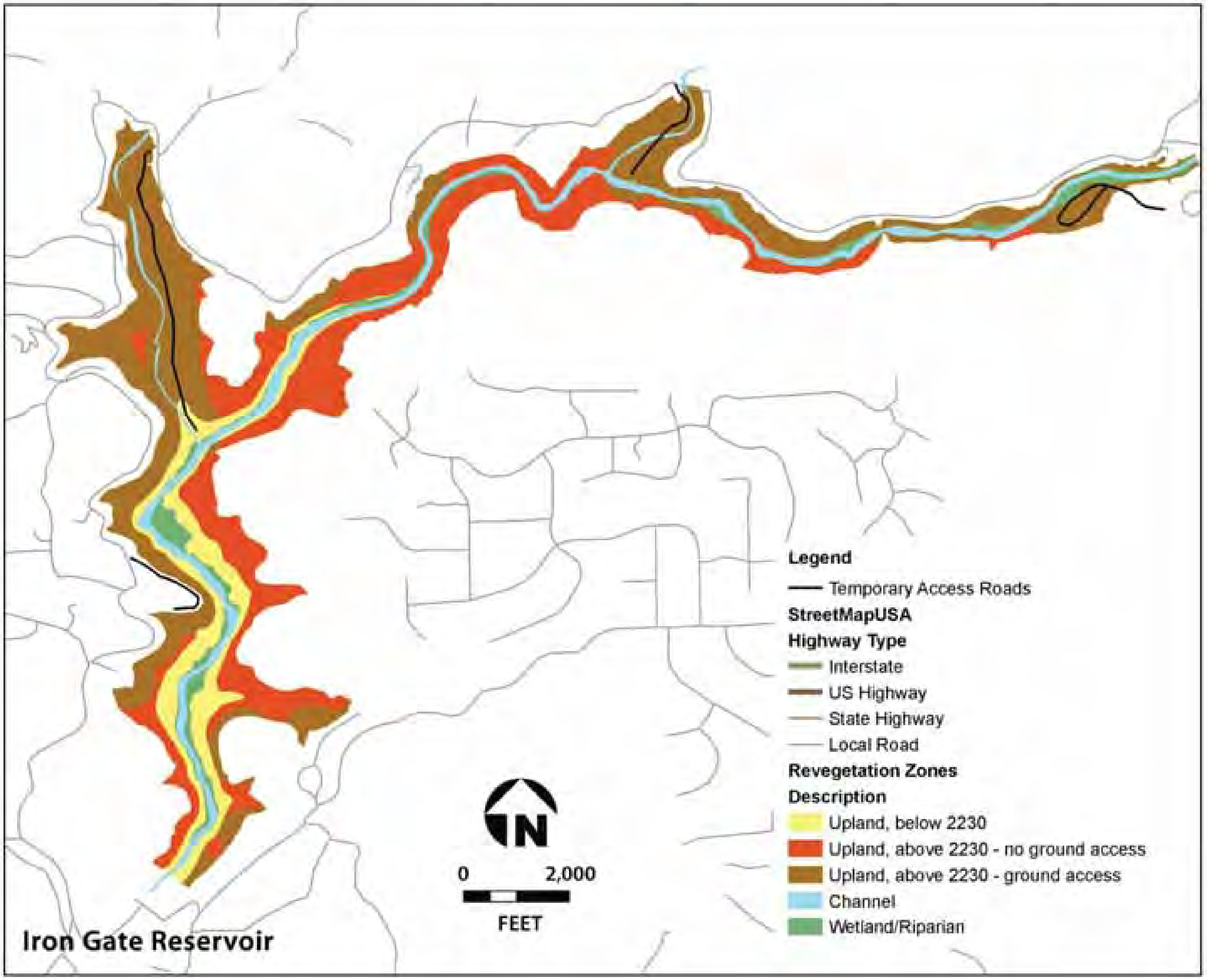

Figure 3.5-8. Iron Gate Reservoir Revegetation.

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 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 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 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.

<u>Long-term Impacts on Bats from Loss of Roosting Habitat</u>
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.

<u>Long-term Impacts on Amphibian Habitat</u>
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 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, Merritt and Wohl 2006, Merritt et al. 2010). A Reservoir Area Management Plan (Reclamation 2011) would be implemented for restoration of native plants and habitat communities at the reservoirs. In addition, the 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 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 (Larson 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.**

<u>Replacement of the Iron Gate Fish Hatchery Water Supply Pipeline</u>
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 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.

<u>Relocation of Recreation Facilities</u>
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.**

<u>Keno Transfer</u>
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 Westside Facility Decommissioning – Programmatic Measure

Decommissioning the East and Westside Facilities could cause adverse effects to terrestrial resources. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA 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 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 City of 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 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 ESA and development of habitat conservation plans by non-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.

<u>Floodplain Rehabilitation</u>
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.**

<u>Wetland and Aquatic Habitat Restoration</u>
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 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 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 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 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).

<u>Impacts on Waterfowl</u>

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).

<u>Impacts on Nongame Waterbirds</u>

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).

<u>Impacts on Habitat Management</u>

If the KBRA was implemented, lease land farming would continue, and 20 percent of 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 to be under the jurisdiction of Reclamation, some of which may or may not 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

<u>Impacts on Water Delivery Needed to Support Wetland Habitat</u>

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, there would be greater flexibility in the draining and refill of Sumps 1(A) and 1(B) compared to the No Action/No Project Alternative. 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).

<u>Impacts on Waterfowl</u>

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).

<u>Impacts on Nongame Waterbirds</u>

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 could be an adverse impact compared to the No Action/No Project Alternative; however, other measures 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(Chui 2008; Kerr 2012). 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 HRP (**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 Westside Facility Decommissioning – Programmatic Measure

The effects of the East and 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 City of 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.**

<u>Long-Term Impacts</u>

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 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 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 Rehabilitation Plan

To reestablish native vegetation communities and wildlife habitat in areas disturbed by construction, a HRP will be developed once the Definite Plan is prepared and construction areas are delineated. The HRP will be a stand-alone document separate from the Reservoir Area Management Plan (Reclamation 2011) that describes rehabilitation of the reservoir areas. The HRP will cover all areas disturbed by construction, including upland sediment disposal sites, access and haul roads, pipeline corridors, and equipment staging areas. Habitat rehabilitation of construction 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 prepared to optimize plant establishment and physically stabilize the 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 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.

Following the maintenance period, the sites will be monitored annually to ensure that rehabilitation goals are 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 5^{th} 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[6]

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 3.5-6 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.

[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 documentation for the Bald and Golden Eagle Protection Act. These BMPs are also described in Appendix B.

Table 3.5-6. 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[7]

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 shall survey those areas to determine if any migratory birds are present and nesting in those areas;

[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 B.

- 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 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 3.5-5). In compliance with the Clean Water Act, a Section 404 Permit 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.

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. 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 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 as part of the Compensatory Wetland Mitigation Plan describing the measures to be implemented to assure wetland habitats are maintained 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.

<u>Mitigation to Avoid Mortality and Disturbance</u>
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.

<u>Mitigation for Loss of Roosting Habitat</u>
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).

<u>Monitoring Measures to Determine Success and Corrective Action Measures</u>
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.**

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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 is in Oregon. The downstream outlet of Upper Klamath Lake is Link River Dam which releases water into the Link River. About one mile below the Link River Dam, the Link River flows into Keno Impoundment/Lake Ewauna. The Keno Impoundment/Lake Ewauna is controlled by the Keno Dam near Keno, Oregon. The Klamath River technically begins at the historic outfall of Lake Ewauna which is above Keno Dam. However, water impounded by Keno Dam, flooded portion of the Klamath River between the outfall of Lake Ewauna and Keno Dam and today forms part of the lake-like waterbody of Keno Impoundment/Lake Ewauna. The Klamath River flows approximately 250 miles from the old outfall of Lake Ewauna, through Keno Dam, through the Klamath Hydroelectric Project into the Pacific Ocean near Klamath, California (see Figure 3.6-1).

The Upper Klamath Basin is upstream 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 management in the Upper Klamath Basin, 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 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

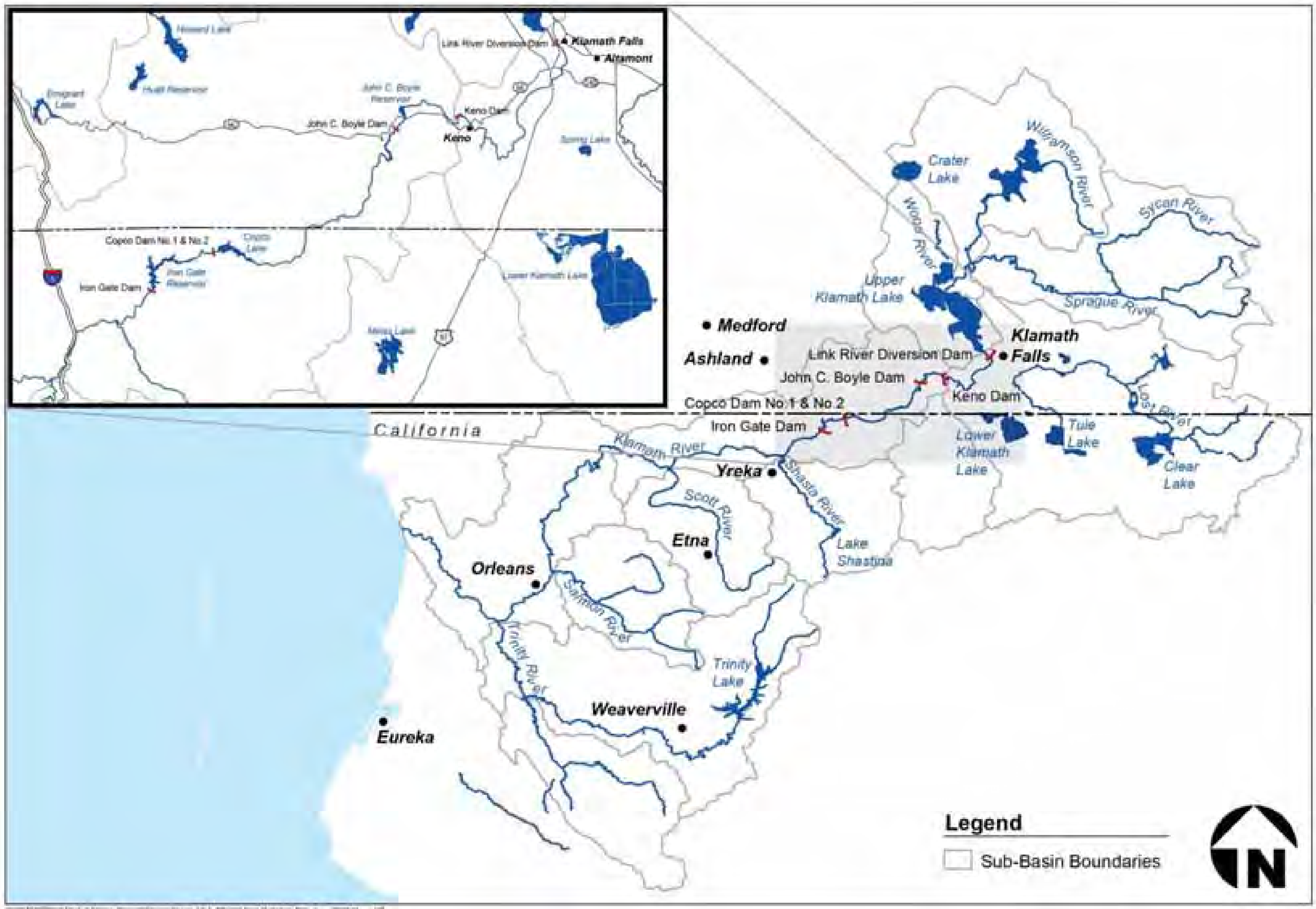


Figure 3.6-1. Flood Hydrology Affected Area.

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.

3.6.2 Regulatory Framework

Flood hydrology within the area of analysis is regulated by several 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 financial assistance for acquisition or construction of buildings and disaster assistance in floodplains. It also "required 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 (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 Lake Ewauna. Within this stretch of river, Lake Ewauna developed because of a natural rock reef dam near Keno, Oregon. Originally before the construction of dams and other water control structures, the Klamath River began at the outfall of Lake Ewauna.

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).

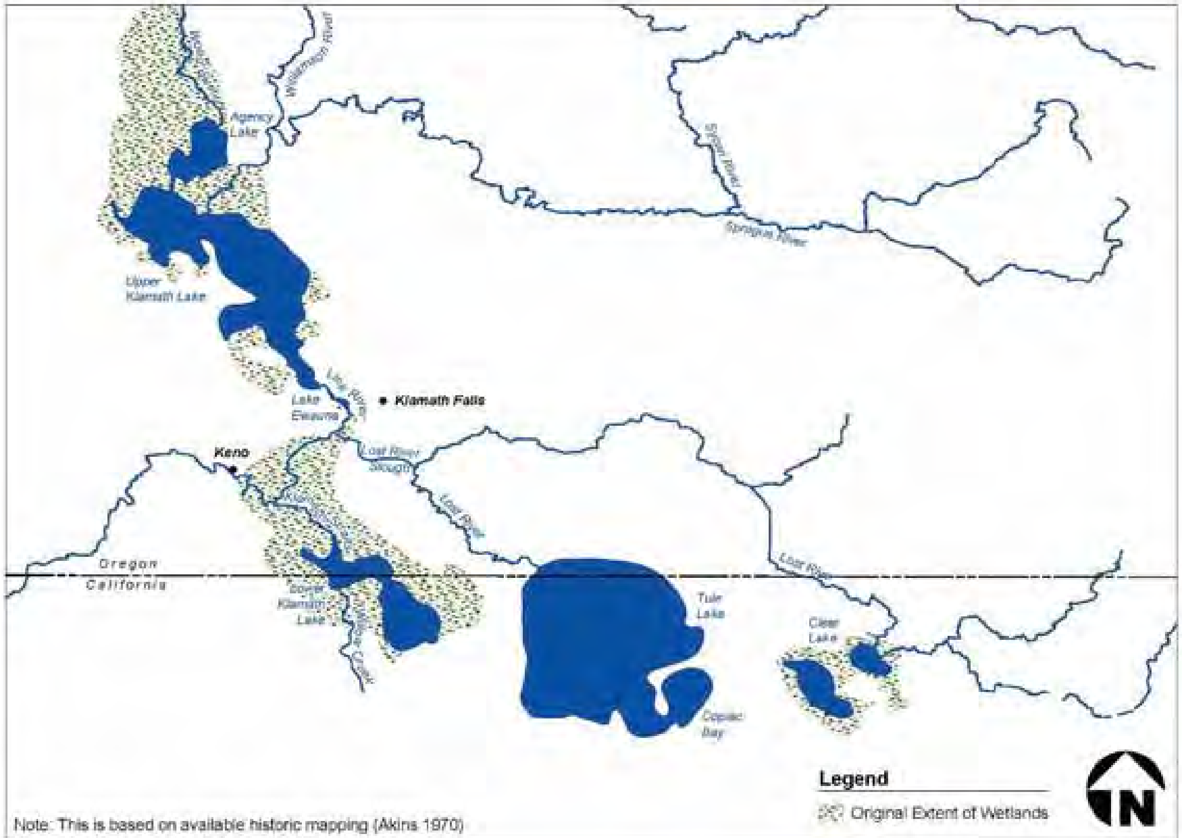


Figure 3.6-2. Historical Upper Klamath Basin Hydrology Before Dams, National Wildlife Refuges, and Reclamation's Klamath Project.

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.

3.6.3.1.2 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 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.

Additional hydrologic changes to the mainstem of the Klamath Basin were triggered by the passage by the U.S. Congress of the Reclamation Act of 1902 and the subsequent authorization of Reclamation's Klamath Project in 1905. The Reclamation Act supported development in the “arid West” by allowing the Federal Government to fund irrigation projects (Department of the Interior [DOI] 2011b). In 1905, the Oregon and California legislatures and the U.S. Congress passed the Cession 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). This infrastructure supported the agricultural community which was already well established in the Upper Klamath Basin and allowed for reclamation of additional wetlands 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 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 (SONCC) coho salmon Ecologically Significant Unit were reviewed in 1996 and listed as threatened in 1997. . The listing was reaffirmed 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 historic average stream flows. Various springs and seeps occur in the vicinity of Iron Gate, Copco and J.C. Boyle Dams and contribute flows to surface water. Springs around Upper Klamath Lake provide inflow to many of the streams feeding 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 from springs and seeps to various surface waters are described below. 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 Lake area are drier than the area where the Klamath River reaches the ocean. The reaches downstream 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 Web Site 2011).

3.6.3.2.2 Upper Klamath Basin

Upper Klamath Lake and Link River Dam

Link River Dam was constructed in 1921 at the natural outlet of Upper Klamath Lake by California Oregon Power Company (now PacifiCorp). The dam, deeded to the United States, is operated and maintained by PacifiCorp to control lake levels and provide water for irrigation. 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 Tulana Farms and Goose Bay and pumped storage at Agency Lake and Barnes Ranches (Reclamation, 2011, Appendix E). Currently, Reclamation manages Upper Klamath Lake for irrigation delivery and in accordance with United States Fish and Wildlife Service (USFWS) and NOAA Fisheries Service biological opinions based on current and expected hydrologic conditions (Reclamation 2010).

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 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. As a Federal agency, Reclamation is required to comply with the Endangered Species Act (ESA). To meet ESA requirements, Reclamation operates the Klamath Project in compliance with the two biological opinions—one issued by U.S. Fish and Wildlife Service in 2008 and one issued by NOAA's Fishery Service in 2010 (USFWS 2008; NOAA Fisheries Service 2010). One component of these biological opinions requires that Reclamation issue an annual operations plan describing how Reclamation's Klamath Project will be operated for a given year based on forecasted inflows to Upper Klamath Lake. The forecast is adjusted each month, using the actual inflows for the year and predicted inflows for the remainder of the water year. The forecast becomes increasingly accurate as time passes because the actual amount of inflow is known, and only the inflow for the remaining portion of the year needs to be predicted.

The biological opinions include requirements for targeted Klamath River flows measured below Iron Gate Dam 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 to meet biological opinion requirements while providing irrigation water according to contracts with the water users. Because the exact amount of water that will be available is only an estimate, the river flows and lake levels are set based on the probability the forecast is correct, or the exceedence level. A 90 percent exceedence means the predicted inflow will actually occur 90 percent of the time. The amount of water that must be released is based on the amount of inflow. As inflow changes, the releases also change. The amount of water that would be released is calculated for each 10 percent increment in exceedance, or probability of occurrence, and releases are adjusted as the forecast changes.

Table 3.6-1 displays flow release requirements in cubic feet per second (cfs) measured below Iron Gate Dam under the biological opinion (NOAA Fisheries Service 2010). Water available in the system is predicted (forecasted) 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)" (NOAA Fisheries Service 2010). Because the forecast is only a prediction, the amount of water actually available may be more or less than forecasted. When additional water is available, due to inaccuracies in the modeling, a team comprised of representatives from NOAA Fisheries Service, 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 determine the best use of the water (NOAA Fisheries Service 2010). For example, if conditions in the river are good for fish, and Upper Klamath Lake is not full, water can be stored for later release.

The flow requirements included in Table 3.6-1 describe the flow release requirements during the corresponding exceedance level during the time periods indicated. For example, as shown in Table 3.6-1, the required flow under the biological opinion in July, for a 90 percent exceedance, would be 840 cfs. Reclamation is required to release adequate flows from Upper Klamath Lake to allow PacifiCorp to meet these flow requirements at Iron Gate Dam.

Keno Impoundment/Lake Ewauna and Keno Reach

Lake Ewauna existed before the construction of Keno Dam due to a natural blockage or reef (Akins 1970). In 1931, Needle Dam was built on the Klamath River near Keno, Oregon and, in 1967, Keno Dam was built to replace Needle Dam. With construction of Keno Dam, the waterbody of Keno Impoundment/Lake Ewauna became 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. The Keno Dam is owned and operated by PacifiCorp. The operations are coordinated with the operations of Link River Dam. Before Keno dam, the river meandered through swamps for approximately 20 miles. It took two to four days for water released at Link River Dam to reach Copco 1 dam. With the construction of Keno Dam, and dikes along the shores of Keno Impoundment/Lake Ewauna, this lag time has been reduced to 12 hours. The currently normal water surface elevation is 4,085 feet in Keno Impoundment/Lake Ewauna(USGS 2009a).

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

On an annual basis, the majority of the water entering Keno Impoundment/Lake Ewauna comes from Upper Klamath Lake through the Link River. Several notable Federal and private facilities upstream of Keno Dam transport water to or from the river including: the Lost River Diversion Channel, Klamath Straits Drain, and the Ady Canal. The surface elevation of Keno Impoundment/Lake Ewauna is maintained to facilitate the operations of these facilities. (FERC 2007).

J.C. Boyle Reservoir

J.C. Boyle Reservoir is approximately 5 miles downstream 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 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 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 (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 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 (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 from the dam (FERC 2007). USGS gage station 11516530 on the Klamath River, downstream 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 from the dam (USGS 2009b). Table 3.6-1 lists the flow requirements measured downstream 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 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 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 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 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 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 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 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 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 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).

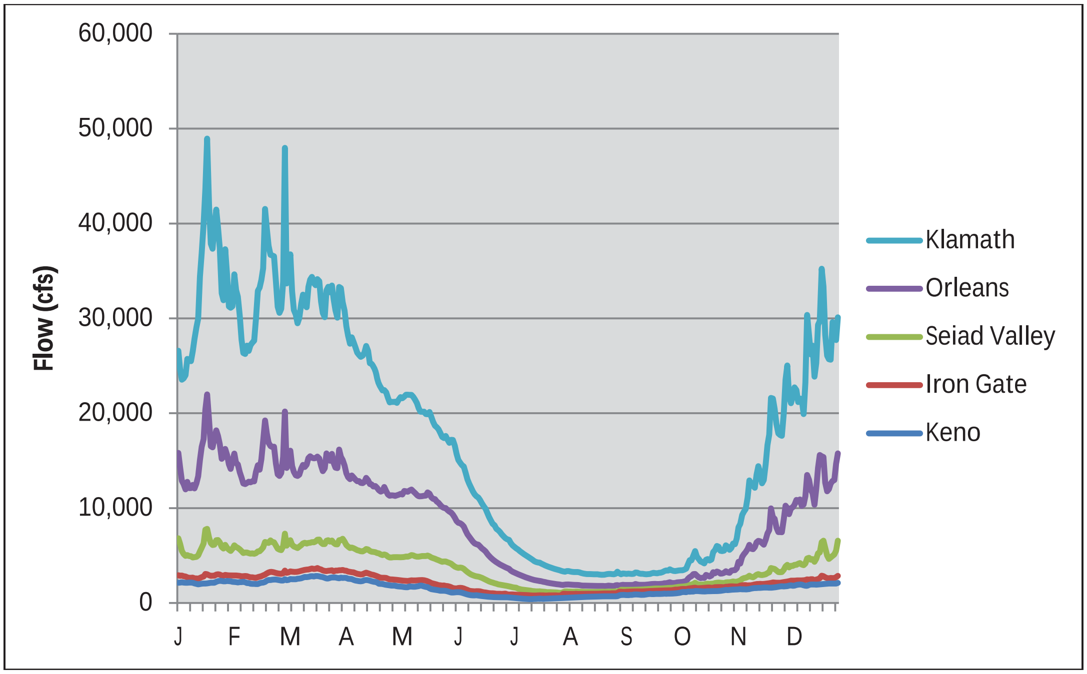
Table 3.6-4 shows the daily average flows at the four dams. The column indicating "% of time equaled or exceeded" indicates the hydrologic conditions, with 99 percent being an extremely dry conditions and 1 percent being an extremely wet conditions. Figures 3.6-5 and 3.6-6 show average daily flows in different conditions downstream from Iron Gate and J.C. Boyle Dams. The gage downstream from J.C. Boyle Dam is also downstream from the return of flow from the J.C. Boyle power plant.

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: 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

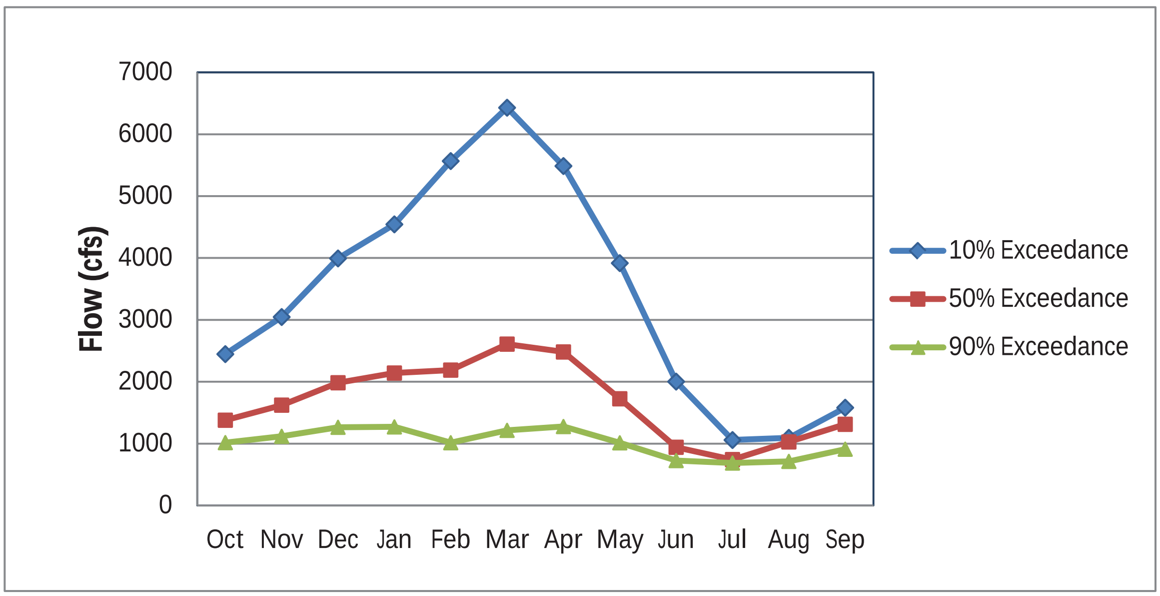
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.
Keno Dam	2053	2625	3304	3645	4703	5691	4543	3046	1525	755	788	1225
J.C. Boyle Dam	2271	2824	3449	3720	4727	5741	4766	3346	1823	1010	1035	1441
Iron Gate Dam	2447	3047	3994	4544	5567	6429	5487	3918	2003	1059	1094	1582
Seiad Valley	3070	4606	9372	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. Annual and Seasonal Daily Flows

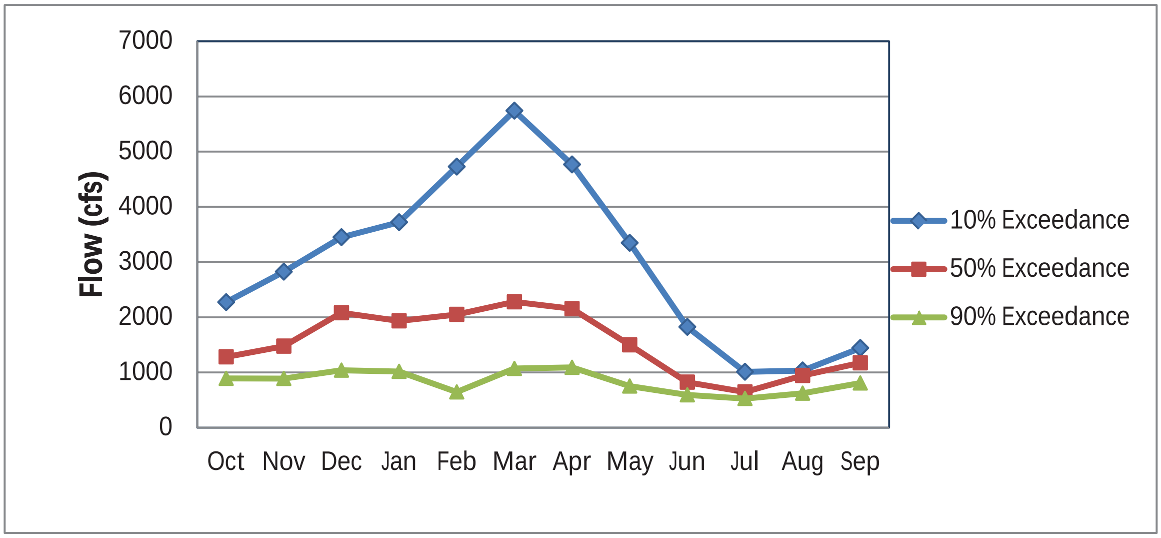
% of time equaled or exceeded	Discharge (cfs)							
	Annual				Seasonal (July 1 – Nov 31)			
	Keno	Boyle	Copco	Iron Gate	Keno	Boyle	Copco	Iron Gate
99	152	331	290	528	147	325	294	441
95	297	522	529	716	292	473	524	701
90	431	635	643	741	417	592	604	725
80	645	802	882	955	621	725	823	846
70	821	962	1,088	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: Reclamation 2012b



Source: USGS 2011

Figure 3.6-5. Stream Flows Downstream from Iron Gate Dam in Wet, Average, and Dry Conditions.



Source: USGS 2011

Figure 3.6-6. Stream Flows Downstream from J.C. Boyle Dam in Wet, Average, and Dry 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 year discharge at Seiad Valley, which is downstream from the Scott River, is 56,500 cfs. The 10 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 (miles²)	Discharge (cfs)			
		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: 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 (Reclamation, 2011, Appendix E). Active storage at Keno, J.C. Boyle, Copco 1, Copco 2 and Iron Gate reservoirs totals approximately 12,244 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 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 the recent breaching of dikes and levees around and near Upper Klamath Lake. During these wet periods, there is little surplus storage at the Four Facilities to help control flooding downstream from Iron Gate Dam. During wet periods, decreased irrigation demands may allow for more water to remain in Upper Klamath Lake for use later in the year. The amount of retained water depends on decisions such as the magnitude of spring flushing flows and fall migration flows. The biological opinions include provisions for average and wet years that increase minimum flow requirements at Iron Gate Dam and surface water elevations in Upper Klamath Lake to more closely mimic natural flow and lake-level conditions during wetter years and provide storage for surplus water. Additional descriptions of area geomorphology are in Section 3.11, Geology, Soils and Geologic Hazards.

Periodically during flood years, the Klamath River overtops its banks and inundates the floodplain. 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 mapping service or can be downloaded from their 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 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 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. 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. 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* (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 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. 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. PacifiCorp would operate 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 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 (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 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 (Reclamation 2012b). **Overall, the ongoing restoration actions would cause no change from existing conditions from flood hydrology related to the affected environment.**

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

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

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 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 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 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 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 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 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 27 to 51 percent of sediment behind J.C. Boyle Dam, 45 to 76 percent of sediment behind Copco 1 Dam, and 24 to 32 percent of sediment behind Iron Gate Dam would be eroded and flushed down the river during removal activities (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 from dam removal activities, however none is expected downstream from Shasta River (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 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 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 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 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 conditions under the No Action/No Project Alternative described in Table 3.6-6. Flows during wet 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 percent flow exceedances between the No Action/No Project Alternative and the Proposed Action.

Table 3.6-8. Flood Flow Exceedance: Modeled Wet 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.

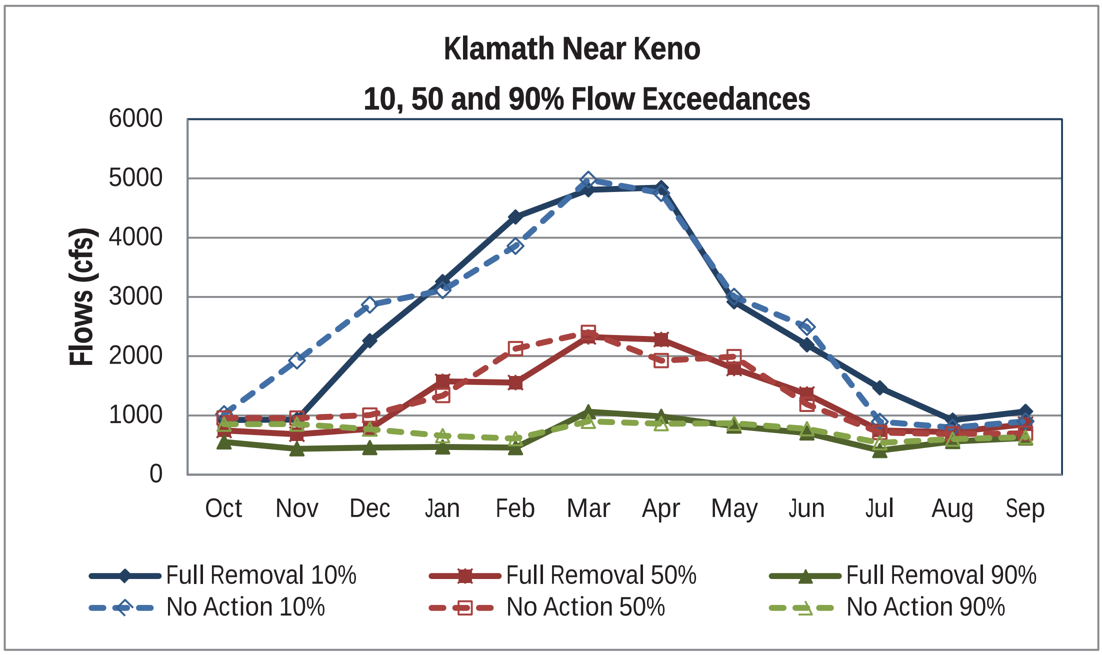


Figure 3.6-7. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Near Keno Dam.

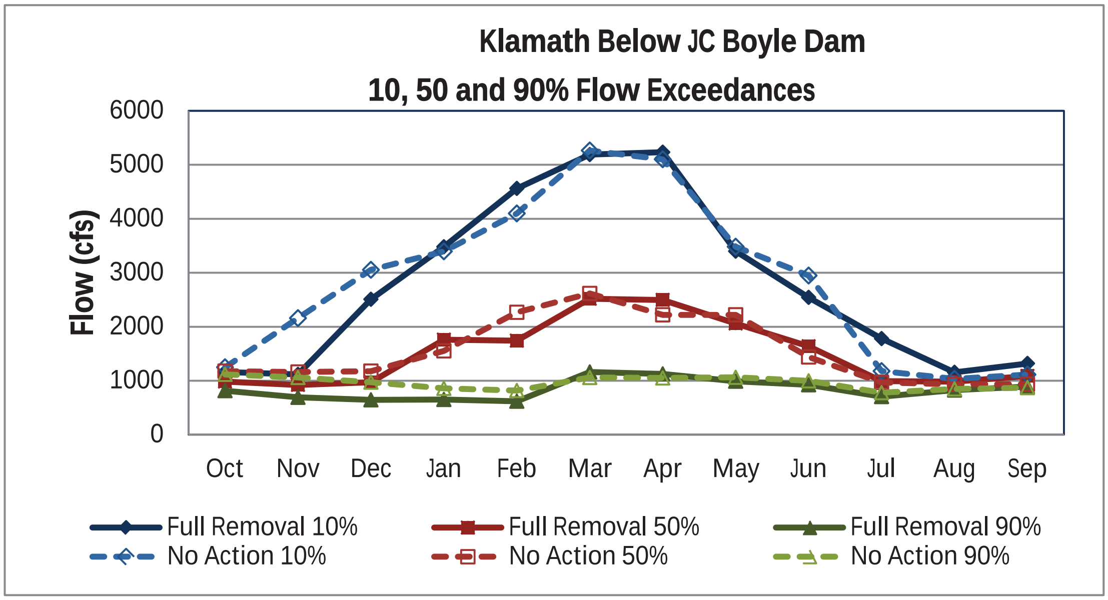


Figure 3.6-8. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Below J.C. Boyle Dam.

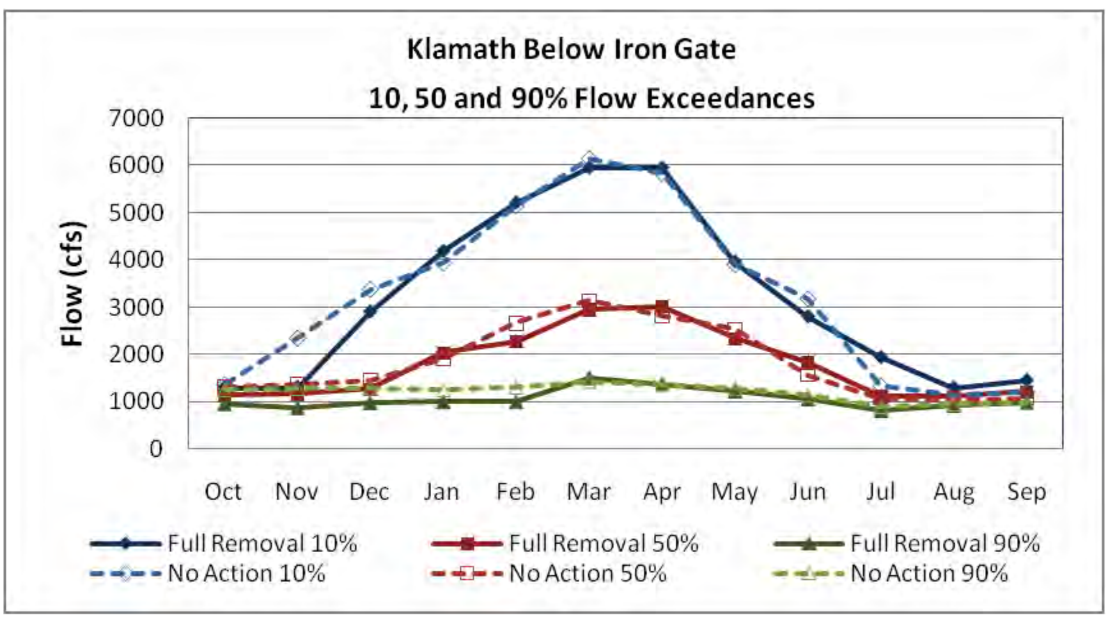


Figure 3.6-9. Modeled Flow Exceedances under the No Action/No Project Alternative and Proposed Action Below Iron Gate Dam.

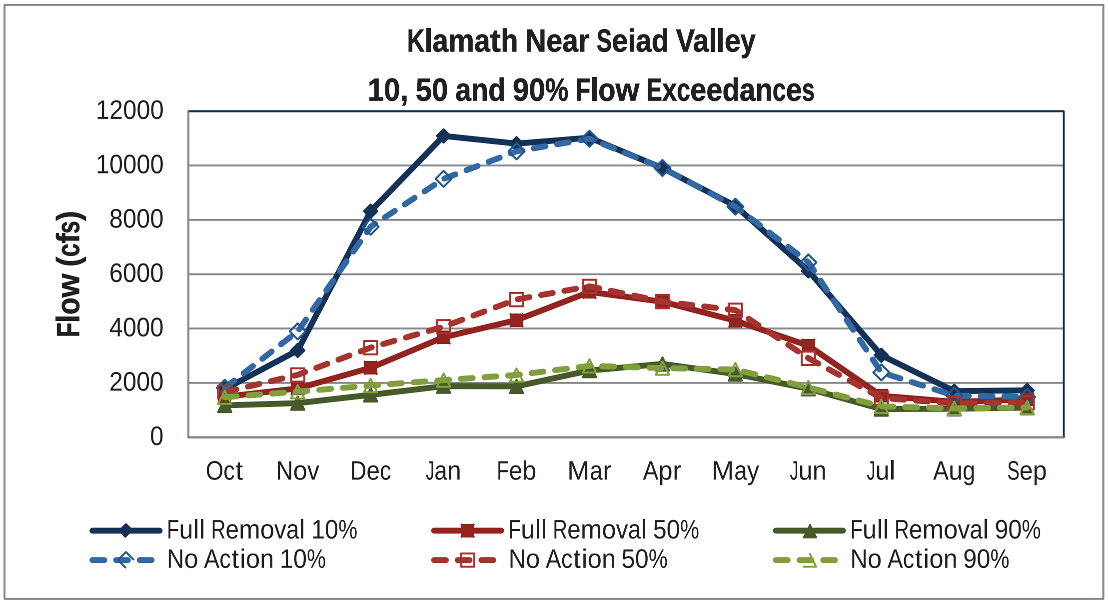


Figure 3.6-10. Modeled Flow Exceedances under the No Action/ No Project Alternative and Proposed Action Near Seiad Valley.

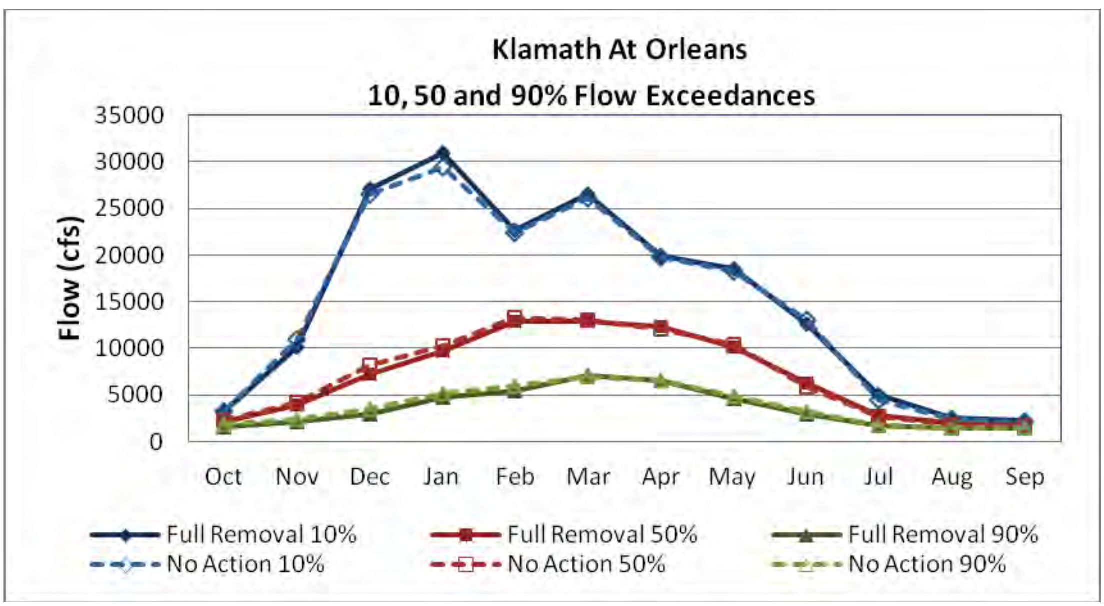


Figure 3.6-11. Modeled Flow Exceedances under the No Action/ No Project Alternative and Proposed Action at Orleans.

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 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 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: 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 designated by FEMA because it is based upon more current information. DOI also 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 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. 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 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. 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 (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. As discussed in the No Action/No Project Alternative, the Four Facilities store over 169,000 acre-feet of water 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. 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.**

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 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 Westside Facilities – Programmatic Measures

Decommissioning the East and Westside Facilities could cause changes in flood risk downstream from the facilities. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would eliminate the need for diversions at Link River Dam into the two canals. Following decommissioning of the facilities there would be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. **Therefore, implementation of the East and 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 City of Yreka Water Supply Pipeline could affect river flows and result in changes to flood risks. The existing water supply pipeline for 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 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 City of Yreka Water Supply Pipeline.

KBRA – Programmatic Measures

The KBRA, which is a 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 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 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 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 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 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 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. 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 Westside Facilities – Programmatic Measures

The surface water and hydrology impacts of the decommissioning the East and 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 the City of 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 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 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 (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 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 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 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.**

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 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 the City of 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: 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 agency that provides official public warning of floods. 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, 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 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 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. Such plan could include measures to move, modify, or elevate structures where feasible.

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.**

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3.7 Ground Water

This section of the Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) describes the changes in ground water 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 ground water 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 ground water 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) ground water model designed to determine effects on ground water from pumping water for irrigation purposes. No model exists for areas below Copco 1 Dam. Ground water issues, such as changes in ground water levels or recharge, are described in this section. Issues related to geology are described in Section 3.11, Geology, Soils, and Geologic Hazards.

3.7.2 Regulatory Framework

Ground water resources within the area of analysis are regulated by the 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 Ground Water Basin Hydrology Description

3.7.3.1.1 Regional Ground Water Conditions

The project area has few wells that completely characterize ground water conditions. Gannett et al. 2007 completed the most recent and comprehensive attempt to estimate the water level gradients and flow patterns within the project area upstream and downstream from the four dam sites. Figures 3.7-1 and 3.7-2 show a generalized ground water flow map for the Upper Klamath Basin and portions of the Lower Klamath Basin. Figure 3.7-2 suggests that the regional ground water flow patterns along the Klamath

River downstream 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 (Bureau of Reclamation (Reclamation) 2011a). Figure 3.7-2 shows a very steep ground water head gradient between Keno Dam and the J.C. Boyle Reservoir. That steep head gradient suggests the presence of a ground water barrier and is also roughly correlative with the mapped trace of the Sky Lakes fault zone (Personius, 2003). A ground water barrier at this location implies that the ground water system above Keno Dam is separate from the ground water 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) (Reclamation 2012a). Numerous springs, where ground water 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 (Reclamation 2012a). The maps also show springs around Copco Reservoir. These springs are similarly less than 50 to more than 800 ft above the reservoir level (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 (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. 2007)). The presence of springs in the area suggests local ground water systems, and possibly a regional ground water system, that are not receiving water directly from the reservoirs (Reclamation 2012a). That is, the water discharging from the springs is not thought to be reservoir water (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 ground water levels adjacent to the reservoir. These higher ground water levels could cause ground water levels to be increased as compared to the condition where the reservoir was not in place. These increased ground water 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 (Reclamation 2012a).

A spring complex about one mile below J.C. Boyle Dam contributes substantial flow to the river (Gannett et al. 2007). The water discharging at this site may be originating from the local ground water 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 ground water system as well as leakage from the reservoir (Reclamation 2012a).

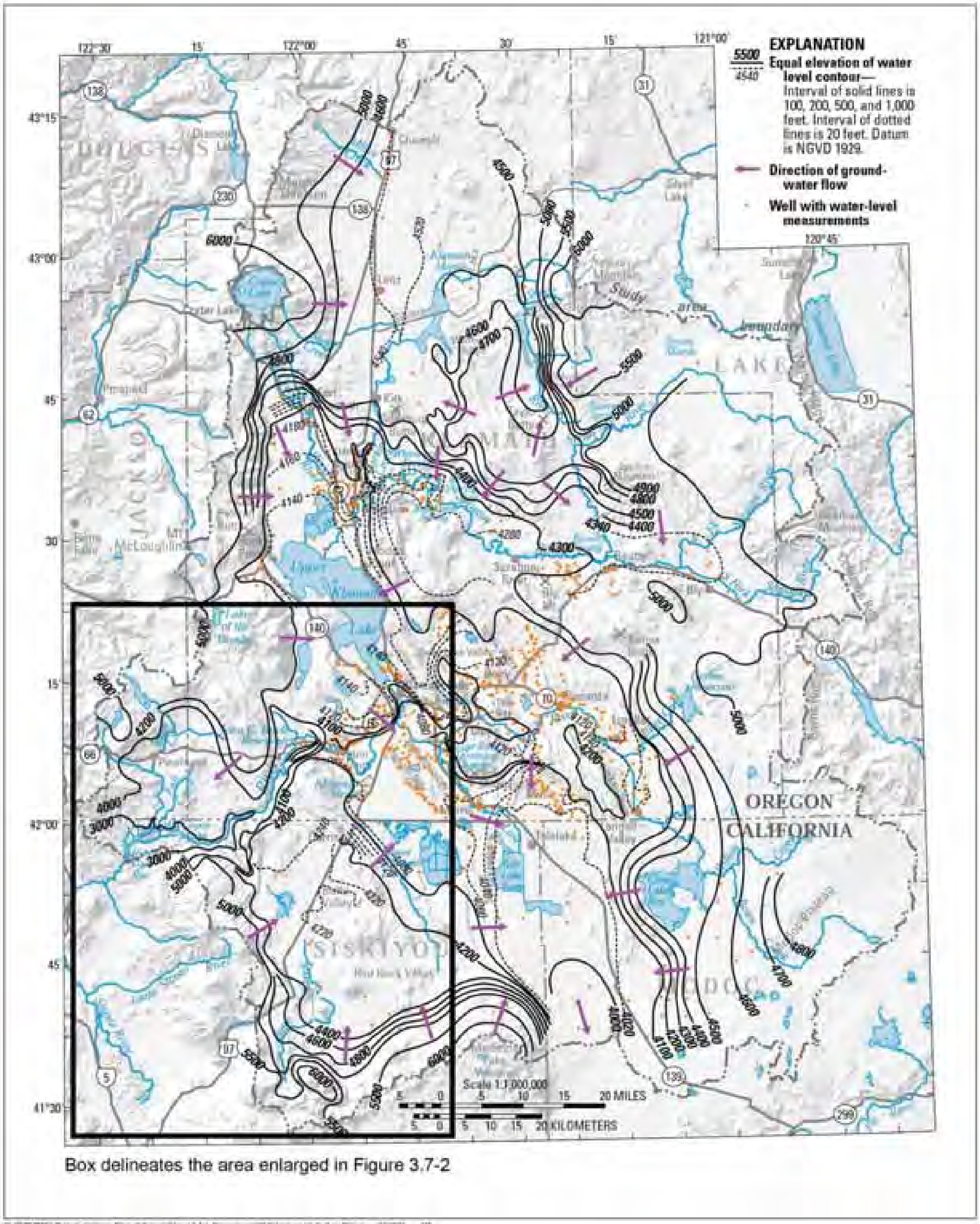
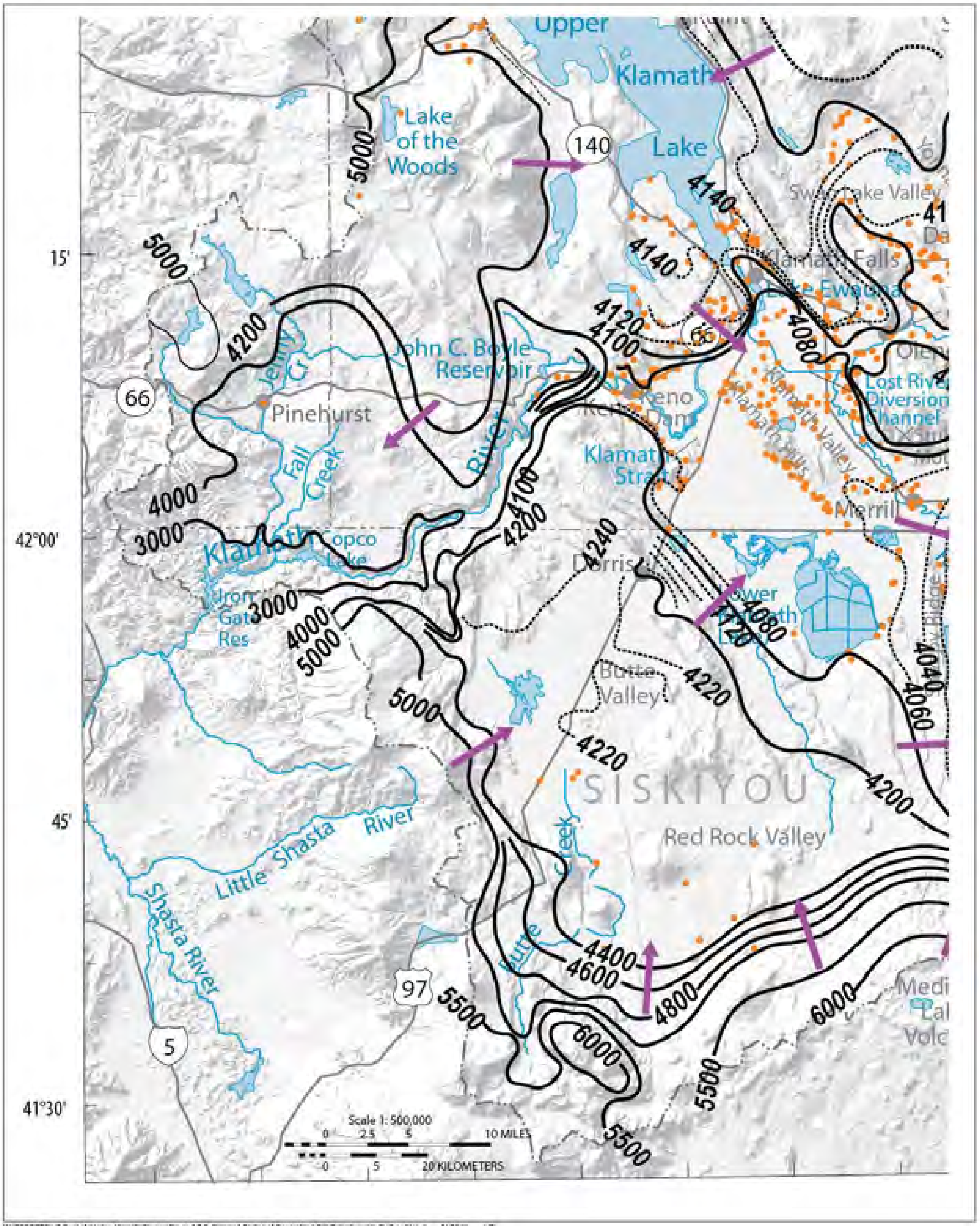


Figure 3.7-1. Generalized Ground Water Potentiometric Surface Contour Map and Ground Water Flow Directions in the Upper Klamath Basin [after Gannett et al. 2007].



W:\REPORTS\US Dept of Interior_Klamath\Figures\Figure 3.7-2_Enlarged Portion of Generalized GW Potentiometric Surface Map.ai 01/06/11

Figure 3.7-2. Enlarged Portion of the Generalized Ground Water Potentiometric Surface Contour Map and Flow Directions for the Areas around J.C. Boyle, Copco, and Iron Gate Reservoirs [after Gannett et al. 2007].

Sources of Ground Water in Project Area

Ground water in the project area is likely fed by the infiltration of precipitation and subsequent percolation through the surface materials to the bedrock units. As Figures 3.7-1 and 3.7-2 show, at a regional scale, ground water flows into the project area near the four dams from upland areas toward the Klamath River and the reservoirs. The figures show an apparent ground water divide in the area just upstream of J.C. Boyle/ Keno Impoundment. These figures also show the regional trends in ground water elevations and flow paths. Where ground water levels are above the river and reservoir elevations, it is generally assumed that ground water levels in the vicinity of the reservoirs are supported by the regional ground water 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.

Ground water in the project area is also maintained by ground water flows from upgradient areas. In the absence of barriers to vertical flow, surface water infiltration is a common source of recharge to ground water 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 ground water flow direction toward the river and reservoirs in the project area, reaches are more likely receiving water from the ground water systems than they are losing water to the ground water systems, while reservoirs are more likely to lose water to the ground water (Reclamation 2012a). However, there are conditions where the reservoirs could be gaining water from the ground water system(s) (Reclamation 2012a). The lack of data from ground water wells in the area makes a more specific characterization of ground water sources in the project area difficult.

Ground Water Sinks in Project Area

In areas where surface water levels are lower than the adjacent ground water level, ground water can discharge to the surface water (e.g., rivers, streams, and reservoirs). This would be called a ground water “sink” because ground water flows towards it and is lost from the ground water system. Gannett et al. (2007) estimates that ground water adjacent to the Klamath River discharges to the river in the project area. An average discharge of 190 cfs of ground water for the reach from Keno Dam to downstream from the J.C. Boyle Powerhouse and 92 cfs for the reach from there downstream to Iron Gate Dam is estimated (Gannett et al. 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.

Ground water pumping is also a typical process in the project area where water is removed from the ground water system. In the project area, ground water 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 ground water sink in the project area (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

(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 (Reclamation 2012a).

A large ground water flow system exists in the Upper Klamath Basin (Gannett et al. 2007). Ground water is recharged in areas in the Cascade Range and upland areas surrounding the basin. Ground water 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 ground water discharge (Gannett et al. 2007). Some streams are fed predominately by ground water (i.e., baseflow) at a consistent rate throughout the year. Ground water is used in the Upper Basin to irrigate agricultural land as well as for domestic, industrial, and municipal purposes. Ground water 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. 2007).

Ground water levels in the Upper Basin vary in response to climatic cycles, ground water pumping, lake levels, and canal operations. Typical annual drawdown and recovery cycles caused by ground water pumping are from one to ten ft. Ground water use in the Upper Basin increased by approximately 50 percent in response to the 2001 biological opinion, primarily in the area surrounding Reclamation's Klamath Project. This pumping increase resulted from changes in surface water management practices . Reclamation's ground water 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 ground water pumping 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, ground water levels were affected by typical climate-based fluctuations of approximately five ft resulting from cycles of dry and wet periods. Near centers of ground water 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, ground water 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 ground water levels dropping 10 to 15 ft in portions of this area between 2001 and 2004 (Gannett et al. 2007).

Local Ground Water Conditions

The California DWR *Bulletin 118 – Update 2003, California's Groundwater,* delineates 515 ground water basins and subbasins throughout the 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 "ground water source area" by the California DWR. A "ground water source area" is "rocks that are significant in terms of being a local ground water 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 from the Four Facilities. Roughly 83 percent of the logs (300 out of 360 logs) included sufficient detail to locate the wells 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 (Reclamation 2012a).

Using the local topography, reservoir bathymetry, and lithologic descriptions on the well logs, representative cross-sections through the reservoirs and adjacent lands were 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 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 (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 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 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 (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 (Reclamation 2012a).

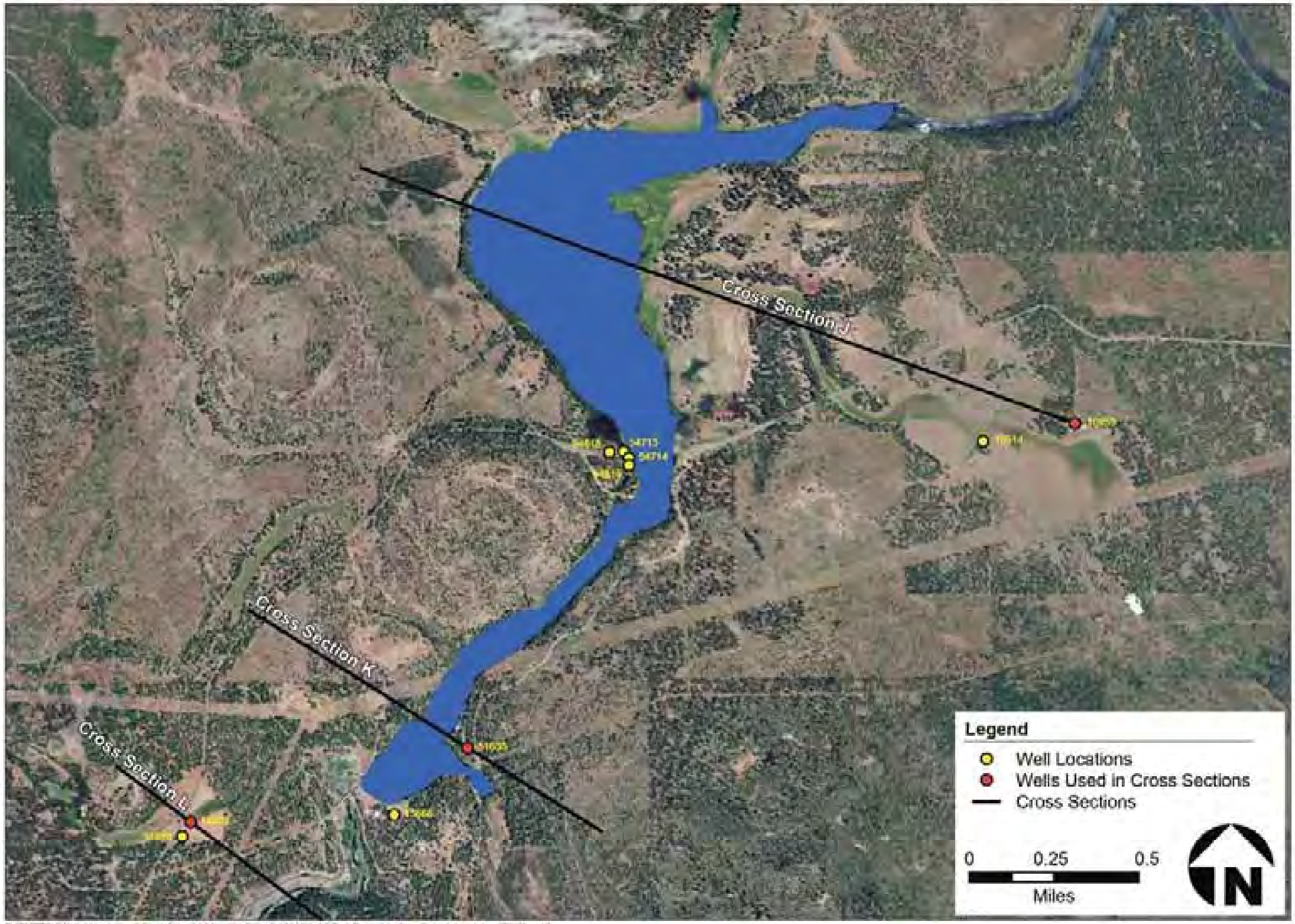


Figure 3.7-3. Locatable Wells within 2.5 Miles of J.C. Boyle Reservoir and Cross-Section Locations.

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: 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:
AMSL: above mean sea level
bgs: below ground surface
in: inches
ft: feet
gpm: gallons per minute

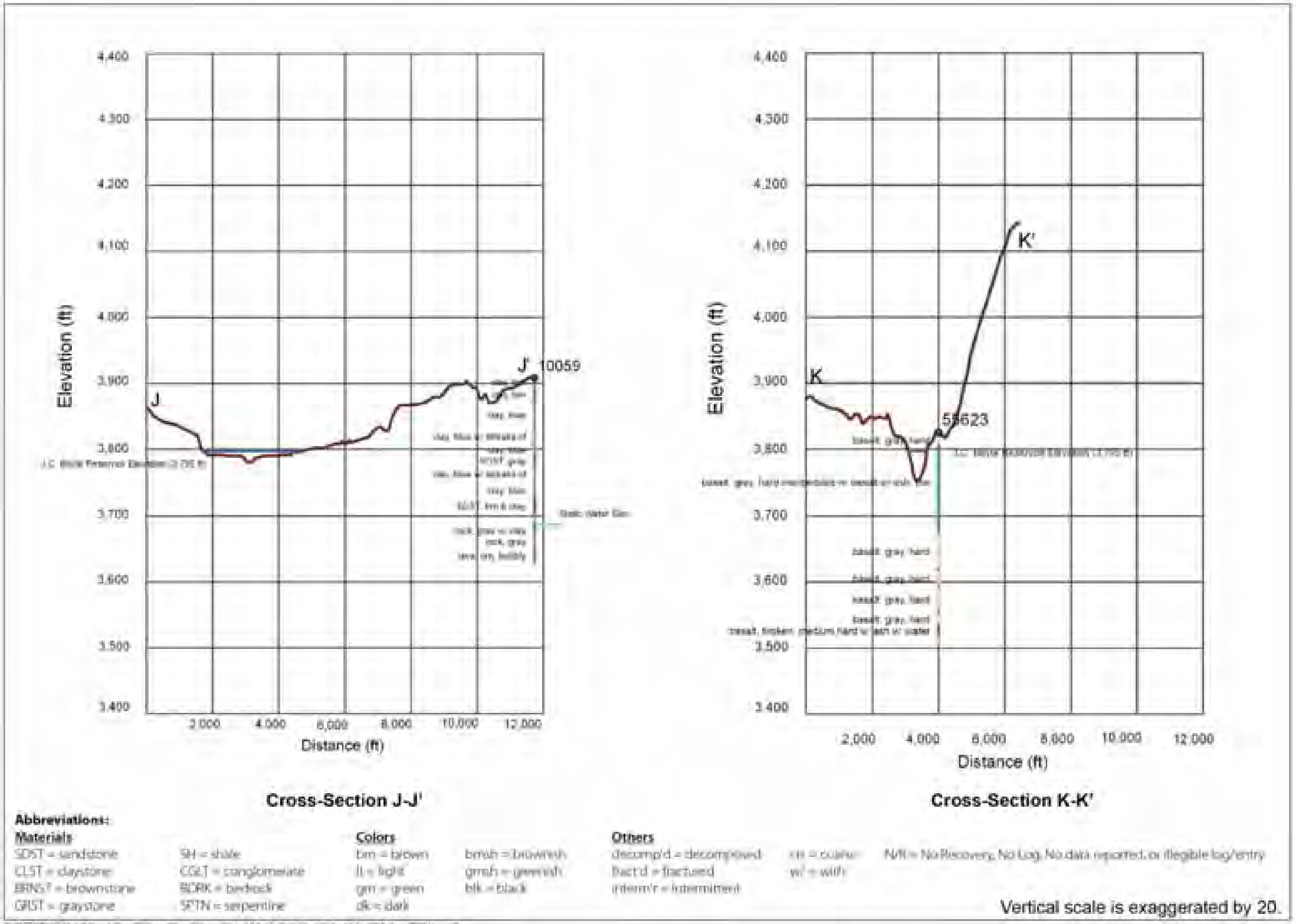


Figure 3.7-4. J.C. Boyle Reservoir Cross-Sections J and K.

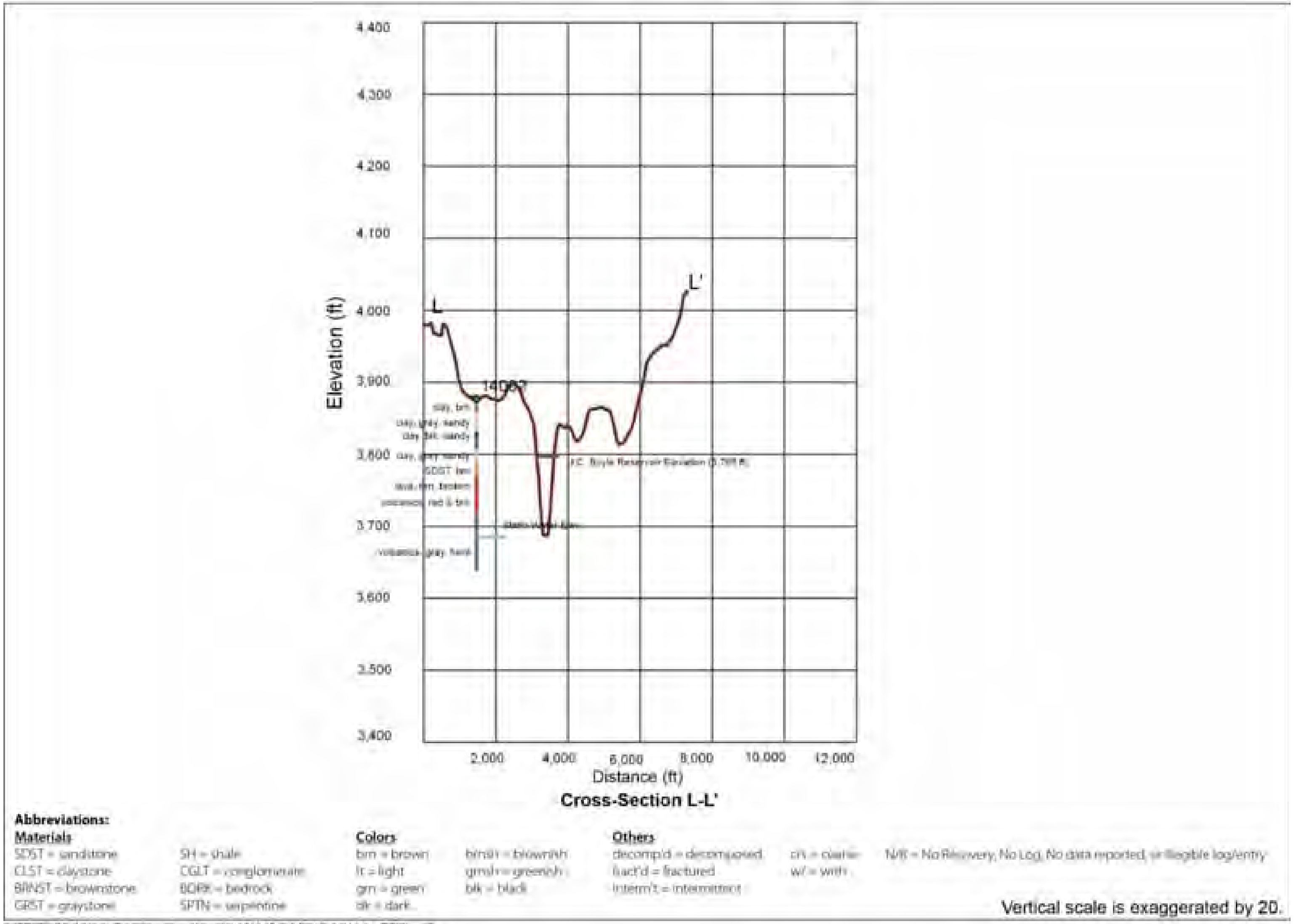


Figure 3.7-5. J.C. Boyle Reservoir Cross-Section L.

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 ground water flow in and between the High Cascade and Western Cascade is complicated and not well understood but the ground water 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 ground water 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 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 ft from the reservoir is 2,591 ft while the average static water level for all wells greater than 400 ft from the reservoir is 2,680 ft (Reclamation 2012a). These levels suggest that there is downward ground water flow near the reservoir (i.e., ground water is flowing down toward the reservoir).
Because

ground water is flowing toward the reservoir, this information suggests that the water level in the reservoir does not have a significant lateral influence on ground water levels in the area around J.C. Boyle reservoir (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 ground water flow in the units of the Western Cascade is complicated and not well understood. Specific ground water well data provides the best understanding of the occurrence of ground water 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 ground water flow direction is towards the reservoir in agreement with the regional ground water gradients (Gannett et al, 2007). Wells within 2,000 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 (Reclamation 2012a).

3.7.4 Environmental Consequences

The section analyzes the environmental consequences on ground water from implementation of the Proposed Action or its alternatives. Effects to ground water quality are not expected because ground water 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 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 ground water information presented in Section 3.7.3 to evaluate potential effects on existing wells and on ground water'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 ground water 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 ground water levels or ground water recharge so there would be changes to the ground water/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 ground water 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 ground water 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. Ground water 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 ground water table in the vicinity of the reservoirs would be expected.**

Under the No Action/No Project Alternative, there could be increased ground water 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 ground water resources include Agency Lake and Barnes Ranches. These actions would provide storage to store additional surface water supplies. In some years, when water is available, ground water use could decrease. However, as with historic conditions, ground water use may fluctuate depending on climatic conditions (i.e., there would likely be more ground water pumping during dry years when surface water diversions are less available). Stored surface water may also increase seepage into underlying ground water basins. **This would be a beneficial effect to ground water resources.**

3.7.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (the Proposed Action)

Under the Proposed Action, ground water 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: a) below the elevation of the original river channel, b) exposed along reservoir walls, or c) above the reservoir stage. The paucity of data regarding the 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 tapped by existing domestic or irrigation wells 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 are expected to be significantly impacted by the removal of the reservoirs. 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 ground water 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.

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 ground water, 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 ground water 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 (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 ground water 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 ground water levels 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 ground water discharge to the Klamath River. Removing the dam and eliminating the reservoir could result in less percolation of surface water to the underlying ground water 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. 2007 concluded that the Klamath River reaches in the project area are gaining reaches (i.e., ground water discharges to the stream). This assessment, and characteristics of the rock surrounding the reservoirs, suggest that any surface water that may have infiltrated to ground water systems under the reservoir would likely discharge back to the river just downstream 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 ground water recharge and the resulting ground water/surface water interaction would be less than significant.**

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 ground water or ground water recharge. **The removal of the recreational facilities would result in no change from existing conditions on ground water resources.**

Keno Transfer

Implementation of the Keno Transfer could cause adverse effects to local ground water. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. There will be no changes in facility operations. This transfer would not result in the generation of impacts to ground water 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 Westside Facilities – Programmatic Measures

Decommissioning the East and Westside Facilities could have adverse effects to ground water resources. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would eliminate the need for diversions at Link River Dam into the two canals. Following decommissioning of the facilities there will be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. Ground water recharge in the area is not expected to change. **The decommissioning of the East and Westside facilities would result in no change from existing conditions on ground water resources.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

The Proposed Action would require the relocation of the City of Yreka Water Supply Pipeline. The existing water supply pipeline for 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 be suspended from a pipe bridge across the river near its current location. The water supply utilized by the City of Yreka would not change, and none of the construction activities are anticipated to interact with or impact existing ground water supplies or require ground water supplies to complete the construction. **The relocation of the City of Yreka Water Supply Pipeline would result in no change from existing conditions on ground water supplies.**

KBRA – Programmatic Measures

The KBRA, which is an action connected to the Proposed Action, encompasses several programs that could affect ground water, 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) could reduce the availability of surface water for irrigation on Reclamation's Klamath Project. These limitations are intended to increase water availability for fisheries purposes at critical times and increase the certainty of water deliveries to Reclamation's Klamath Project. 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, ground water 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 ground water, as compared to historic levels, because of the Water Diversion Limitations program, such increased use could affect ground water levels in the pumped aquifer and reduce ground water inflow into the Klamath River and its tributaries.

Recognizing the potential for increased reliance on ground water, the KBRA includes provisions that would require monitoring of pumping at existing wells, the monitoring of ground water levels in the pumped aquifer, and the monitoring of springs affected by drops in ground water levels. Additionally, the KBRA specifies the development of an On-Project Plan objective prohibiting adverse effects on ground water levels within Reclamation's Klamath Project boundaries. The KBRA defines adverse effects as the flow of certain springs being reduced by more than six percent from year 2000 flows when the ground water 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 ground water use (KBRA Appendix C-2). As part of this effort to mitigate any effects on ground water, the KBRA requires implementation of the work plan in Appendix E-2 of the KBRA which provides for investigation and monitoring of the ground water resources of the Upper Klamath Basin.

The USGS, in support of this ground water investigation and monitoring effort, developed a ground water model that will be utilized to assess the effects of ground water use in the basin and identify any adverse changes in ground water levels (Gannett 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 ground water level monitoring sites and data and to also identify the additional sites where streamflow, spring discharge, or ground water 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 ground water through the increased use of ground water to replace surface water deliveries. These effects would be reduced through: the implementation of ground water monitoring and pumping restrictions as described in KBRA 15.2.4.A.i, the reduction of ground water pumping in the driest years, increased data collection, new modeling of the maximum potential ground water withdrawals, and increased funding related to mitigating adverse effects on ground water. 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 ground water 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 ground water 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 ground water improvements generated by this program to contribute to ground water 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 ground water resources by protecting them from overuse (through provisions prohibiting adverse impacts to ground water, where none currently exist), but because such benefits cannot be accurately assessed at this time, the effect on ground water 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-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 ground water recharge. The geographic separation between actions proposed under this program and the hydroelectric facility removal actions analyzed above reduce any potential for ground water improvements generated by this program to contribute to ground water effects generated by facility removal. **Implementation of the WURP would benefit**

ground water resources by increasing ground water 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 ground water use given provisions developed to prevent adverse impacts to ground water 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 ground water effects generated by this program contributing to ground water effects generated by facility removal. **Implementation of the Interim Flow and Lake Level Program would result in less than significant impacts on ground water resources in the short term, and would be expected to benefit ground water 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 ground water 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 2.4.3.10 and include potential emergency response measures and processes to implement emergency responses. Implementation of an Emergency Response Plan could potentially reduce emergency ground water 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 ground water generated by the hydroelectric facility removal action. **Therefore, it is anticipated that implementation of the Emergency Response Plan would result in no change from existing conditions on ground water resources. However, implementation of the Emergency Response Plan would likely help to reduce ground water use due to a facility or dike failure which would be a beneficial**

effect to ground water 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 ground water impacts of the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

Keno Transfer

The ground water impacts of the Keno Facility transfer under the Partial Facilities Removal of Four Dams Alternative would be the same as for the Proposed Action.

East and Westside Facility Decommissioning – Programmatic Measure

The ground water impacts of the East and 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 ground water impacts of the City of Yreka Water Supply Pipeline relocation would be the same as the Proposed Action.

KBRA – Programmatic Measures

The ground water 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 ground water 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 ground water table in the vicinity of the reservoirs would be expected. **There would be no ground water 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

Ground water impacts associated with the removal of Copco 1 and Iron Gate would be the same as under the Proposed Action. Ground water 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 ground water well so the ground water 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 ground water 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 ground water would be anticipated. If the amount of ground water 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 ground water 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 ground water resources.

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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 agricultural use. Reclamation's Klamath Project also provides water to two National Wildlife Refuges (NWRs). 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 from Iron Gate Dam to the river's mouth on the California coastline. Downstream from 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 and 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 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 treaties, statutes, and Executive orders, and vest no later than the date the reservation was established. Unlike State appropriative rights, 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 reserved water rights may be quantified by a State under the McCarran Amendment's narrow waiver of sovereign immunity, they are governed by Federal, not State, law.

3.8.2.2 State Water Law

Two basic State water law doctrines exist in the United States, and States administer water resources within their boundaries in accordance with one or some combination of the doctrines. Under the doctrine of prior appropriation, water rights are based on beneficial use, with the first person putting water to use accruing the 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, including Oregon, recognize certain riparian rights, but require all water users, including riparian landowners, to obtain water use permits from the 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 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 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 water right claims, including claims for and by the Klamath Tribes, for 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 non-Indian 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. 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 no such proceeding to determine all rights in the Klamath Basin, including Federal reserved rights, has been initiated to date in California. If the SWRCB determines a stream is fully appropriated, no new permits are issued. The SWRCB has determined the mainstem of the Klamath River, from 100 yards downstream from Iron Gate Dam to the Pacific Ocean, is fully appropriated during the entire calendar year (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 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 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 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 are generally made by compact – a negotiated interstate agreement made with the consent of Congress – or by Federal judicial proceeding. No 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, 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/Westside Facilities) and KBRA. The Klamath Basin water supply is described, including 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.

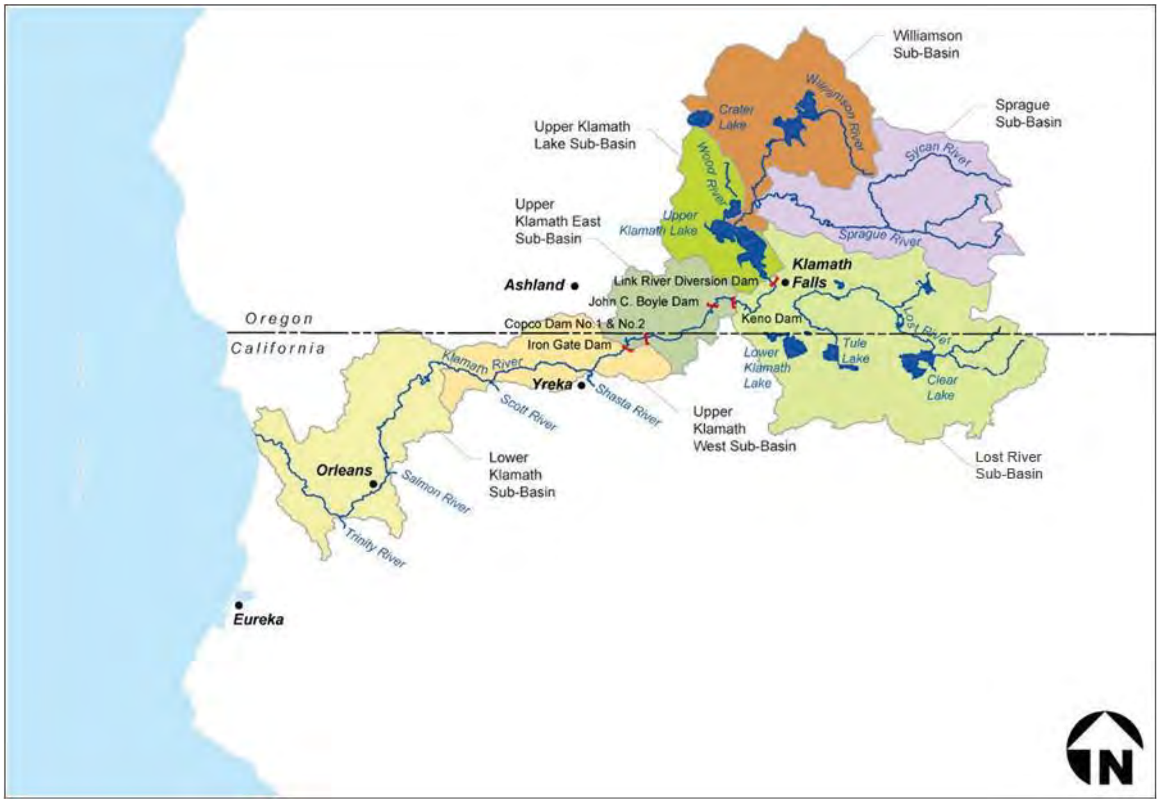

Figure 3.8-1. Area of Analysis.

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.

Multiple entities rely 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% ground water
Sprague River	1,020,000	61,600	65% diverted from streams, 35% ground water
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 ground water, individual surface water rights, or special Reclamation contracts.
Tule Lake Sub-basin	*296,600*	*64,800*	Ground water 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. Ground water flows from west to east out of the sub-basin toward Lower Klamath Lake. Irrigation water is from ground water 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 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 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 reserved instream flow rights of the Klamath Tribes that may reduce the available water to junior water rights users. Private irrigators in the Upper Klamath Basin have filed claims in the adjudication 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 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; two are adjacent to, 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. USFWS has also claimed Federal reserved water rights for Lower Klamath, Tule Lake, Klamath Marsh and Upper Klamath NWRs and *Walton* rights for Klamath Marsh 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 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 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 Lower Klamath Lake by returning Lost River 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.

Beginning in April, Reclamation forecasts the available water supply and establishes a general management plan for the coming year. 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 estimates water availability and has been provided to the water users’ community since 1995 (Reclamation 2000).

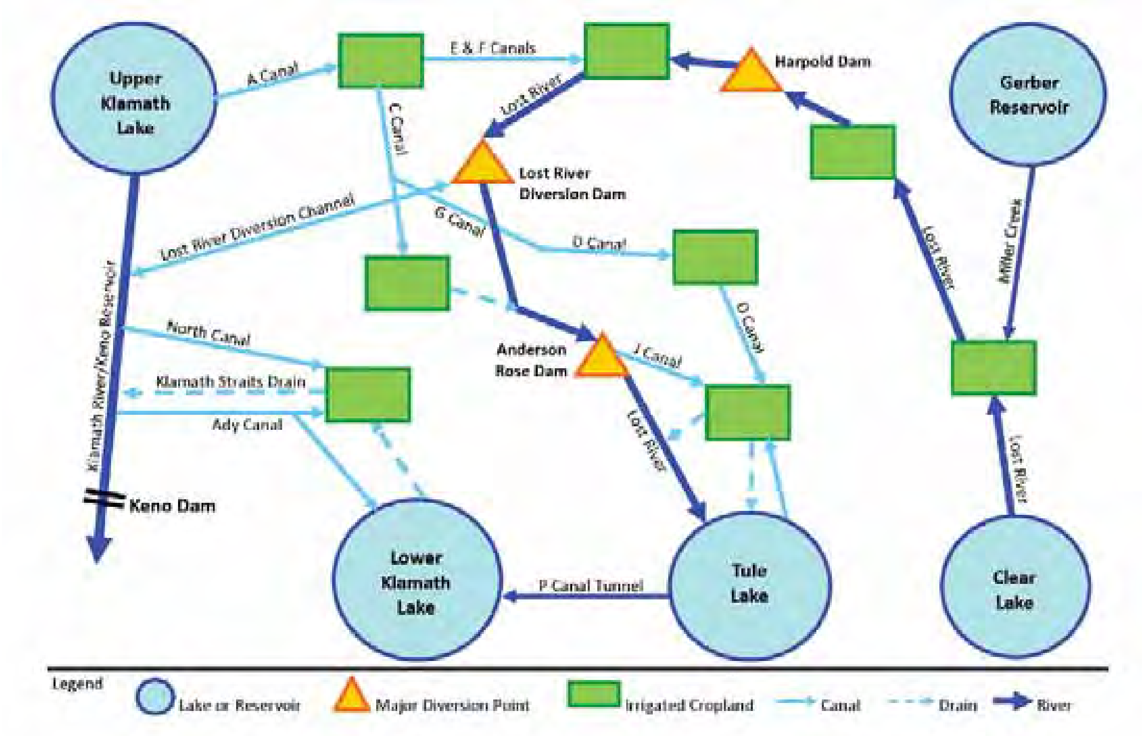

Figure 3.8-2. Schematic of Reclamation's Klamath Project.

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. 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 controls Upper Klamath Lake. The East and Westside powerhouses, downstream from Link River Dam, represent the upstream boundary of the Klamath Hydroelectric Project; 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, 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, 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 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. 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 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 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). 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.

3.8.3.2 Lower Klamath Basin

As described above, the Lower Klamath Basin includes seven sub-watersheds downstream from 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 from the California State line, the mainstem of the Klamath River flows through Siskiyou, Del Norte, and Humboldt Counties to the Pacific Ocean. A query on California's Electronic Water Rights Information Management System provided 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 from Iron Gate Dam. Appendix L contains the query results and has a map that displays the documented locations.

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 ground water 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.

Indian Tribes

Quartz Valley Indian Reservation

The members of the Quartz Valley 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 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 652 acres in Siskiyou County and 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 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 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 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 from 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 (Reclamation 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 Services, Solid Waste, 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 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 result in no change from existing adverse conditions.**

[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).

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 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 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)

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 from 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 from 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.

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 from Seiad Valley. As shown in Appendix L, approximately 8 of the 32 California water rights are downstream from Seaid Valley. **Under the Proposed Action, impacts on water supply downstream from Seiad Valley would be less than significant.**

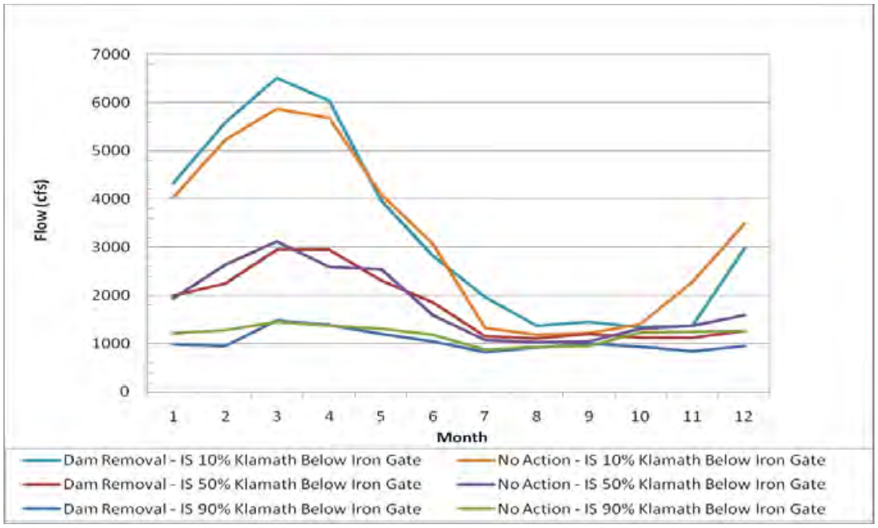

Figure 3.8-3. Flows for different year types under the Proposed Action and No Action Alternatives just downstream from Iron Gate Dam (Reclamation 2012).

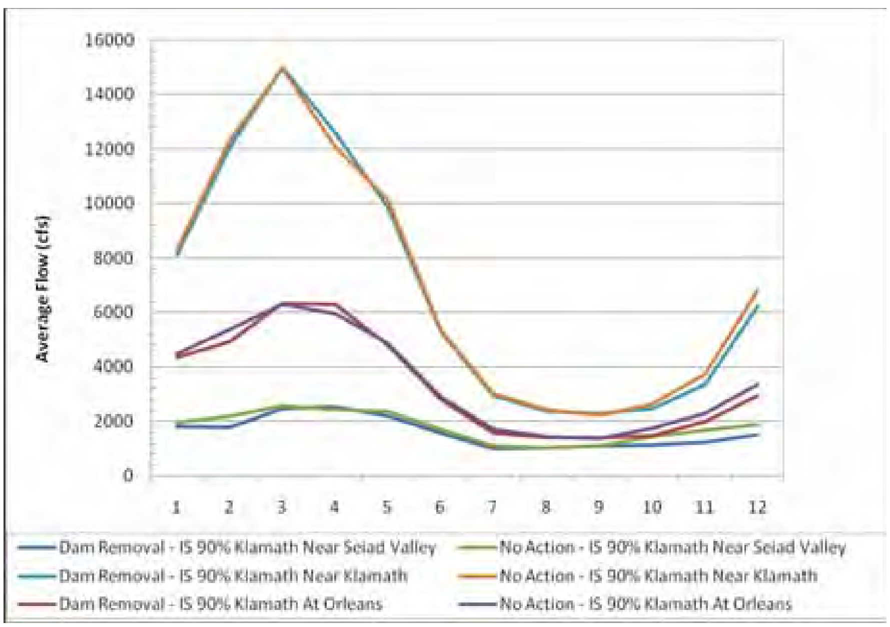

Figure 3.8-4. 90% Exceedance Flows Near Seiad Valley, Orleans, and Klamath for Dam Removal and No Action Alternatives.

Dam removal could cause changes in water supply compared to the No Action/No Project Alternative. Flow rates just downstream from 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. 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. 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 monthly diversion flow rate associated with all of the active and inactive water rights, aside from the four reserved 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 from 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 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

[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] 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.

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 from 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 from the dam, around Cottonwood Creek. There are 14 water rights registered on this reach; five are listed as inactive, two are 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 from 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 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 Westside Facilities – Programmatic Measures

Decommissioning the East and Westside Facilities could cause adverse impacts to water supply and water rights. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA will stop diversions of water flows at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there 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 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 City of Yreka Water Supply Pipeline after drawdown of the Iron Gate Reservoir could affect water supply. The existing water supply pipeline for 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 be suspended from a pipe bridge across the river near its current location. The water intake for the City of 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 the City of Yreka. **The relocation of the City of Yreka Water Supply Pipeline would result in no change from existing conditions.**

KBRA – Programmatic Measures

The KBRA, which is a connected action 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 from 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].

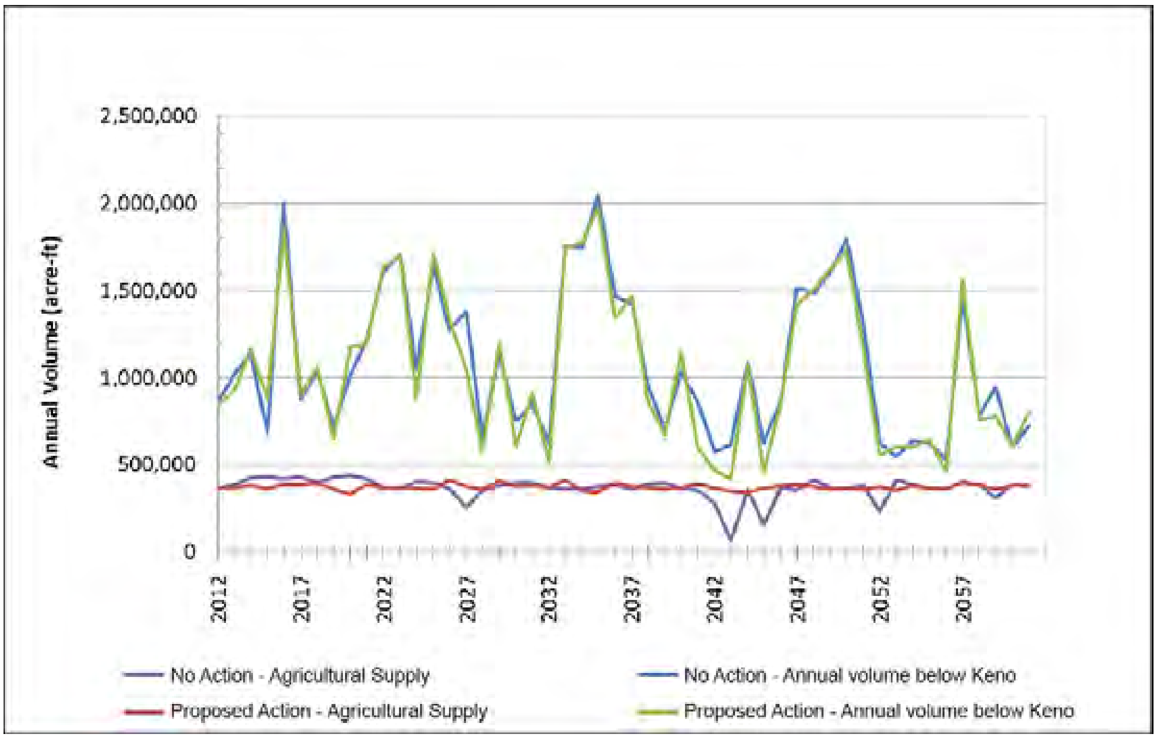

Figure 3.8-5. Annual flows under the No Action/No Project Alternative and Proposed Action (Reclamation 2012).

Fisheries Reintroduction and Management Plan

Implementation of the trap and haul element of the Fisheries Reintroduction and Management Plan could require water rights to divert water for the fish handling facilities. Fish handling facilities to collect fish downstream from 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. Trap and haul is likely to be an exempt use under ORS 537.141(d) and OAR 340-0010(2)(c)(B) if it causes no injury to existing water rights and if it is found to be not

[4] Minimum flows may change in the future. Hydrologic modeling assumed that the Drought Plan would include a minimum flow of 800 cfs (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.

harmful to fish or wildlife after consultation with Oregon Department of Fish and Wildlife (ODFW). 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. 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 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. 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 demand and actual diversion. These actions include: land fallowing and shifting to dryland crop alternatives, efficiency and conservation measures, development of ground water sources, or creation of additional storage. A specific objective is included in the plan that ground water pumping would not reduce flow greater than 6 percent to springs upstream of Copco Dam; which includes the Klamath, Wood and Williamson Rivers. 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. Off-stream storage is likely to improve water supply reliability and assist with alleviating short-term impacts related to water supply delivery during 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 2.4.3.10. 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. Changes in flows upstream of 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 the water supply for public health and safety because there would be no changes to downstream 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, 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. Changes in irrigation deliveries upstream of 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 necessary to meet the commitments of the KBRA. The components of the Emergency Response Plan are described in Section 2.4.3.10 and includes providing a notice and response in case of a failure of a Klamath Reclamation Project facility, such as a pump or dike. 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 restore supply as 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, changes in water deliveries during the interim period would not contribute to any changes in water supply or water rights in the vicinity of the Four Facilities. This is due to the fact that there is very limited water supply for irrigation in the Hydroelectric Reach and the Interim Flow and Lake Program are focused on Upper Basin agricultural water supplies. **Therefore, implementation of the Interim Flow and Lake Level Program would cause a less than significant impact to water rights as leases and purchases of water would be from willing sellers. Implementation of the Interim Flow and Lake Level Program is expected to have less than significant impact to the water supply for public health and safety as changes in water supply during the interim period would not contribute to any changes in the vicinity of the Four Facilities. 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, ground water substitution, or ground water sharing. The effects of these actions could improve short-term water supply reliability and could have potential short-term ground water elevation effects. Because users would have a choice between irrigating and being compensated for not irrigating, the current priority system in place within 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 the reliability of water supply used for public health and safety. 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 removal of recreation facilities at reservoirs would have no effect to water supply or water rights. Flow changes downstream from 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 Westside Facilities – Programmatic Measures

The effects of the decommissioning of the East and 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 the City of 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 from 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 from 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. Trap and haul is likely to be an exempt use under ORS 537.141(d) and OAR 340-0010(2)(c)(B) if it causes no injury to existing water rights and if it is found to be not harmful to fish or wildlife after consultation with ODFW. **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 from 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 from 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 the City of 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 from 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

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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.

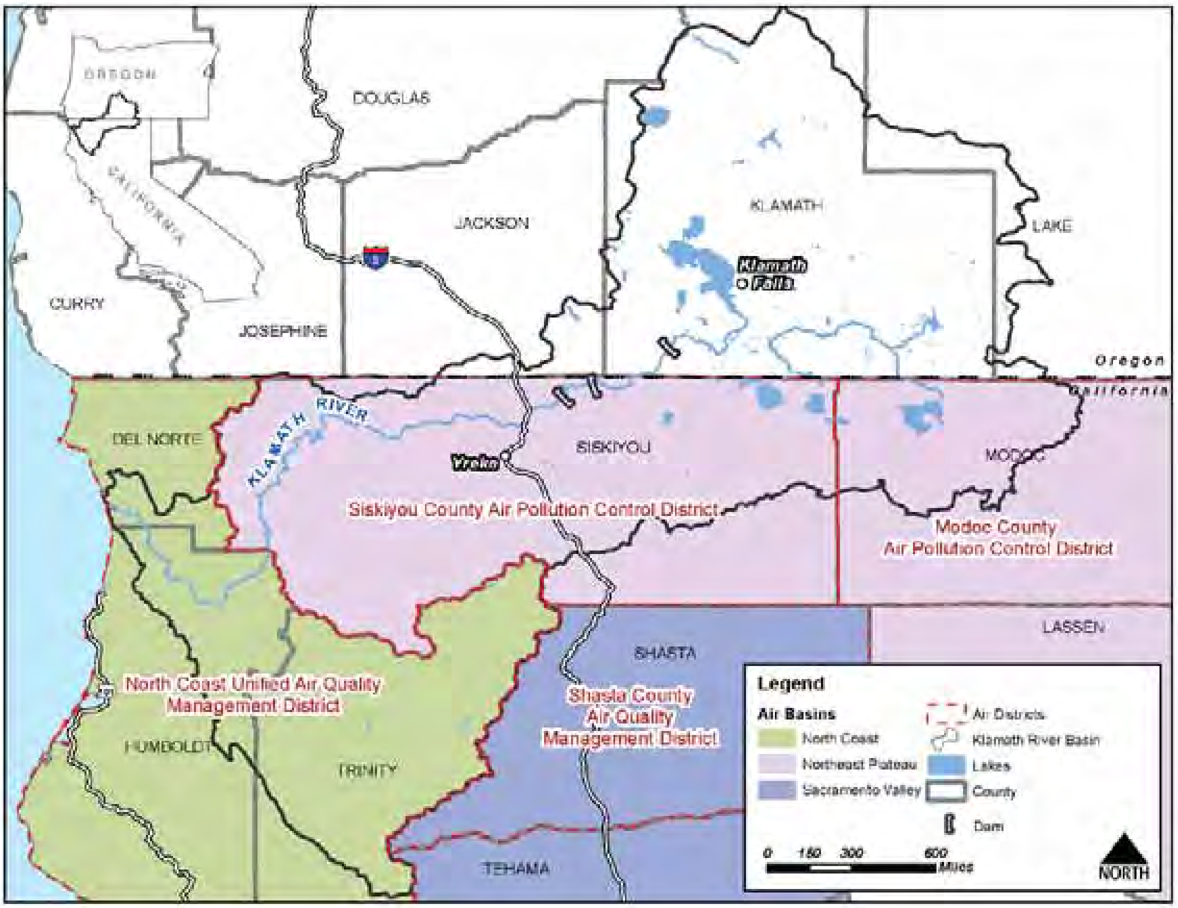
The area of analysis includes the Curry County in Oregon and Del Norte, Humboldt, Modoc and Trinity counties in California for a qualitative analysis of the impacts that would be caused by implementation of programmatic elements of the alternatives.

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

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

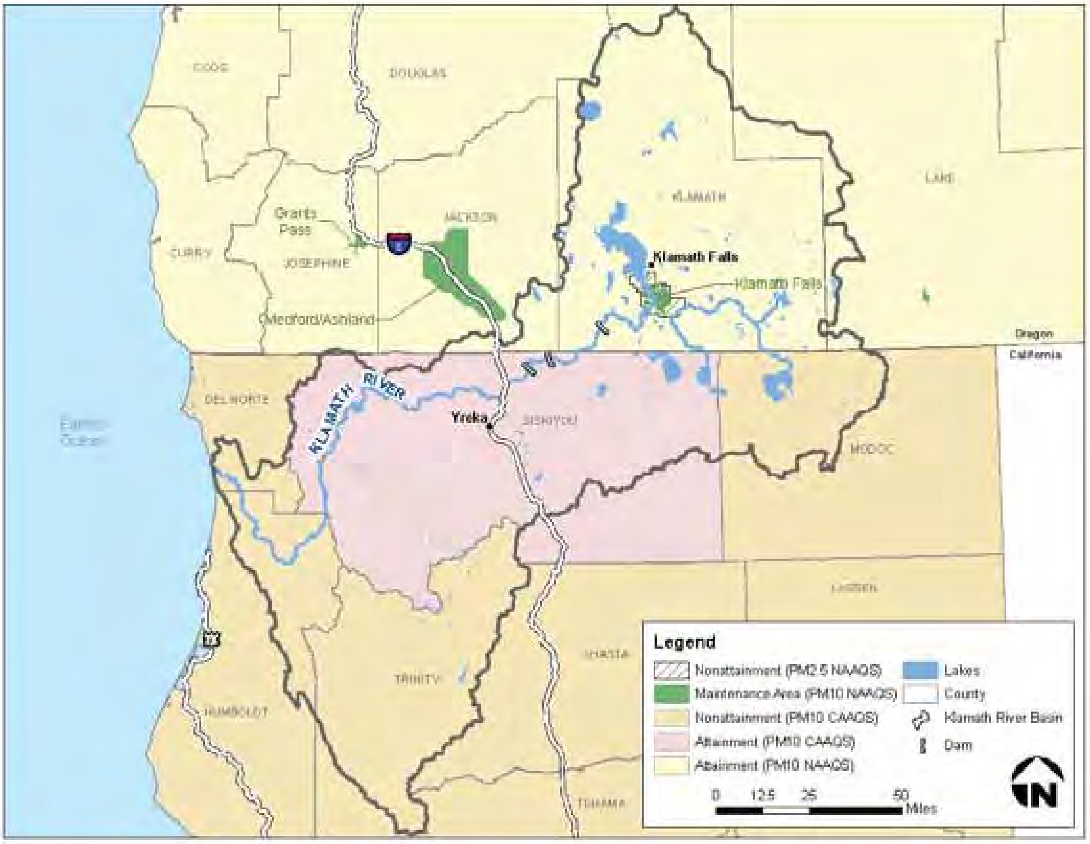
Regions are designated as nonattainment, maintenance, or attainment areas with respect to the various National and California ambient air quality standards, based on their compliance with the standards. A nonattainment area is defined as a region that does not meet the Federal or State ambient air quality 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 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 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

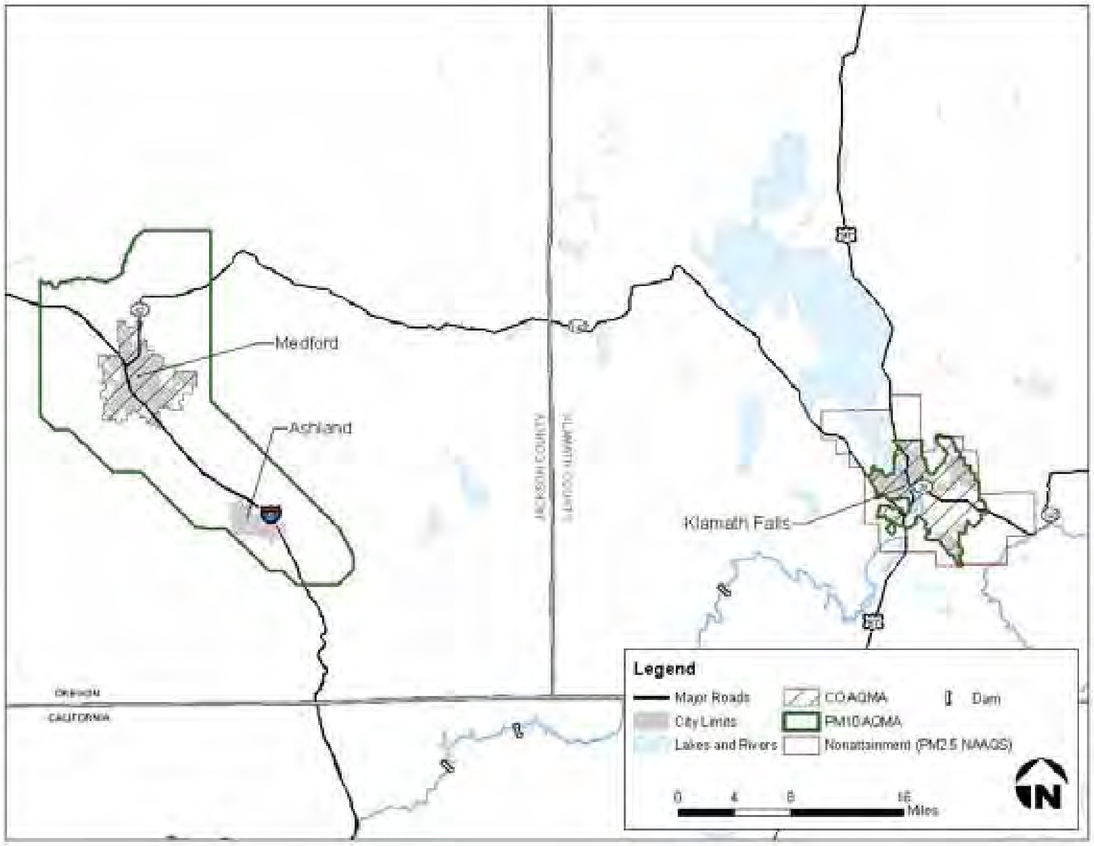
Source: United States Environmental Protection Agency (USEPA) 2010a; OAR 340-204.
AQMA: Air Quality Maintenance Area
UGB: urban growth boundary

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 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.

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 Federal 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.

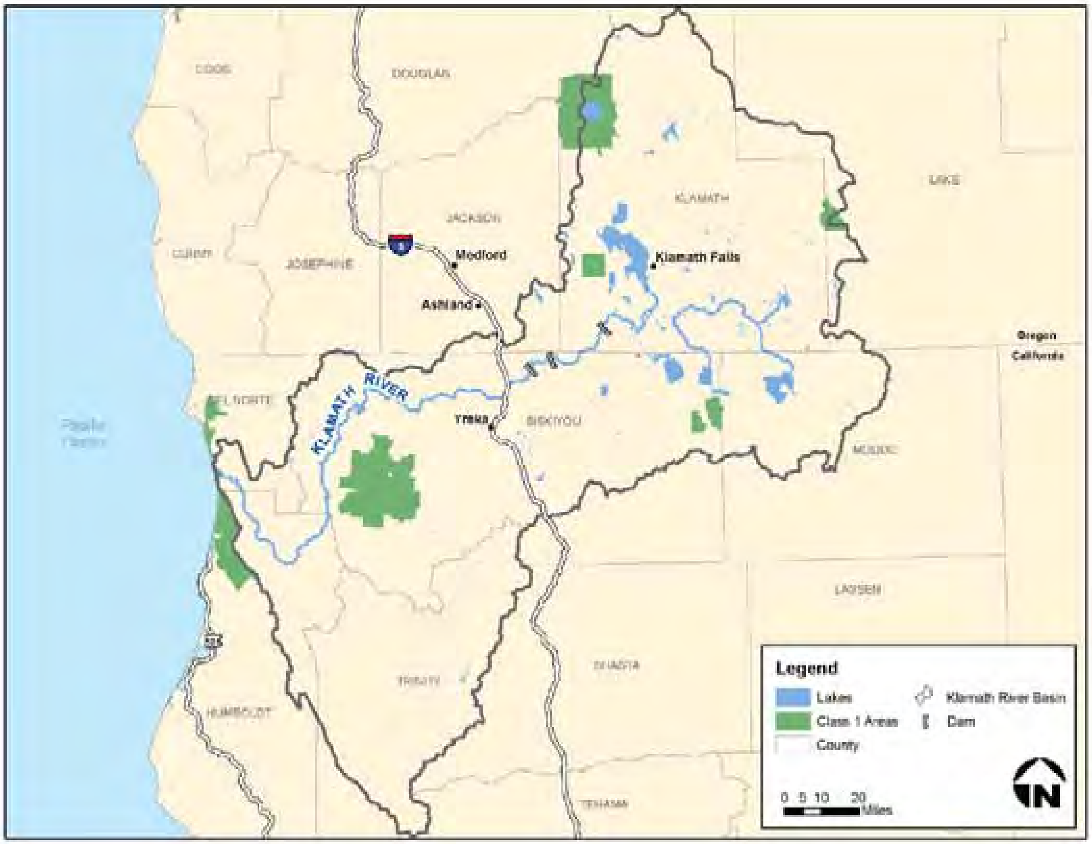
- Crater Lake National Park (Oregon)
- Gearhart Mountain Wilderness (Oregon)
- Lava Beds National Monument (California)
- Marble Mountain Wilderness (California)
- Mountain Lakes Wilderness (Oregon)

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.



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 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 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

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. **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.

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. 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 reconstructed or demolished. On- and off-road construction equipment would be used to complete these activities, which would occur after the dam demolition actions. 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.

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. 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. 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 Westside Facility Decommissioning – Programmatic Measures

Decommissioning the East and Westside Facilities could cause adverse air quality effects. Decommissioning of the East and Westside canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would cease the current diversion of water at Link River Dam into the two canals 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 Westside Facilities decommissioning action would be less than significant.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

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 equipment would be used to complete the relocation and construction of the City of 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 City 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 City of 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 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 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 3.9-7 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 3.9-7 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.**

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. **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 3.9-7. 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. 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. 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

The effects of the Keno Transfer would be the same as those for the Proposed Action.

East and Westside Facility Decommissioning – Programmatic Measures

The effects of the East and 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 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 City of 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 3.9-8 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.**

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 of 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.**

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

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 3.9-9 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 3.9-9 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 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 3.9-9. 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

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. 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

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. Annual GHG emissions were estimated using information provided in the *Detailed Plan for Dam Removal – Klamath River Dams* (Reclamation 2011) and CalEEMod. Table 3.9-11 summarizes emissions from the relocation and demolition of recreation facilities.

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 3.9-9 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 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 City of 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 City of 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 3.9-12 summarizes the expected emissions after mitigation.

Table 3.9-12. 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.
[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 from 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.**

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3.10 Greenhouse Gases/Global Climate Change

This section discusses potential greenhouse gas (GHG) and global climate change impacts from the Proposed Action and alternatives. The analysis related to climate change was organized into two distinct categories: 1) issues related to how climate change would affect the Proposed Action, and 2) issues related to the quantification of GHG emissions. This section describes the affected environment/environmental setting, analysis methods, significance criteria, and impacts for each of the alternatives. Appendix N provides detailed GHG emission calculations.

3.10.1 Area of Analysis

The area of analysis is the Klamath Basin, which includes multiple counties in northern California and southern Oregon. A quantitative analysis of GHG emissions associated with dam removal consistent with implementation of the Klamath Hydroelectric Settlement Agreement (KHSA) was restricted to Siskiyou and Shasta Counties in California and Klamath and Jackson Counties in Oregon. This area was defined to encompass GHG emissions associated with dam removal activities and construction-related vehicle trips (e.g., trucks and construction worker commuting).

A qualitative analysis of GHG impacts was completed for the aforementioned counties, as well as Del Norte, Humboldt, Modoc, and Trinity Counties in California and Curry County in Oregon. These counties would encompass areas affected hydrologically by implementation of the KHSA and the Klamath Basin Restoration Agreement (KBRA). In other words, regions that could be affected by the effects of climate change, such as increased temperature, changes in precipitation, and reduced snowpack, were evaluated.

Although project-related emissions are restricted to the area of analysis described above, data on the existing GHG emissions are only available at the State-level for California and Oregon (California Air Resources Board [CARB] 2009; Oregon 2010). The climate change analysis is based on global circulation models that typically do not have resolutions finer than the region or State. As a result, it was necessary to use a larger region than that included the area of analysis to establish existing conditions.

3.10.2 Regulatory Framework

Greenhouse gas and global climate change are governed by several Federal and State laws and policies, which are listed below.

3.10.2.1 Federal Authorities and Regulations

- Department of the Interior (DOI) Secretarial Order No. 3289
- Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule (75 FR 31514)

3.10.2.2 State Authorities and Regulations

- California Executive Order S-3-05
- California Executive Order S-13-8
- California Executive Order S-14-08
- California Executive Order S-21-9
- California Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32)
- California Renewable Energy Resources Act (Senate Bill 2, First Extraordinary Session [SBX1 2])
- California Environmental Quality Act (CEQA) Guidelines (14 CCR §15064)
- Oregon House Bill 3543

3.10.2.2.1 Existing Conditions/Affected Environment

Data generated from global circulation models are used to project changes to climate. Climate change projections are based on varying global circulation models and emissions scenarios documented in reports, as described below. Because each report is based on different models and scenarios, each has varying levels of uncertainty associated with the projected changes. For this analysis, the ranges of projected changes published in each report are presented. In addition, the models used for each report were conducted at different scales (regional, State or local), as indicated in the descriptions below.

- **The United States Global Change Research Program (USGCRP)[1] climate impact analyses (USGCRP 2009):** The foundation for the USGCRP report is a set of 21 Synthesis and Assessment Products, as well as other peer-reviewed scientific assessments, including those of the Intergovernmental Panel on Climate Change (IPCC), the United States Climate Change Science Program, the United States National Assessment of the Consequences of Climate Variability and Change, the Arctic Climate Impact Assessment, the National Research Council's Transportation Research Board report on the Potential Impacts of Climate Change on United States Transportation, and a variety of regional climate impact assessments (USGCRP 2009). The scale of the USGCRP results is for the Northwest.
- **The Oregon Climate Assessment Report by the Oregon Climate Change Research Institute (OCCRI) (OCCRI 2010):** The Oregon Climate Assessment Report draws on research on climate change impacts in the western United States from the Climate Impacts Group at the University of Washington and the California Climate Action Team (OCCRI 2010). The scale for the OCCRI results is for the State of Oregon.

[1] United States Global Change Research Program is a consortium of 13 Federal departments and agencies authorized by Congress in 1989 through the Global Change Research Act (Public Law 101-606). The USGCRP coordinates and integrates Federal research on changes in the global environment and their implications for society.

- **The regional climate change effects synthesized by the Federal Highway Administration (FHWA 2010):** The FHWA report is based on the USGCRP report and the supporting database (CMIP3), as well as publicly available publications and literature on model results. In addition, FHWA high-resolution temperature and precipitation projections for the continental United States developed through statistical downscaling of the results of 16 climate models of the CMIP3 database were provided for low and moderately high emission scenarios for three future projections, including near-term, mid-century, and end-of-century. The scale of the FHWA results is for the Northwest.
- **Impacts to the Klamath Basin prepared by the National Center for Conservation Science and Policy; and the Climate Leadership Initiative (Barr et al. 2010):** For the Klamath Basin by the National Center for Conservation Science and Policy and the Climate Leadership Initiative, three global climate models—CSIRO, MIROC, and HADCM—and a vegetation model (MC1) simulated future temperature, precipitation, vegetation, runoff, and wildfire in the Klamath Basin (Barr et al. 2010). The scale of the results for this report is for the Klamath Basin.
- **Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration (Bureau of Reclamation [Reclamation] 2011c):** For the hydrologic, hydraulic, and sediment transport studies conducted by the Reclamation Technical Service Center, five different future climate scenarios were simulated. The scenarios were chosen to bracket the range of results simulated by global circulation models. Four scenarios correspond to combinations of the 25th and 75th quantiles of the precipitation and temperature simulated by the global circulation models for the Upper and Lower Klamath Basins. The fifth is the 50th quantile of the precipitation and temperature. The precipitation and temperature simulated by the global circulation models were downscaled to the Upper and Lower Klamath Basin. See Section 3.6, Flood Hydrology.
- **SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water (Reclamation 2011):** This report was prepared by Reclamation to address the effect of, and risk resulting from, global climate change with respect to the quantity of water resources located in each major Reclamation river basin. Information in the report was derived from available literature and from key findings from peer-reviewed studies. An original assessment was completed for the climate change implications for snowpack and natural hydrology.

3.10.2.2.2 Summary

The projected changes in climate conditions are expected to result in a wide variety of effects in the Pacific Northwest[2] and the Klamath Basin with regard to the Proposed

[2] The Pacific Northwest is defined by the USGCRP as Washington, Oregon, Idaho, and western Montana. Although the USGCRP "Pacific Northwest" region does not include California, it has the climate most representative of the Klamath Basin. The USGCRP region that contains California is the "Southwest" climate region, which includes California, Nevada, Arizona, Utah, and parts of New Mexico, Colorado, and Texas. The Southwest data represents the desert climates, which is not applicable to the Klamath Basin.

Action and the alternatives. The most relevant consequences related to the Proposed Action include changes to stream flow, temperature, precipitation, ground water, vegetation changes, and flow. In general, climate model projections include:

- Increased average ambient air and water temperature
- Increased number of extreme heat days
- Changes to annual and seasonal precipitation, including increased frequency and length of drought, less winter snow and more winter rain, and changes in water quality
- Increased heavy precipitation
- Reduced snow pack and snow melt, resulting in less runoff during the late spring through early autumn
- Vegetation changes
- Ground water hydrology changes
- Changes to annual stream flow

These projected changes are discussed in detail in the following paragraphs. The potential impacts related to the Proposed Action are discussed in Section 3.10.4.3, Effects Determination.

3.10.2.2.3 Increased Temperature

Future regional average annual air temperatures in Oregon are projected to increase by 0.2 to 1°F per decade depending on future GHG emissions, as compared to temperatures in the 20th century (OCCRI 2010). Projected temperature increases for the Pacific Northwest and the Klamath Basin are presented in Table 3.10-1.

Table 3.10-1. Projected Changes in Air Temperature under Existing Conditions

Region	Next Two Decades	Mid-21st Century	End of 21st Century
Pacific Northwest	+3.0 °F	+3.6 to 5.0 °F	+5.1 to 8.3 °F
Klamath Basin[1]	--- (---)	+2.1 to 3.6 °F (+2.7 to 3.0 °F)	+4.6 to 7.2 °F (+5.0 to 6.0 °F)

Source: USGCRP 2009, Barr et al. 2010, Reclamation 2011

Note:

[1] Data in (parentheses) from SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water (Reclamation 2011).

Key:

--- = data not available

Baseline conditions for the Pacific Northwest are based on data from 1961 to 1979 (USGCRP 2009). Baseline conditions for the Klamath Basin are based on data from 1961 to 1990 (Barr et al. 2010). Baseline conditions in the Klamath Basin are also considered to be the 1990s in the SECURE Water Action Section 9503(c) Report (Reclamation 2011).

In addition, the results of the hydraulic, hydrologic and sediment studies conducted to support this document show an average temperature increase of 2.5 to 4.0 °F in the Upper Klamath Basin between 2020 and 2069, as compared to temperatures during the period 1950 –1999 (Reclamation 2012c).

Increased temperature may result in a variety of general consequences for the Pacific Northwest and the Klamath Basin:

- Increased evaporation rates (USGCRP 2009).
- Increased incidence of wildfire (OCCRI 2010).
- Increased occurrence of short-term and long-term drought conditions (USGCRP 2009).
- Changing water quality of natural surficial water bodies, including higher water temperatures, decreased and fluctuating dissolved oxygen content (Barr et. al 2010), and increased cycling of detritus.
- Earlier, longer, and more intense algae blooms (Barr et al. 2010).
- Changes to soil moisture (USGCRP 2009), which may lead to soil subsidence under structures.
- Increased energy demand for cooling, refrigeration and water transport (Barr et al. 2010; USGCRP 2009).
- Buckling of pavement or concrete structures (USGCRP 2009).
- Decreased lifecycle of equipment or increased frequency of equipment failure (USGCRP 2009).
- Increased frequency of freeze-thaw cycles in winter months (USGCRP 2009).
- Changes to salmon populations due to increased water temperatures and other water quality changes (USGCRP 2009).
- Drought stresses and higher temperatures that could decrease tree growth and change habitat in most low- and mid-elevation forests (Barr et al. 2010).
- Warmer winters and longer growing seasons that may increase the frequency and intensity of insect attacks, such as those of the mountain pine beetle (Barr et al. 2010).
- Disruption of the coordination between predator-prey or plant-pollinator life cycles that may lead to declining populations of many native species (Barr et al. 2010).
- Increased water temperature (Barr et al. 2010).

As discussed in Section 3.3, Aquatic Resources, high water temperatures are detrimental to anadromous species when eggs or juveniles are present. High water temperatures have also been associated with fish die offs in the Lower Klamath River downstream from Iron Gate Dam.

3.10.2.2.4 Increased Number of Extreme Heat Days

By mid-century, heat events are projected to increase in the Pacific Northwest (FHWA 2010). By mid-century, the Pacific Northwest could experience an additional one to three heat waves annually (i.e., three or more days with the daily heat index exceeding 90°F), with other locations experiencing up to one additional heat wave each year under a moderate emission scenario (Salathe et al. 2009).

Increases in the number of extreme heat days may result in declining air quality due to increased ozone concentrations and increased incidence of heat-related illness and death.

3.10.2.2.5 Annual Precipitation

Over the next century, mean precipitation is projected to change gradually from existing precipitation averages. By mid-century (2035-45), the annual precipitation projections in the Klamath Basin exhibit a large range, from an 11 percent reduction to a 24 percent increase overall (Barr et al. 2010). Baseline conditions for the Klamath Basin are based on data from 1961 to 1990 (Barr et al. 2010).

The results of the hydraulic, hydrologic and sediment studies conducted to support this document show a change in total precipitation under the climate change scenarios ranging from 5 percent less to 5 percent greater precipitation between 2020 and 2069, as compared to precipitation during the period 1950–1999 (Reclamation 2012c).

Precipitation changes associated with climate change are complicated by the El Niño Southern Oscillation (ENSO). ENSO produces a cool, dry winter in the Klamath Basin and has cycles of 2–7 years of building and declining precipitation (Independent Science Advisory Board 2007). Climate change could affect the frequency or severity of ENSO events, which would change precipitation patterns in the Klamath Basin (Kiparksy and Gleick 2003). In addition, the Klamath Basin is at the southern edge of a low pressure cell during ENSO events, with the primary effect being a shift of storms southward towards southern California (National Oceanic and Atmospheric Administration Fisheries Service 2008). Climate change could move the low pressure area northward, which could change the types of ENSO effects within the basin from producing a drier winter to producing more intense winter storms.

3.10.2.2.6 Changes to Seasonal Precipitation

While only a slight increase in precipitation (defined as annual total precipitation divided by the number of “wet” days where precipitation exceeds 1 millimeter per day) is projected for the Pacific Northwest (Salathe et al. 2009), changes in seasonal precipitation, including winter rain replacing winter snow, are projected to result in earlier and higher spring stream flows and lower late summer stream flows (USGCRP 2009; Barr et al. 2010). Table 3.10-2 summarizes projected seasonal changes in precipitation for the Pacific Northwest and the Klamath Basin.

Table 3.10-2. Projected Seasonal Changes in Precipitation

Region	Season	Next Two Decades	Mid-21st Century	End of 21st Century
Pacific Northwest	Winter	+3 to +5%	+5 to +7%	+8 to +15%
	Spring	+3%	+3 to +5%	+5 to +7%
	Summer	-6%	-8 to -17%	-11 to -22%
	Fall	+3 to +5%	+5%	+7 to +9%
Klamath Basin[1]	Summer	---	-15 to -23%	-3 to -37%
	Winter	---	+1 to +10%	-5 to +27%
	Annual	---	-9 to +2% (+2.2 to +2.7%)	-11 to+24% (-0.2 to +2.2%)[2]

Source: USGCRP 2009, Barr et al. 2010, Reclamation 2011

Note:

[1] Data in (parentheses) from SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water (Reclamation 2011).

[2] Data based on expected change in the 2070s.

Key:

--- = data not available

Baseline conditions for the Pacific Northwest are based on data from 1961 to 1979 (USGCRP 2009). Baseline conditions for the Klamath Basin are based on data from 1961 to 1990 (Barr et al. 2010).

Summer months in the Klamath Basin are projected to have precipitation decreases ranging from 15 to 23 percent from historic baseline (1961-1990) (Barr et al. 2010). However, less than 12 percent of the average annual precipitation in the Klamath Basin falls from June-August (Western Regional Climate Center 2010), so the effect on average actual summer precipitation would be small (less than 0.2 inches). In the Upper Klamath Basin, dry-season (April to September) and summer (July to September) stream flow have already declined 16 percent and 38 percent, respectively, during the period between 1961-2009 (Mayer and Naman 2011).

Changes to seasonal precipitation may result in a variety of general consequences for the Pacific Northwest and Klamath Basin, which are listed below.

- Shifting stream flow patterns, including higher and earlier peak spring flows and lower late summer flows may alter the timing of fish migration (Barr et al. 2010).
- Decreased summer water supply (OCCRI 2010).
- Increased fine sediment in streams may result in negative impacts on the spawning of native fish that build their nests in the areas of clean rocks and gravel (Barr et al. 2010).
- Cessation of flow from springs fed by ground water may reduce the amount of refuge that these areas provide for fish survival (Barr et al. 2010).
- More variable flow from smaller ground water springs may occur, with potential disappearance in the driest years (Barr et al. 2010).
- Increased frequency and severity of flooding may occur (USGCRP 2009).

- Increased runoff may lead to surface water quality changes, including increased turbidity, increased organic content, color changes, and alkalinity changes (Barr et al. 2010).

3.10.2.2.7 Increase in Heavy Precipitation

Projections show that by mid-century, heavy precipitation, defined as annual total precipitation divided by the number of “wet” days where precipitation exceeds one millimeter per day, would increase slightly in the Pacific Northwest (FHWA 2010). The fraction of precipitation that falls on days where precipitation exceeds the 95th percentile was projected to decrease along the leeward side of the Cascade Mountains (Salathe et al. 2009). The characteristics along the leeward side of the Cascade Mountains are comparable to the Klamath Basin. Diffenbaugh (2005) projected an increase of up to 10 extreme precipitation events per year in the Pacific Northwest (up to a 140 percent increase) under a higher emission scenario with some variation depending on location within the region.

Increases in heavy precipitation may result in a variety of general consequences for the Pacific Northwest:

- Increased fine sediment in streams may result in negative effects on the spawning of native fish that build their nests in the areas of clean rocks and gravel (Barr et al. 2010).
- Increased frequency and severity of flooding may occur (USGCRP 2009).
- Increased runoff may lead to surface water quality changes including increased turbidity, increased organic content, color changes, and alkalinity changes (Barr et al. 2010).

3.10.2.2.8 Reduced Snowpack

By the 2040s, April 1st snowpack is projected to decline by as much as 40 percent in the Cascade Mountains (Payne et al. 2004) and between 37 percent and 65 percent in the Klamath Basin (Hayhoe et al. 2004). Cascade snowpack is projected to be less than half of what it was in the 20th century, with lower elevation snowpack being most vulnerable (OCCRI 2010). Projections show that by mid-century, warm-season runoff will decrease by 30 percent or more on the western slopes of the Cascade Mountains and by 10 percent in the Rocky Mountains (USGCRP 2009). By the end of the century, snowpack is projected to decline by 73 percent to 90 percent (Hayhoe et al. 2004).

The reduction in snowpack and snowmelt is also expected to result in less runoff during the late spring through early autumn. Snowpack decreases are projected to be more substantial in the warmer parts of the Klamath Basin. Projected warming might also change runoff timing, with more rainfall-runoff during the winter and less runoff during the late-spring and summer (Reclamation 2011).

Similarly, the results of the hydraulic, hydrologic and sediment studies conducted to support the Secretarial Determination on the Klamath Dam Removal and Basin Restoration show a more rapid snow melt for all climate change simulations.

Reduced snowpack may result in a variety of general consequences for the Pacific Northwest, including increased incidence of short- and long-term drought and limited inundation periods for side channels, which serve as nurseries for young fish and other aquatic animals (Barr et al. 2010). Summer water supply will also decrease as a result of reduced snowpack (OCCRI 2010).

3.10.2.2.9 Ground Water Hydrology

Projected increases in temperature and changes to seasonal precipitation will impact ground water hydrology. Projected changes in ground water hydrology include alterations of the timing and amount of recharge, increases in evapotranspiration, lowering of heads in boundaries such as streams, lakes, and adjacent aquifers, sea-level rise, and increased pumping demand, which will be exacerbated by population growth (OCCRI 2010). The high Cascade basins that are primarily fed by deep ground water systems could sustain low flow during summer months (OCCRI 2010). Basins in the east of the Cascades are projected to have low summer flow in a distant future as ground water recharge declines over time (OCCRI 2010).

Ground water hydrology changes may result in a variety of general consequences for the Pacific Northwest and Klamath Basin, including the following:

- Decreased stream flows for rivers and streams that are primarily fed by ground water supplies (Barr et al. 2010).
- Decreased availability of ground water for agricultural use and water supply (USGCRP 2009).

Reduced cool water refuge for aquatic animals due to the decline of springs fed by ground water and the cessation and increased variability of flow to smaller springs (Barr et al. 2010).

3.10.2.2.10 Vegetation Changes

Conditions in the Upper Klamath Basin are projected to favor grasslands in areas that are currently suitable for sagebrush and juniper (Barr et al. 2010). In the Lower Klamath Basin, conditions suitable for oaks and madrone may expand while those suitable for maritime conifer forest could decrease (Barr et al. 2010). The percentage of the Klamath Basin burned by wildfire is expected to increase from current levels by 11 percent to 22 percent per year by the end of the 21st century (Barr et al. 2010). In addition, decreased soil moisture and increased evapotranspiration may result in the loss of wetland and riparian habitats (Barr et al. 2010).

Vegetation changes may result in a variety of general consequences for the Pacific Northwest and Klamath Basin, including the following:

- Changes in water quality (e.g., sediment) from burn area runoff (Barr et al. 2010).
- Changes in the tree canopy that affect rainfall interception, evapotranspiration, and infiltration of precipitation, affecting the quantity of runoff (Barr et al. 2010).

- Changes in the shading over surface waters, which may affect surface water temperatures and other water quality characteristics (USGCRP 2009).
- Changes in wood and organic debris recruitment, which may affect water quality and channel morphology and complexity (Barr et al. 2010).
- Reduced ability to respond to flooding due to changes in wetland and riparian zone plant communities and hydraulic roughness (USGCRP 2009).
- Increased stress on species populations due to loss of wetland and riparian habitats (USGCRP 2009).
- Shifting distribution of plant and animal species on land, with some species becoming more or less abundant (OCCRI 2010).
- Rare or endangered species may become less abundant or extinct (OCCRI 2010).
- Insect pests and invasive species may become more abundant (OCCRI 2010).

3.10.2.2.11 Flow

Future annual stream flow effects calculations based on projected precipitation amount and timing changes are particularly difficult to project. Annual stream flows (the volume of flow in a year) were evaluated by comparing future model-estimated flows (based on runoff estimates from the three climate models) against actual stream flow measurements. Annual stream flows at the four stations evaluated (Iron Gate, Sprague River, Shasta River, and Salmon River) were "similar" to past records when comparing the frequency of "particularly" high and low flow events. The three models' results vary regarding projections of higher or lower annual flows—two models projecting lower flows and one projecting higher annual flows as compared to current flows (Barr et al. 2010).

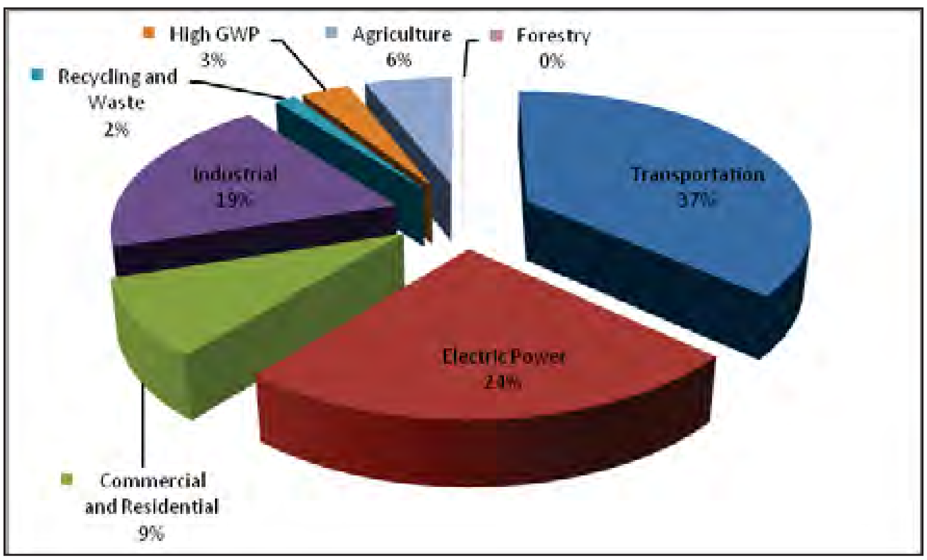
Similarly, the results of the hydraulic, hydrologic and sediment studies conducted to support this document show that the climate change scenarios are not sufficiently refined to determine effects to peak flows and therefore it is difficult to determine if climate change will have a significant impact on flood risk or geomorphology. However, if the future climate is wetter and with a faster snowmelt runoff during the spring, then peak flows would likely increase as well. However, if the climate is drier, faster snowmelt may result in peak flows that are not substantially higher (Reclamation 2012c).

Though the model used to project future flows did not identify a consistent trend, it is known that free-flowing rivers respond better to changes in climate conditions due to the ability to adjust to and absorb disturbances through flow adjustments that buffer against impacts (Palmer et al. 2008). A natural riverine system is in constant, dynamic equilibrium, absorbing highly variable flow forces by changing channel morphology and dissipating energy via sediment transport and woody debris. A natural river system is capable of using those "tools" to gradually adjust to flow regime changes due to climate-induced precipitation change. Consequently, the more physical changes the river system has been subjected to, such as changes in sediment budgets and flow regimes due to dams or land clearing, the less capable the system is of responding to or absorbing changed flow regime.

3.10.3 Existing Conditions/Affected Environment

The GHG analysis completed for the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) evaluated the following three pollutants: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). The other two pollutants commonly evaluated in various mandatory and voluntary reporting protocols, hydrofluorocarbons and perfluorocarbons, are not expected to be emitted in large quantities and are not discussed further in this section.

Worldwide, California[3] is the twelfth to sixteenth largest emitter of CO_2 (based on data source), and is responsible for approximately two percent of the world's CO_2 emissions (California Energy Commission [CEC] 2006b). As shown in Figure 3.10-1, transportation is responsible for 37 percent of the State's GHG emissions, followed by electricity generation (24 percent), the industrial sector (19 percent), commercial and residential (9 percent), agriculture and forestry (6 percent) and other sources (5 percent). Emissions of CO_2 are largely byproducts of fossil fuel combustion. Nitrous oxide is produced naturally in soil and can be increased by various agricultural practices and activities; fossil fuel combustion is also responsible for N_2O emissions. Methane, a highly potent GHG, results largely from off-gassing associated with agricultural practices and landfills. Sinks of CO_2, which are sources that absorb more CO_2 then release CO_2, include uptake by vegetation and dissolution into the ocean. California GHG emissions in 2008 (the last year inventoried) totaled approximately 474 million metric tons CO_2 equivalent ($MMTCO_2e$) (CARB 2009).

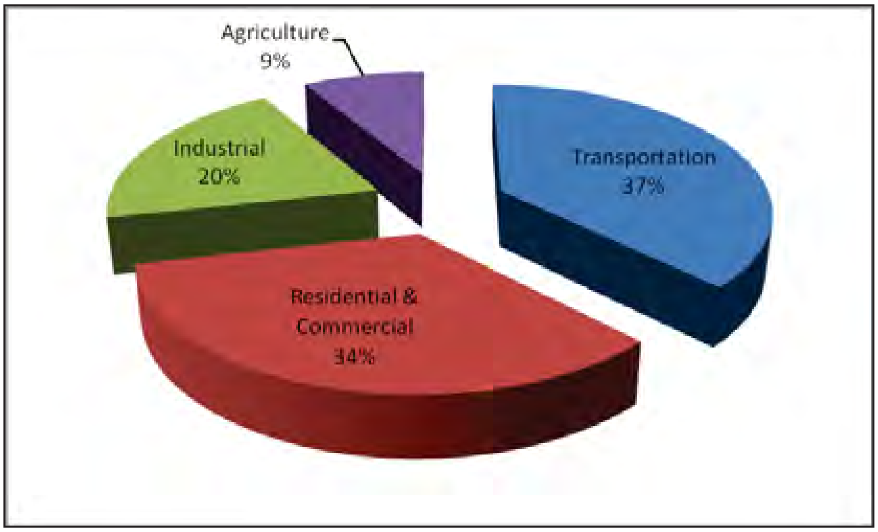


Source: CARB 2009.

Figure 3.10-1. California GHG Emission Sources (as of 2008).

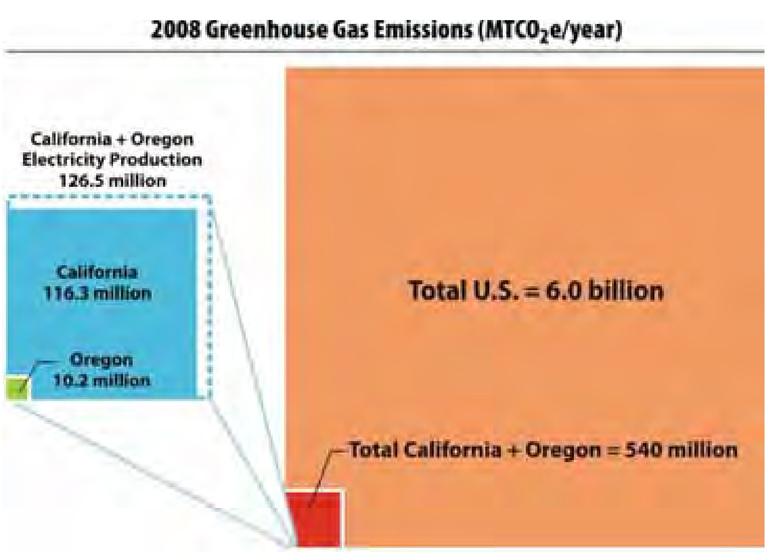
[3] Although the area of analysis for the project is restricted to portions of northern California and southern Oregon, GHG emissions data is not available at this level of detail; therefore, background emissions data (i.e., existing conditions) is presented at the State-level for both California and Oregon.

As shown in Figure 3.10-2, the distribution of emission sources in Oregon is similar to that in California, with the majority of emissions occurring from the transportation sector (37 percent), followed by the residential and commercial sector (34 percent), then by industrial sources (20 percent), and agriculture (9 percent). Oregon GHG emissions in 2007 (the last year inventoried) totaled approximately 68 $MMTCO_2e$ (Oregon 2010).



Source: Oregon 2010.

Figure 3.10-2. Oregon GHG Emission Sources (as of 2007).



Source: CARB 2011; Oregon 2010; USEPA 2011.

Figure 3.10-3. Greenhouse Gas Emissions Comparison.

Figure 3.10-3 illustrates the difference between GHG emissions associated with electricity production for Oregon and California with the economy-wide GHG emission inventories for the two States and for the United States. As shown in the figure, GHG emissions associated with electricity production are approximately 23 percent of the total emissions for Oregon and California and a fraction of the total GHG emissions for the United States.

3.10.4 Environmental Consequences

By its very nature, climate change is a cumulative phenomenon, and it is not possible to link a single project to specific climatological changes. The Proposed Action and alternatives would result in temporary GHG emissions from construction-related activities. Total GHG emissions from deconstruction or construction activities at the three dams in California (Iron Gate, Copco 1, and Copco 2 Dams) would make up 0.0007 to 0.002 percent of Statewide emissions, depending on the alternative. Emissions associated with activities at J.C. Boyle Dam in Oregon would make up 0.001 to 0.004 percent of Statewide emissions, depending on the alternative.

3.10.4.1 Environmental Effects Determination Methods

The analysis related to climate change was organized into two distinct categories: 1) issues related to how climate change would affect the Proposed Action, and 2) issues related to the quantification of GHG emissions.

The quantification of GHG emissions was performed similarly to the one for the air quality (Section 3.9) analysis with a few exceptions. Project-related emissions were compared to applicable thresholds of significance to evaluate environmental impacts from GHG.

Direct GHG emissions include those associated with on- and off-site construction equipment, construction worker commuting, and haul truck emissions. Indirect GHG emissions include changes that could occur from alterations in land use, agricultural resources, and recreation from implementation of the KHSA and KBRA. See Section 3.9, Air Quality, for additional detail relevant to the estimation of these emissions. In addition, consideration is provided in this section to the potential emissions associated with other power sources that may be used to replace the hydropower associated with the Four Facilities.

This analysis also evaluates how the GHG emissions resulting from the project might affect global climate change. GHG emissions are quantified or qualitatively described, as discussed above, for the changes associated with each project alternative, including land use changes and changes to recreational use.

3.10.4.1.1 Climate Change

The purpose of this climate change analysis is to determine how projected changes to climate conditions might affect the Proposed Action and alternatives. The Lead Agencies used the results of global climate models from leading institutions around the world, combined with publicly available, peer-reviewed studies, to identify the projected climate change effects and their consequences specific to the Pacific Northwest region and the Klamath Basin.

The main resources for identifying the project effects and general consequences were the USGCRP climate impact analyses (USGCRP 2009), the Oregon Climate Assessment Report by the OCCRI (OCCRI 2010), the regional climate change effects synthesized by the FHWA (FHWA 2010), the climate change impacts analysis prepared specifically for the Klamath Basin by the National Center for Conservation Science and Policy; and the Climate Leadership Initiative (Barr et al. 2010). The 2009 California Climate Change Strategy also provided guidance for the analysis. For consequences specific to the project alternatives, publications by Palmer et al. (2008), Dinse et al. (2009), and Reclamation (2011c) were used to evaluate the effect of dams on a natural system's ability to adjust to and absorb disturbances caused by potential changes in climate conditions.

3.10.4.1.2. Greenhouse Gas Emissions Quantification

Emissions of GHG were quantified using the same emission factor models identified in the air quality section (Section 3.9). Emissions of CO_2, CH_4, and N_2O were estimated for on- and off-site combustion sources, including mobile and stationary sources.

Each GHG contributes to climate change differently, as expressed by its global warming potential (GWP). GHG emissions are discussed in terms of carbon dioxide equivalent (CO_2e) emissions, which express, for a given mixture of GHG, the amount of CO_2 that would have the same GWP over a specific timescale. CO_2e is determined by multiplying the mass of each GHG by its GWP[4]. This analysis uses the GWP from the IPCC *Second Assessment Report* (IPCC 1996) for a 100-year time period to estimate CO_2e. Although subsequent assessment reports have been published by the IPCC, the international standard, as reflected in various Federal, State, and voluntary reporting programs, is to use GWPs from the *Second Assessment Report*.

GHG emissions were calculated for construction activities related to dam demolition and/or fish passage construction including heavy equipment use, hauling of demolition debris to landfill, as well as worker transportation.

If a United States Environmental Protection Agency (USEPA)-approved emissions factor model (e.g., EMFAC2007, MOBILE6.2, OFFROAD, or NONROAD) does not estimate emissions of a particular pollutant, then emission factors were obtained, if possible, from the Federal Mandatory Reporting of Greenhouse Gases Rule (40 CFR Part 98).

Restoration activities would use helicopters and barges for reseeding. The Federal Aviation Administration's Emissions and Dispersion Modeling System was used to simulate emissions that could occur from landing and takeoff operations associated with aerial seed application. Emission factors for barge propulsion engines were derived from the USEPA's *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data* (2000), while generator emissions for the seed sprayer were estimated from the USEPA's *Compilation of Air Pollutant Emission Factors* (1995).

Fugitive dust and exhaust emission factors associated with constructing the City of Yreka pipeline were estimated using the Sacramento Metropolitan Air Quality Management

[4] As an example, CH_4 has a GWP of 21, as specified in the Intergovernmental Panel on Climate Change's *Second Assessment Report* (1996). One metric ton of CH_4 is equal to 21 metric tons of CO_2e (1 metric ton x 21).

District's Road Construction Emissions Model, Version 6.3.2 (2009). The Siskiyou County Air Pollution Control District does not have a comparable model to estimate emissions from linear projects like this pipeline construction action.

The California Emissions Estimator Model (CalEEMod), Version 2011.1.1, was used to estimate exhaust emissions that would occur from grading activities associated with restoring parking lots associated with recreational facilities proposed for removal. CalEEMod makes general assumptions about the quantity and types of construction equipment needed to grade a site based on its size (acreage).

The analysis provides a quantitative comparison between removing a renewable source of energy from the hydroelectric dams and estimated emissions that may result from use of an alternative power source, such as fossil fuels, biomass, or other renewable energy sources.

Both Oregon and California have Renewable Portfolio Standard (RPS) goals that seek to increase the amount of renewable energy resources used by certain utilities. The RPS goal for California is to have 33 percent of an electricity seller's load served with renewable power by 2020 (Executive Order S-14-08; and SBX1 2), while Oregon's RPS goal is for 25 percent of a utility's retail sales of electricity to be from renewable energy by 2025 (Senate Bill 838). PacifiCorp is currently on track to meet its Oregon RPS target, but is not expected to meet California's RPS target without the use of tradable renewable energy credits (PacifiCorp 2011). Since PacifiCorp is on a trajectory to increase its use of renewable energy, any modifications to the Four Facilities, either by demolition or power generation reductions, would decrease the amount of renewable power that PacifiCorp has in its portfolio. Although short-term effects could occur from modifications to the hydroelectric dams, these effects would be offset in the long term because PacifiCorp would need to continue increasing its renewable energy share to meet the RPS goals in the two States.

3.10.4.2 Significance Criteria

At the present time, neither of the Lead Agencies has adopted significance thresholds for the analysis of GHG emissions. However, the CEQA Guidelines instructs:

"A lead agency should consider the following factors, among others, when assessing the significance of impacts from greenhouse gas emissions on the environment:

1. The extent to which the project may increase or reduce GHG emissions as compared to the existing environmental setting.
2. Whether the project emissions exceed a threshold of significance that the lead agency determines applies to the project.
3. The extent to which the project complies with regulations or requirements adopted to implement a Statewide, regional, or local plan for the reduction or mitigation of GHG emissions." (14 C.C.R. § 15064.4.)

In reference to factor number 1 stated above, the Klamath Facilities Removal would produce a temporary increase in direct GHG emissions by virtue of the construction and restoration activities, but once activities are complete, direct project emissions be reduced. With complete facilities removal, there would be no continuing operation or maintenance since the area occupied by the facilities would be returned to natural riverine and riparian setting. The partial facilities removal alternatives would still continue to have operation and maintenance emissions, but to a lesser degree than the No Action/No Project Alternative. Indirect GHG emissions would increase with the project as a result of replacing hydropower produced at the dams with power that is likely to be produced, at least in part, from fossil fuels through other regional sources.

As for factor number 2 (above) from the CEQA guidelines, the nature of the GHG emissions from the Klamath Facilities Removal differs from most projects considered highest priority for curbing emissions either on a Statewide or regional basis. Typical emission sources considered for quantitative thresholds of significance involve construction and ongoing operational emissions from stationary industrial projects with high rates of combustion emissions (for example, refineries, power plants, other processing that utilizes industrial boilers) or the construction and increased power and transportation needs from newly constructed residential/commercial projects. In these cases ongoing emissions from combustion and transportation are likely to be cumulatively considerable.

For the Proposed Action and alternatives, there are no direct operational GHG emissions. Appreciable direct emissions would occur only for a limited time as a result of construction (dam deconstruction and/or fish passage construction) and restoration. However, the Proposed Action would indirectly produce ongoing GHG emissions through conversion from the electricity produced by the local hydropower facilities to regional power from a mixture of sources likely including GHG-emitting fossil fuels.

Currently, there are no adopted numerical thresholds of significance in California that are specifically applicable to the Klamath Facilities Removal. The South Coast Air Quality Management District (SCAQMD) and the Bay Area Air Quality Management District have adopted numerical CEQA thresholds of significance for industrial stationary source GHG emissions; both districts use a threshold of 10,000 $MTCO_2e$ per year (Bay Area Air Quality Management District 2011; SCAQMD 2008). Only the SCAQMD's threshold addresses construction emissions. SCAQMD amortizes construction emissions over a 30-year period. The annual quantity is combined with a project's annual operational emissions and compared to the 10,000 $MTCO_2e$ per year threshold to determine significance.

Regarding the Statewide plan for reducing GHG emissions for factor number 3 from the CEQA guidelines, a GHG impact could be considered significant if emissions from either the Proposed Action or the alternatives exceed at least one of the two thresholds utilized in this EIS/EIR for GHG emissions. The first threshold is based on SCAQMD's methodology and as a result, GHG emissions would be significant if they exceed 10,000 $MTCO_2e$ in a year. SCAQMD developed its threshold to address emissions from stationary source/industrial projects. However, because there are no adopted numerical thresholds for construction emissions, and the SCAQMD threshold incorporates construction emissions to its determination, using the SCAQMD method for the current project is justified.

The second manner in which a GHG impact would be significant is if GHG emissions from either the Proposed Action or the alternatives would substantially obstruct compliance with the GHG emission reductions in AB 32 and Executive Order S-3-05. Compliance with the AB 32 goal of reducing California's GHG emissions by 2020 to 1990 levels requires cutting at least 29 percent of business-as-usual emissions (i.e., emissions projected by CARB for the year 2020 without any emission reduction measures) (CARB 2008). Executive Order S-3-05 further reduces the State's emissions to 80 percent below 1990 levels by 2050. Thus, the calculated emissions from Proposed Action or from any alternative should be compared to emissions that would be produced if implemented in accordance with the assumptions CARB used to calculate its business-as-usual scenario. If emissions from the Proposed Action or alternatives are at least 29 percent below business-as-usual in 2020, impacts could be considered less than significant. For purposes of this EIS/EIR, the calculated GHG emissions from the Proposed Action or alternatives will be compared to existing numerical thresholds of significance for industrial and residential projects (factor 2) and to the Statewide plan for reducing emissions outlined in AB 32 and Executive Order S-3-05.

40 CFR 1508.27(b)(10) defines the term "significantly" under NEPA related to both context and intensity of an impact, which includes whether a proposed action "threatens a violation of Federal, State, or local law". For that reason, consideration of AB 32 and Executive Order S-3-05 informs the NEPA analysis as well.

3.10.4.3 Effects Determinations

Emissions of GHG would occur from construction activities associated with either removing dams or constructing fish passage facilities. Direct emissions of GHG would occur from engine exhaust emissions from off-road construction equipment, on-road trucks, and construction worker commuting vehicles. Emissions were estimated using various emission factor models, including CARB's EMFAC2007 and OFFROAD2007 for on- and off-road exhaust emissions and USEPA's MOBILE6.2 and NONROAD2008 for engine exhaust emissions. Fugitive dust emissions were also estimated using CARB's URBEMIS2007 (version 9.2.4) model and additional calculations from AP-42 (USEPA 1995). Detailed calculations from each alternative are provided in Appendix N.

Indirect GHG emission changes could also occur from alterations in land use, agricultural resources (including the creation of new agricultural areas), and recreation from implementation of the KHSA and KBRA. These emission changes could occur from changing open water reservoirs to one of the following categories that could replace the reservoirs:

- Grassland/pasture (including cattle grazing)

- Wetlands (with increased sequestration)[5]
- Re-planting of forests (including riparian vegetation)

Changes in recreational activities, such as decreases in motorized vehicles and increases in non-motorized vehicles, would also occur from the potential removal of the dams. It is expected that the removal of the dams would result in a decrease in motorized recreation activities from the elimination of the open water reservoirs, which would consequently result in a reduction of GHG emissions.

Sediments in reservoirs contain carbon that is formed from the decomposition of accumulated dead plankton and other debris that could be released when a dam is decommissioned. If anoxic digestion causes the carbon to be released in the form of CH_4, then there could be a net negative impact of the existing reservoirs associated with the dams because of the higher GWP of CH_4 as compared to CO_2 (Pacca 2007).

Except for emissions from power plant operations and maintenance, GHG emissions from hydropower are negligible because no fuels are burned; however, plant matter can decay in the reservoir, causing the buildup and release of CH_4 (USEPA 2007). Analyzing the magnitude of these CH_4 emissions is difficult, but it is important to understand that open water reservoirs associated with hydropower may have a certain level of CH_4 emissions from their operation. The Klamath Hydroelectric Project reservoirs have characteristics that would favor high (at least one percent of the amount of GHG emissions that could occur from removing the hydroelectric facilities) CH_4 emissions: they receive massive organic/nutrient loads from upstream, have large in-reservoir algal blooms, and have anoxic hypolimnions (See Section 3.2, Water Quality).

The USEPA has also estimated carbon sequestration rates from a variety of agricultural and forestry practices. Table 3.10-3 summarizes the carbon sequestration rates documented by the USEPA. Insufficient information is available to estimate the exact carbon sequestration that could occur from the conversion of the open water reservoirs to one of these other land uses; however, it is expected that a net reduction in carbon emissions could occur from the land use conversion.

If the land behind the removed dams is converted to agricultural use such a cattle grazing, certain agricultural practices could result in an increase in GHG emissions. For example, grasslands and pastures could serve as carbon sinks, but cattle grazing could actually counteract some of these sinks. Section 4.9 of the Federal Energy Regulatory Commission (FERC) EIS discusses this issue further. Emissions from the digestion of cattle feed and manure management would result in net GHG emissions. Additional information on the number of head of cattle and the total size of the land conversion would be necessary to estimate whether there would be a net benefit or adverse impact from possible cattle grazing.

[5] Sequestration is the process of removing carbon from the atmosphere and storing it in carbon sink.

Table 3.10-3. Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural and Forestry Practices

Activity	Representative Carbon Sequestration Rate (metric tons of C per acre per year)	Time Over Which Sequestration May Occur Before Saturating[1]
Afforestation[2]	0.6 – 2.6[3]	90–120+ years
Reforestation[4]	0.3 – 2.1[5]	90–120+ years
Changes in forest management	0.6 – 0.8[6]	If wood products included in accounting, saturation does not necessarily occur if C continuously flows into products
	0.2[7]	
Conservation of riparian buffers	0.1 – 0.3[8]	Not calculated
Conversion from conventional to reduced tillage	0.2 – 0.3[9]	15–20 years
	0.2[10]	25–50 years
Changes in grazing land management	0.02 – 0.5[11]	25–50 years
Biofuel substitutes for fossil fuels	1.3 – 1.5[12]	Saturation does not occur if fossil fuel emissions are continuously offset

Source: USEPA 2010a.

Notes:

[1] Values refer to the level of time during which sequestration could be occurring. After the stated period, then there would cease to be a positive effect from the carbon sink.

[2] Values are for average management of forest after being established on previous croplands or pasture.

[3] Value calculated over 120-year period. Low value is for spruce-fir forest type in lake States; high value is for Douglas Fir on Pacific Coast. Soil carbon accumulation is included in estimate.

[4] Values are for average management of forest established after clear-cut harvest.

[5] Values calculated over 120-year period. Low value is for Douglas Fir in Rocky Mountains; high value is for Douglas Fir in Pacific Coast. No accumulation in soil carbon is assumed.

[6] Select examples, calculated over 100 years. Low value represents change from 25-year to 50-year rotation for loblolly pines in Southeast; high value is change in management regime for Douglas Fir in Pacific Northwest. Carbon in wood products included.

[7] Forest management here encompasses regeneration, fertilization, choice of species, and reduced forest degradation. Average estimate here is not specified to US, but averaged over developed countries.

[8] Assumed that carbon sequestration rates are the same as average rates for lands under United States Department of Agriculture Conservation Reserve Program.

[9] Estimates include only conversion from conventional to no-till for all cropping systems except for wheat-fallow systems, which may not produce net carbon gains. Estimates of changes in other GHG not included.

[10] Assumed that average carbon sequestration rates are the same for conversion from conventional till to no-till, mulch till, or ridge till. Estimates of changes in other GHG not included.

[11] See Improve/Intensity Management section in Table 16.1 of Follett et al. (2001). Low end is improvement of rangeland management; high end is changes in grazing management on pasture, where soil organic carbon is enhanced through manure additions. Estimates of flux changes in other GHG not included.

[12] Assumes growth of short-rotation woody crops and herbaceous energy crops, and that burning this biomass offsets 65 to 75 percent of fossil fuel in CO_2 estimates. Estimates of changes in other GHG not included.

Key:

C = carbon

30.10.4.3.1 Alternative 1: No Action/No Project Alternative

Effects of Climate Change on the No Action/No Project Alternative

The No Action/No Project Alternatives would likely require greater management actions, policies, and mitigation measures to protect the surrounding ecosystems and communities as compared to actions that include dam removal because the Klamath Basin is more likely to experience a greater magnitude of consequences from the projected changes in climate conditions than if the dams were removed. The situation might require costly future projects to prevent or respond to the consequences of climate change. For example, disturbances caused by drought, changes to vegetation, changes to water quality characteristics, and changes to fish and shellfish populations and patterns might not be able to be adjusted to or absorbed as easily with the dams in place as without them. The baseline temperatures on the mainstem of the Klamath River are stressful for fish, and fish rely on small areas of refugia (typically near tributary inflow). Increased ambient temperatures could increase water temperatures. Therefore climate change is likely to reduce or possibly eliminate these refugia, making the temperature in the mainstem of the river unsuitable for fish rearing and movement during critical times of the year. Increased energy expenditure for rescuing fish or removing them to controlled (hatchery-type) situations may then be necessary for maintaining viable fish populations in the Klamath Basin.

Also, free-flowing rivers, in general, respond better to changes in climate conditions due to the ability to adjust to and absorb disturbances through flow adjustments that buffer against impacts (Palmer et al. 2008). A natural riverine system is in constant, dynamic equilibrium, absorbing highly variable flow forces by changing channel morphology and dissipating energy via sediment transport and woody debris. A natural river system is capable of using those "tools" to gradually adjust to flow regime changes due to climate-induced precipitation change. Consequently, the more physical changes the river system has been subjected to, such as changes in sediment budgets and flow regimes due to dams or land clearing in the basin or riparian zones, the less capable the system is of responding to or absorbing changed flow regime.

As described in Section 3.2, Water Quality, climate change would cause general increases in water temperature that could decrease the 100 percent saturation level for dissolved oxygen. This decrease in dissolved oxygen concentration at saturation would act in opposition to successful total maximum daily load implementation. Climate change would increase the possibility of continued exceedance of the minimum dissolved oxygen objectives in the region.

As described in Section 3.3, Aquatic Resources, the temperature 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. Warmer water temperatures associated with climate change would increase the frequency and duration of stressful water temperatures for cold-water species, including all anadromous fish and salmonids in the basin. For warm-water species, little effect would likely result from this level of warming.

Effects of the No Action/No Project Alternative on Climate Change

Vehicle exhaust from operation and maintenance of the Four Facilities and continued water impoundment in the reservoirs could result in GHG emissions. Under the No Action/No Project Alternative, neither dam removal consistent with KHSA nor installation of fish ladders would be completed. Since the removal of the dams or the construction of fish passages would not occur, there would be no emissions associated with construction; however, ongoing CH_4 emissions from anaerobic decay in the impoundment would still occur under the No Action/No Project Alternative. Continual emissions would also occur from equipment use and worker commute for operation and maintenance of facilities.

The Karuk Tribe (2006) estimated the total amount of CH_4 released from Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, calculated by multiplying the reservoirs' area by areal emissions rates from reservoirs around the world with similar characteristics (poor water quality). The resulting estimate ranged from approximately 8,000 to 29,000 $MTCO_2e$ per year[6]. Without Keno Impoundment, CH_4 emissions would be approximately 4,000 to 14,000 $MTCO_2e$ per year for Iron Gate, Copco, and J.C. Boyle Reservoirs. Under the No Action/No Project Alternative, releases of CH_4 from the reservoirs would continue at the same levels. See Appendix N for detailed calculations. **There would be no change from existing conditions from GHG emissions from vehicle emissions or continued impoundment of water relative to existing conditions.**

Activities associated with several interim measures (IMs) could result in short-term and temporary increases in GHG emissions from vehicle exhaust. Several IMs would be implemented under the No Action/No Project Alternative. Several of these measures could result in increased GHG 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 1 year of this measure. GHG 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 GHG emissions are expected to be less than those quantified for the removal of Copco 1 from demolition activities.

Based on the limited amount of construction equipment expected to be used simultaneously, it is likely that emissions from implementation of the IMs would not exceed the significance criteria. **The impact on GHG emissions and climate change from implementing the IMs would be less than significant.**

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[6] The emission estimation ranges provided in this section are based on a GWP of 21 for CH_4; the original Karuk Tribe calculation assumed a GWP of 23, but the calculation was changed to be consistent with the rest of the report.

Reducing a renewable source of power could result in GHG impacts from possible non-renewable alternate sources of power. Under the No Action/No Project Alternative, the Four Facilities would continue to operate under annual licenses. Continued operation would not change existing GHG emissions from the Four Facilities. While the No Action/No Project Alternative assumes annual renewal of licenses, eventual relicensing of the Four Facilities could result in the need for replacement power and subsequent changes in GHG emissions from any changes in renewable sources of power. If relicensing occurred, the amount of electricity produced could reduce as a result of redirecting a certain quantity of river flow from power generation to bypass or fish passage. If relicensing were to require the annual average electricity output to be reduced, then the reduction in power would need to be replaced with another source. These other sources of electricity may result in increased GHG emissions (i.e., coal-fired power plant(s)). **Under the No Action/No Project Alternative that assumes annual licensing, there would be no change from existing conditions from GHG emissions relative to existing conditions.**

Vehicle exhaust from several ongoing restoration actions could increase GHG emissions. 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. The Fish Habitat Restoration activities could result in GHG emissions. This project would involve some limited construction activities that could result in short-term temporary GHG emissions in the Upper Basin. In addition, the Climate Change Assessment would ensure that long-term climate change in the Klamath Basin is assessed early and continuously. **The GHG emissions related to construction of ongoing restoration actions would be less than significant.**

3.10.4.3.2 Alternative 2: Full Facilities Removal of Four Dams (Proposed Action) Effects of Climate Change on the Proposed Action

The projected changes in precipitation would result in drier summers and increased frequency and severity of extreme events (USGCRP 2009; Barr et. al. 2010; OCCRI 2010). These precipitation changes would produce some adverse effects in the Klamath Basin. Adverse effects could include increased flooding, decreasing water quality (due mainly to the effects of higher water temperatures and changing vegetation), higher fire potential (with subsequent water quality impacts), and adverse low flow conditions due to summer droughts.

Average annual air temperatures are projected to increase by 3°F to over 8°F in the next century. Temperature changes would increase water temperature; water temperature increases could create stressful conditions for fish during some times of the year and reduce the migration window. The Proposed Action would create initial decreases in water temperature by removing dams and increasing river flows, but climate change could partially offset some of these temperature improvements.

The Proposed Action is better positioned to respond to the changes in climate conditions compared to the No Action/No Project Alternative. Dam removal can increase ecosystem resiliency by restoring floodplain wetlands, which allow the river system to handle the projected changes in seasonal precipitation (Dinse et al. 2009). Also, sediment budgets may return to pre-controlled conditions, revegetation of the watershed can replace missing large woody debris, and more dynamic flow regimes can diversify channel morphology and increase habitat complexity.

Benefits of full dam removal would begin to offset the projected changes and impacts from climate change. These benefits include additional floodplain and riparian zone to reduce peak flooding impacts; improved water quality by removing large quiescent water areas that are subject to temperature increases and evaporation; increased woody debris and restored natural sediment budget to improve in-channel habitat diversity; more available stream channel habitat; a migration corridor for fish to move further upstream to find cooler water; access to the largest concentration of cold springs and spring-dominated tributaries in the Klamath Basin; and improved habitat quality, water quality, and riparian and floodplain functionality in and above Upper Klamath Lake. In contrast, the No Action/No Project Alternative would require modified management and dam operations to off-set flow regime changes; provide no new opportunities for new in-channel or riparian/floodplain habitat; and be subject to greater water quality impacts due to projected temperature increases.

As described in Section 3.2, Water Quality, removal of the reservoirs under the Proposed Action would result in a 1 to 2 degrees Celsius (^{o}C) increase in spring water temperatures and a 2 to 10 ^{o}C decrease in late-summer/fall water temperatures immediately downstream from Iron Gate Dam. These effects would decrease in magnitude with distance downstream from the dam and would not be evident by the Salmon River confluence (approximately river mile [RM] 66) (PacifiCorp 2004, Dunsmoor and Huntington 2006, North Coast Regional Water Quality Control Board 2010, Perry et al. 2011). General warming of water temperatures under climate change is projected to be on the order of 1 to 3°C in the Klamath Basin (Bartholow 2005, Perry et al. 2011), which would partially offset anticipated water temperature improvements from the Proposed Action, particularly further downstream from Iron Gate Dam where the improvements would be of smaller magnitude. However, overall 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. This return would also include increased daily fluctuations in water temperature immediately downstream from Copco 1 and Iron Gate Dams, as water temperatures once again achieve equilibrium with (and reflect) daily fluctuations in ambient air temperatures. In contrast, in the Bypass Reach downstream from J.C. Boyle Dam, daily fluctuations in water temperature would decrease under the Proposed Action, as hydropower peaking flows would not occur.

As described in Section 3.3, Aquatic Resources, improvement in the river thermal regime by the Proposed Action would likely moderate the anticipated stream temperature increases resulting from climate change.

Effects of the Proposed Action on Climate Change

Vehicle exhaust from dam removal activities could increase GHG emissions in the short term to levels that could exceed the significance criteria. The emission sources would include off-road construction equipment, on-road trucks, and construction worker commuting vehicles. These emissions would be temporary, occurring only during the dam removal period of 9 months (January through September 2020). Table 3.10-4 summarizes uncontrolled annual emissions (not controlled by any mitigation measures) associated with the Proposed Action. Appendix N contains detailed GHG emissions calculations.

Table 3.10-4. Uncontrolled Direct GHG Emissions Inventories for Proposed Action – Full Facilities Removal

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
	2020			
Iron Gate	4,106	4	n/a	4,110
Copco 1	1,459	1	n/a	1,461
Copco 2	970	1	n/a	971
J.C. Boyle	2,016	<1	n/a	2,016
Total Emissions	**8,551**	**6**	**n/a**	**8,558**
California Total	6,535	6	n/a	6,542
Oregon Total	2,016	n/a	n/a	2,016

Notes:
[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
[2] N_2O emissions are not estimated directly from the various emission calculation models; therefore, emissions estimates are zero for most equipment.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

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. Construction of the cofferdams from materials salvaged from the dam demolition activities would reduce the need for importing new construction materials.

It is likely that sulfur hexafluoride (SF_6) would be released during deconstruction because the breakers would be emptied. Although SF_6 has a relatively high GWP, sufficient data was not available at the time of this writing to quantify emissions.

As Table 3.10-4 shows, there would be a net increase in GHG emissions from deconstruction of the dams; however, these emissions would be temporary and would not contribute to long-term emissions.

Construction related activities associated with decommissioning of the dams would contribute 8,558 $MTCO_2e$ to California's GHG emission for 1 year.[7] Amortizing these construction emissions over 30 years results in approximately 285 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over 30 years such emissions are 1,442 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions from dam removal would be 0.002 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, the Proposed Action would equal approximately 1 percent of allowable construction emissions. **The 1-year construction emissions would not exceed the established significance threshold for ongoing industrial emissions. Therefore, the GHG emissions related to construction would be less than significant.**

Restoration actions could result in short-term and temporary increases in GHG emissions 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 sediment. Upper areas would be reseeded from a barge until the reservoir levels become too low to operate and access the barge. Barge based seeding activities would only occur during January 2020 at the Iron Gate and Copco Reservoirs. 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.

Annual GHG emissions were estimated using information provided in the *Detailed Plan for Dam Removal – Klamath River Dams* (Reclamation 2012a). 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 (USEPA 2000)
- AP-42, Chapter 3.3: Gasoline and Diesel Industrial Emissions (USEPA 1995)
- 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

[7] The value of 8,558 $MTCO_2e$ includes emissions from the JC Boyle Dam. Although JC Boyle Dam is located in Oregon, GHG emissions related to JC Boyle Dam could affect California because climate change is a global phenomenon. Therefore, and for purposes of full disclosure, emissions related to JC Boyle Dam are being analyzed under CEQA.

- 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 3.10-5 summarizes emissions from reservoir restoration.

Table 3.10-5. Uncontrolled Direct GHG Emissions Inventories for Reservoir Restoration (Reseeding)

Location	Project Emissions ($MTCO_2e$/year)[1]			
	Ground Equipment	Barges	Aerial	Total
Iron Gate	29	88	149	266
Copco	32	88	298	419
J.C. Boyle	19	n/a	n/a	19
Total Emissions	80	177	447	704

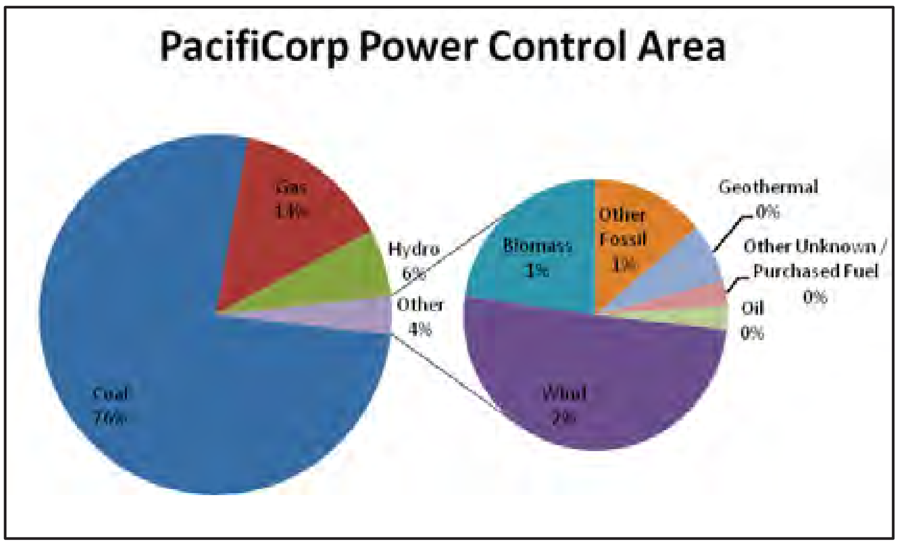
Notes:
[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
Key:
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

As shown in Table 3.10-5, total GHG emissions would not exceed 704 $MTCO_2e$ per year. Furthermore, the addition of new grassland and other vegetation would sequester CO_2 emissions in the long term, but the sequestered CO_2 would likely not offset all of the emissions occurring during restoration on an annual basis. **The impact on GHG emissions and climate change from revegetation would be less than significant.**

Relocation and demolition of various recreation facilities could result in short-term and temporary increases in GHG emissions from vehicle exhaust. The demolition of the Four Facilities would change recreational opportunities from reservoir-based recreation to river-based recreation. This change would require several recreation facilities to be relocated or demolished. On- and off-road construction equipment would be used to complete these activities, which would occur after the dam demolition actions. Annual GHG emissions were estimated using information provided in the Detailed Plan for Dam Removal – Klamath River Dams (Reclamation 2012a) and CalEEMod, Version 2011.1.1. Approximately 160 $MTCO_2e$ would be emitted during relocation and demolition of the recreation facilities. Since dam demolition activities would be less than significant and changes to the recreation facilities would not overlap, emissions from these activities would also not exceed the significance criteria. **The impact on GHG emissions and climate change from the relocation and demolition of recreation facilities would be less than significant.**

Removing a renewable source of power by removing the dams could result in increased GHG emissions from possible non-renewable alternate sources of power. GHG emissions could occur in the event that the renewable source of power represented by the

Four Facilities was replaced by other emissions sources. As shown in Figure 3.10-4, the 2007 electricity generation resource mix for the PacifiCorp Power Control Area (PCA), which is a region of the power grid in which all power plants are centrally dispatched, is dominated by coal (76 percent), natural gas (14 percent), and hydroelectricity (6 percent). The data provided is the most recent data available from the USEPA (2010b) and represents the resource mix that would be available if any replacement energy was obtained from PacifiCorp's resource mix as of 2007. It is acknowledged that PacifiCorp's current resource mix is different than the 2007 data (PacifiCorp 2011), specifically with a decrease in the reliance on coal and an increase in reliance on natural gas, hydroelectricity, and other renewable energy sources; however, the information in the 2011 Integrated Resource Plan (PacifiCorp 2011) is not sufficient to develop emission factors.



Source: USEPA 2010b.

Figure 3.10-4. PacifiCorp Power Control Area Generation Resource Mix (as of 2007).

Although using the 2007 data provides emissions results that would be higher than the current resource mix, using Emissions and Generation Resource Integrated Database (eGRID) data is consistent with inventory requirements of multiple voluntary and mandatory reporting protocols; therefore, the 2007 eGRID data was used for the analysis.

Electricity originally produced from the Four Facilities, if removed, would likely be replaced with another source within the PacifiCorp PCA because the amount of electricity provided by the Four Facilities is approximately 2 percent of PacifiCorp's total generation capacity (CEC 2006a). Emission rates from the grid were estimated assuming that all power sources within the PCA would remain except for East Side, West Side, J. C. Boyle, Copco 1, Copco 2, Iron Gate Dams.

PacifiCorp's 2011 Integrated Resource Plan provides an overview of the company's available generation capacity. According to the Integrated Resource Plan, PacifiCorp will be at "summer peak resource deficit" beginning in 2011 (PacifiCorp 2011). This deficit is to be met in the short term with additional renewable, demand-side programs, and market purchases from other generating companies (PacifiCorp 2011). PacifiCorp outlined a series of actions in the plan to meet the widening resource deficit, including the addition of 800 megawatts (MW) of wind resources by 2020, the acquisition of 1,200 MW of demand side management programs by 2020, acquisition of 8.7 MW of solar, and economic investigation of 30 MW from solar hot water heating resources and over 100 MW of geothermal resources (PacifiCorp 2011). Although it may be possible for PacifiCorp to replace the existing hydropower from the Four Facilities with additional renewables, this analysis assumes the replacement power will come from the resource mix shown in Figure 3.10-3 of PacifiCorp power sources to provide a worst-case analysis of emissions. The analysis was adjusted so that the base load was assumed to be served by this resource mix, while peaking power would be supplied by natural gas because it is the typical fuel source for peaker power power plants.

In the long term, PacifiCorp is under obligation to meet the Renewable Portfolio Standard (RPS) goals in California and Oregon. The RPS goal for California is to have 33 percent of an electricity seller's load served with renewable power by 2020 (Executive Order S-14-08; and SBX1 2), while Oregon's RPS goal is for 25 percent of a utility's retail sales of electricity to be from renewable energy by 2025 (Senate Bill 838). PacifiCorp is currently on track to meet its Oregon RPS target, but it expected to be under California's RPS target (PacifiCorp 2011). PacifiCorp plans on using flexible compliance mechanisms (e.g., banking, earmarking, and tradable renewable energy credits) to meet California's RPS standards. In the long term, it is expected that PacifiCorp would be able to eventually replace the lost energy from the dams with other sources of renewable energy.

Two different emissions calculations are provided. In one calculation, emissions were calculated assuming there were no changes to PacifiCorp's resource mix. In a second calculation, emissions were calculated assuming that PacifiCorp met its RPS obligations (i.e., 33 percent renewable power in California). As a result, the off-peak emissions were calculated assuming that 33 percent of the power would be served by renewable power (an increase from the existing portfolio assumption of approximately nine percent renewable power).

The average annual electricity generation from the Klamath Hydroelectric Project is 716,800 megawatt-hours (MWh). This includes generation from the following developments: East Side, West Side, J.C. Boyle Dam, Copco 1 Dam, Copco 2 Dam, Fall

Creek Dam, and Iron Gate Dam. Since East Side, West Side, and Fall Creek Dam are not part of the Proposed Action, then the total amount of power that would need to be replaced would be equal to 686,000 MWh[8].

Data from eGRID was used to estimate GHG emissions from a potentially different mix of energy sources (USEPA 2010b). It is recognized that the FERC Final EIS used carbon intensity factors from Hadley and Sale (2000); however, the carbon intensity factors were based on the entire Western Electricity Coordinating Council and represented CO_2 emissions only. The eGRID method of estimating emissions is consistent with the recommendations in multiple general and mandatory reporting protocols and was based on electricity generated by PacifiCorp-owned facilities. As a result, it reflects a conservative estimate of emissions.

The Lead Agencies acquired data for all of the plants within the PacifiCorp PCA and derived emission factors from this source with the applicable dams removed from the

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[8] The GHG analysis is based on an estimate of the annual reliable hydroelectric power generation for the PacifiCorp Klamath Hydroelectric Project. Power generation was estimated using annual electricity generation estimates provided for each alternative in Chapter 4 of the Federal Energy Regulatory Commission (FERC) Final Environmental Impact Statement (EIS) for Hydropower License (2007). The FERC Final EIS power generation results allowed for a quantitative comparison of GHG effects for all alternatives considered in this EIS/EIR using information publically available on June 14, 2010 when the notice of intent was published. Since that time, United States Department of the Interior (DOI) modeled annual reliable hydroelectric power generation with updated hydrology and inclusion of planned upgrades that would improve the efficiency and maximum capacity of the hydroelectric project (for the Alternative 1: No Action/No Project Alternative and Alternative 2: Proposed Action [Reclamation 2012a; Reclamation 2012b, Reclamation 2012d]). Under the Alternative 1: No Action/No Project Alternative, annual reliable hydroelectric power generation is greater than the annual generation estimates in the FERC EIS. Therefore, under the Alternative 2: Proposed Action, the DOI model generated increased annual reliable hydropower generation, increasing the estimated replacement power needed to compensate for decommissioning of power facilities, and in turn increasing the overall GHG production attributed to the Proposed Action as compared to the FERC EIS. While the overall GHG emissions may increase from something less than 400,000 $MTCO_2e$ to approximately 500,000 $MTCO_2e$ (CDM Smith 2012), the magnitude of the impact is relatively unchanged when compared to the threshold of 10,000 $MTCO_2e$. When considering this contribution to total GHG emissions from power production in the Western United States (PacifiCorp's resource mix is represented throughout the west, and the EPA estimated that GHG emissions in the Western United States are in excess of a billion $MTCO_2e$ annually), the total emissions from replacement power are relatively minor and represent only a fraction of the total. The additional emissions do not appreciably change the severity of the impact, and the impact is still considered significant and unavoidable after mitigation. No additional mitigation measures exist that could lessen the impacts beyond those already described in the EIS/EIR. For purposes of CEQA, the DOI model does not affect the analysis of Alternative 2: Proposed Action because baseline power generation will not change from what was presented in the FERC Final EIS and therefore there is no change from what is presented in the EIS/EIR. The hydroelectric facilities are not anticipated to be upgraded if there is an Affirmative Secretarial Determination and the updated hydrology does not result in greater power production (Reclamation 2012d). As a result, annual reliable hydropower generation will not be higher than current estimates so the EIS/EIR's analysis of replacement power and its related GHG emissions remains accurate.

mix. The power plants within the PacifiCorp PCA are in California, Colorado, Idaho, Montana, Oregon, Utah, Washington, and Wyoming; all or most of the emissions from these plants would occur outside of the area of analysis. Table 3.10-6 summarizes replacement power emissions that would be associated with the removal of the dams assuming that the current power resource mix was used. Table 3.10-7 summarizes replacement power emissions that would be associated with the removal of the dams assuming that PacifiCorp's RPS obligations were met.

Iron Gate, Copco 1, and Copco 2 are California RPS-eligible facilities (CEC 2011)[9]. he reduction in renewable energy sources is contrary to implementation of AB 32 but the significance would diminish as new renewable sources are developed. Although it is expected that PacifiCorp would add new sources of renewable power that would replace the removed dams, this analysis provides a conservative assumption that emissions could still occur when the dams are removed.

Table 3.10-6. Electricity Generation GHG Emissions from Replacement Sources after Removal of Four Dams (Existing Resource Mix)

Location	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
Iron Gate	116,000	66,802	2	1	66,802	38	219	67,059
Copco 1	106,000	61,043	2	1	61,043	35	200	61,278
Copco 2	135,000	77,744	2	1	77,744	44	255	78,043
J.C. Boyle	329,000	189,465	5	2	189,465	107	622	190,194
Total	686,800	395,054	11	4	395,054	224	1297	396,575

Notes:

1 Generation based on FERC Final EIS (based on 2007 generation data).

2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Off-peak emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b) except for the dams proposed to be removed.

3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide
CO_2e = carbon dioxide equivalent
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds
lb/GWh = pounds per gigawatt-hour
GWP = global warming potential
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

[9] For a hydroelectric facility to qualify for California's RPS, it must be 30 MW or less. Since J.C. Boyle's rated capacity is 98.7 MW, it does not qualify as a small hydroelectric facility.

Table 3.10-7. Electricity Generation GHG Emissions from Replacement Sources after Removal of Four Dams (33 Percent RPS)

Location	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2$e/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
Iron Gate	116,000	57,545	2	1	57,545	35	173	57,753
Copco 1	106,000	52,585	2	1	52,585	32	158	52,774
Copco 2	135,000	66,971	2	1	66,971	41	201	67,212
J.C. Boyle	329,000	163,210	5	2	163,210	99	489	163,799
Total	686,800	340,311	10	3	340,311	207	1020	341,539

Notes:

1 Generation based on FERC Final EIS (based on 2007 generation data).

2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Off-peak emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b) except for the dams proposed to be removed. It was also assumed that PacifiCorp would meet its RPS obligation.

3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide
CO_2e = carbon dioxide equivalent
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds
lb/GWh = pounds per gigawatt-hour
GWP = global warming potential
$MTCO_2$e/year = metric tons carbon dioxide equivalent per year

As previously described for the No Action/No Project Alternative, CH_4 would be released from the reservoirs because of poor water quality conditions. Under the No Action/No Project Alternative, CH_4 emissions from the reservoirs would range from 4,000 to 14,000 $MTCO_2$e per year, which is equivalent to approximately 1 to 4 percent of replacement power emissions[10] of the 396,575 $MTCO_2$e per year (based on the current electricity mix).[11] Under the Proposed Action, these CH_4 emissions would cease to be a factor and would partially offset the possible increase in emissions from power replacement. Table 3.10-8 summarizes the expected range in emissions from power replacement that would occur when this emissions offset is considered.

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[10] Emissions range is valid for both renewable portfolio standard assumptions (i.e., current grid mix or 33 percent renewable power).

[11] Approximately 2 to 8 percent of the 341,539 $MTCO_2$e per year would be emitted assuming that the renewable portfolio standard goal of 33 percent was met. Emissions range is valid for both renewable portfolio standard assumptions (i.e., current grid mix or 33 percent renewable power).

Table 3.10-8. Adjusted Power Replacement Emissions Without Methane Emissions from Reservoirs

Scenario	Annual CO_2e Emissions ($MTCO_2$e/year)	CH_4 Emissions from Reservoirs ($MTCO_2$e/year)		Adjusted Emissions ($MTCO_2$e/year)[1]	
		Low	High	Low	High
Current Grid Mix	396,575	4,000	14,000	392,575	382,575
33 Percent RPS	341,539	4,000	14,000	337,539	327,539

Notes:
1 Adjusted emissions reflect the difference between each scenario and the estimated CH_4 emissions from the reservoirs.
Key:
CO_2e = carbon dioxide equivalent
$MTCO_2$e/year = metric tons carbon dioxide equivalent per year

Restoration activities at the dam sites are expected to increase the carbon sequestration in the area. As shown in Table 3.10-3, restoration of formerly inundated areas could sequester 0.3 metric tons of carbon per acre per year, while conservation of riparian buffers could sequester 0.1 metric tons of carbon per acre per year. The total amount of acreage wetland/riparian and upland acreage expected to be restored at J.C. Boyle, Copco, and Iron Gate Dams would be 272 acres and 1,602 acres, respectively. As a result, the total amount of sequestered carbon would be approximately 508 metric tons of carbon per year, or 1,862 metric tons of CO_2 per year (based on equivalent weights of carbon and CO_2). Although this sequestration would minimize the effects of GHG emissions, it would not eliminate the increased emissions from replacement power.

CARB expects that implementation of its Scoping Plan (2008) would reduce 21.3 $MMTCO_2$e by 2020 (from 2005 baseline) from California's RPS; therefore, the possible increase in emissions from removing the dams would account for three percent of the expected emissions reduction. Under a business-as-usual scenario, which assumes that the Scoping Plan would not be implemented, this would impede California's ability to meet its emission reduction goal. **Emissions from power replacement would therefore be a significant impact**. **Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

3.10.4.4 Interim Measures

Activities associated with several IMs could result in short-term and temporary increases in GHG emissions from vehicle exhaust. 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 GHG 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 reaches using a passive approach before high flow periods or to provide for other habitat enhancement. The Proposed Action includes 7 years of implementing this measure. GHG 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 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.

Since dam demolition activities would be less than significant, and the scale of emissions expected from the IMs is expected to be substantially less than dam removal, it is likely that emissions from implementation of the IMs would also not exceed the significance criteria. The impact on GHG emissions and climate change from implementing the IMs would be less than significant.

3.10.4.4.1 Keno Transfer

Implementation of the Keno Transfer could cause short-term and temporary increases in GHG emissions. 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 greenhouse gases compared with existing facility operations. Following transfer of title, DOI would operate the Keno Facility 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.**

3.10.4.4.2 East and Westside Facility Decommissioning – Programmatic Measures

Decommissioning the East and Westside Facilities could cause short-term and temporary increases in GHG emissions. The East and Westside canals and hydropower facilities, which are owned and operated by PacifiCorp, are located in Oregon at Reclamation's Link River Dam. Within 6 months of the enactment of Federal legislation authorizing the Secretary to make a Determination, PacifiCorp will apply to FERC for an order approving partial surrender of their hydropower license for the purpose of decommissioning the East and Westside generating facilities. PacifiCorp will then decommission the facilities in accordance with the FERC order. The Decommissioning would eliminate the need for diversions at Link River Dam into the two canals. Construction equipment used in the decommissioning action would be substantially less than the equipment required to complete dam demolition activities and the decommissioning action would be conducted in the years prior to 2020. Prior to decommissioning, PacifiCorp will request to abandon the East and Westside Facilities in place. Since dam demolition activities would be less than significant, it is likely that emissions from the decommissioning action would also not exceed the significance criteria. **The impact on GHG emissions and climate change from the East and Westside Facility Decommissioning would be less than significant.**

3.10.4.4.3 City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

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 GHG emissions from vehicle exhaust. On- and off-road construction equipment would be used to complete the relocation and construction of the City of Yreka Water Supply Pipeline.

These emissions would occur in 2019 and would last approximately 1 month. These construction actions would not overlap with other construction or demolition activities. 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. The Road Construction Emissions Model estimated that approximately 36 short tons (33 metric tons) would be emitted for the project. **The impact on GHG emissions and climate change from the construction of the City of Yreka Water Supply Pipeline would be less than significant.**

3.10.4.4.4 KBRA – Programmatic Measures

The KBRA has several programs that could cause temporary increases in GHG emissions. The following KBRA programs could cause GHG and climate change impacts from various construction activities:

- Phases I and II Fisheries Restoration Plans
- Fisheries Reintroduction and Management Plan
- Wood River Wetland Restoration
- On-Project Plan
- Power for Water Management
- Climate Change Assessment and Adaptive Management
- Water Use Retirement Program
- Fish Entrainment Reduction
- Drought Plan

Construction activities associated with the KBRA programs involving construction could cause temporary increases in GHG emissions and climate change. The above KBRA programs may cause some GHG emission impacts from the use of heavy equipment. Potential KBRA construction activities include channel construction, mechanical thinning of trees, road decommissioning, fish passage and facilities construction, breaching levees, and fish hauling. Emissions would occur both from on-site construction operations with heavy equipment and from off-site activities like the trap-and-haul of fish required under the Fisheries Reintroduction and Management Plan. Sufficient information is not currently available to quantify emissions; however, the quantity of equipment and associated emissions required to complete these activities is expected to be less than the equipment and resulting less than significant emission quantities required to complete the facility removal activities analyzed above. Emissions generated by these construction actions are not expected to exceed the SCAQMD's threshold of significance for industrial emissions (10,000 $MTCO_2e$ per year), especially when amortized over 30 years. When considered together the emissions associated with KBRA construction actions and facility removal would also not be expected to exceed the SCAQMD's threshold of significance. **The impact on GHG emissions and climate change from construction activities associated with implementing the KBRA would be less than significant. 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 GHG emissions from vehicle exhaust associated with trap-and-haul activities. 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 to Upper Klamath Lake or its tributaries. Downstream-migrating fish would be collected at Link River Dam (and the East Side and Westside canals) and relocated downstream from Keno Dam. Operational emissions are not expected to exceed the SCAQMD's threshold of significance, especially when amortized over 30 years, because of the limited amount of haul trucks that would be expected to be used. When considered together the emissions associated with KBRA construction actions and facility removal, the total operational emissions would also not be expected to exceed the SCAQMD's threshold of significance. **The impact on GHG emissions and climate change from operational emissions associated with implementing the KBRA would be less than significant. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Implementation of the Power for Water Management Program of the KBRA could create new renewable energy sources which would provide affordable electricity to allow efficient use, distribution, and management of water. This could also involve the development of renewable energy sources, which would provide green energy. However, given the uncertainty as to how the Power for Water Management Program would ultimately be implemented, this analysis will not consider the program as a mitigation measure. The Power for Water Management Program could however offset some of the effects of hydroelectric facility removal. **Implementation of the Power for Water Management Program could result in beneficial effects. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Implementation of the Drought Plan and the Climate Change Assessment and Adaptive Management Plan could affect climate change-related impacts. The Drought Plan identifies water and resource management actions to minimize risk associated with drought, which is a projected climate change impact for the Klamath Basin and the Pacific Northwest. The Climate Change Assessment and Adaptive Management Plan includes early and frequent assessment of the existing and future impacts of climate change. The Climate Change Assessment and Adaptive Management Plan is also intended to develop actions to respond to climate change and protect the resources of the basin. These plans will assist the region in planning and responding to the climate change impacts identified in this EIS/EIR over the short-term, mid-term, and long-term horizons. The Climate Change Assessment and Adaptive Management Plan could offset some of the effects of hydroelectric facility removal. **Implementation of these plans is expected to result in reduction in impacts of climate change to the resources and would have beneficial effects. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

3.10.4.4.5 Alternative 3: Partial Facilities Removal of Four Dams Alternative Effects of Climate Change on the Alternative

The Partial Facilities Removal Alternative would result in the creation of a free-flowing, unimpeded river, and the effects of climate change on this alternative would be the same as for the Proposed Action.

Effects of the Alternative on Climate Change

Vehicle exhaust from dam removal activities could increase GHG emissions in the short term to levels that could exceed the significance criteria. Under the Partial Facilities Removal Alternative some of the structures at J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams would remain in place. Projected GHG emissions are generally lower for this alternative than for the Proposed Action because this alternative would generate fewer materials that would need to be removed from the sites, and hence, less truck traffic. Please see Section 3.22, Traffic and Transportation, for additional analysis of expected truck trips.

Table 3.10-9 summarizes uncontrolled annual emissions inventories for the Partial Facilities Removal Alternative. Appendix N provides detailed calculations.

It is likely that SF_6 would be released during deconstruction because the breakers would be emptied. Although SF_6 has a relatively high GWP, sufficient data was not available at the time of this writing to quantify emissions.

Table 3.10-9. Uncontrolled Direct GHG Emissions Inventories for Partial Facilities Removal

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
	2020			
Iron Gate	4,114	4	n/a	4,118
Copco 1	1,459	1	n/a	1,460
Copco 2	829	1	n/a	830
J.C. Boyle	1,341	<1	n/a	1,341
Total Emissions	**7,742**	**6**	**n/a**	**7,748**
California Total	6,401	6	n/a	6,408
Oregon Total	1,341	n/a	n/a	1,341

Notes:
[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
[2] N_2O emissions are not directly estimated from the various emission calculation models; therefore, emissions are estimated as zero for most equipment.
Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

As Table 3.10-9 shows, there would be a net increase in GHG emissions from deconstruction of the dams; however, these emissions would be temporary and would not contribute to long-term emissions. Demolition activities associated with the decommissioning of the dams would contribute 7,748 $MTCO_2e$ to GHG emission for one year.[12] Amortizing these construction emissions over 30 years results in approximately 258 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over thirty years such emissions are 2,252 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions from dam removal would be 0.002 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, the Proposed Action would equal approximately 1 percent of allowable construction emissions. **The 1-year construction emissions would not exceed the established significance threshold for ongoing industrial emissions. Therefore, the GHG emissions related to construction would be less than significant.**

Activities associated with several IMs could result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated with implementation of IMs would be the same as those discussed for the Proposed Action.

[12] The value of 7,748 $MTCO_2e$ includes emissions from the J.C. Boyle Dam. Although JC Boyle Dam is located in Oregon, GHG emissions related to J.C. Boyle Dam could affect California because climate change is a global phenomenon. Therefore, and for purposes of full disclosure, emissions related to J.C. Boyle Dam are being analyzed under CEQA.

The impact on GHG emissions and climate change from implementing the IMs would be less than significant.

Restoration actions would result in short-term and temporary increases in GHG emissions from the use of helicopters, trucks, and barges. GHG emission impacts associated with the restoration actions would be the same as those discussed for the Proposed Action. **The impact on GHG emissions and climate change from revegetation would be less than significant.**

Relocation and demolition of various recreation facilities would result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated with the recreation facilities would be the same as those discussed for the Proposed Action. **The impact on GHG emissions and climate change from the relocation and demolition of recreation facilities would be less than significant.**

Removing a renewable source of power by removing the dams could result in increased GHG emissions from possible non-renewable alternate sources of power. As with the Proposed Action, the Partial Facilities Removal Alternative would result in decreased capacity to generate electricity from all of the dams. Although some of this infrastructure would remain under this alternative, the power-generating ability of the dams would be eliminated. As a result, electricity generation would need to be replaced from other sources of power.

As discussed for the Proposed Action, in the long term, it is expected that PacifiCorp would be able to eventually replace the lost energy from the dams with other sources of renewable power. Furthermore, some degree of GHG emissions could be offset with reforestation, but the increased carbon sequestration would not be sufficient to counteract increased emissions that may result from use of an alternative power source. The expected increase in GHG emissions from replacing these four dams with a different energy source would be the same as those shown in Table 3.10-6 and Table 3.10-7. The expected emissions increases that could occur when water is no longer impounded in the reservoirs would be the same as those shown in Table 3.10-8. **Emissions from power replacement would therefore be a significant impact. Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

Keno Transfer

Implementation of the Keno Transfer could cause short-term and temporary increases in GHG emissions. The effects of the Keno Transfer would be the same as those for the Proposed Action. **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and Westside Facility Decommissioning – Programmatic Measures

Decommissioning the East and Westside Facilities could cause short-term and temporary increases in GHG emissions. The effects of the East and Westside Facilities removal would be the same as those described for the Proposed Action. **The impact on GHG emissions and climate change from the East and Westside Facility Decommissioning would be less than significant.**

City of Yreka Water Supply Pipeline Relocation – Programmatic Measures

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 GHG emissions from vehicle exhaust. The effects of the City of Yreka Water Supply Pipeline relocation would be the same as those described for the Proposed Action. **The impact on GHG emissions and climate change from the construction of the City of Yreka Water Supply Pipeline would be less than significant.**

KBRA – Programmatic Measures

Construction activities associated with the KBRA programs involving construction could cause temporary increases in GHG emissions and climate change. Similarly to the Proposed Action, under this alternative the KBRA would be fully implemented. The effects of implementing the KBRA would be the same as those described in the Proposed Action**. The impact on GHG emissions and climate change from implementing the KBRA would be less than significant.**

Implementation of the Power for Water Management Program, the Drought Plan, and the Climate Change Assessment and Adaptive Management Plan could result in climate change-related impacts. Implementation of the Power for Water Management Program of the KBRA could create new renewable energy sources as described for the Proposed Action. Additionally, the KBRA includes two plans to assess and address climate change impacts as described in the KBRA discussion for the Proposed Action. **Implementation of these plans may cause beneficial effects to climate change.**

3.10.4.4.6 Alternative 4: Fish Passage at Four Dams Alternative Effects of Climate Change on the Alternative

The Fish Passage at Four Dams Alternative would likely result in a greater magnitude of consequences associated with climate change than the Full Facilities Removal Alternative. Greater needs for management actions, policies, and mitigation measures to protect the surrounding ecosystems and communities would likely be required without dam removal, and could result in costly future projects to either prevent or respond to the consequences of climate change. For example, disturbances caused by drought, changes to vegetation, and changes to water quality characteristics patterns might not be able to be adjusted to or absorbed as easily with the dams in place as without them.

Under existing conditions, summer and early fall water temperatures in the Klamath River regularly exceed the range of chronic effects temperature thresholds for full salmonid support (Section 3.2.3.2). The exception to this occurs in the J.C. Boyle Bypass Reach during daily powerhouse peaking periods, when warm reservoir discharges are diverted from the Bypass Reach allowing cold spring flows to dominate hydrology and water temperatures. Under the Fish Passage at Four Dams Alternative, water temperatures in the Hydroelectric Reach and the Klamath River downstream from Iron Gate Dam would not change from existing conditions (i.e., they would still exceed chronic effects thresholds during summer months), with the exception of the J.C. Boyle Bypass Reach where the extreme daily temperature fluctuations due to hydropower peaking flows would occur less frequently (i.e., weekly rather than daily) and would approach the (warmer) natural thermal regime of the river. 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 Dam Alternative. Overall, this would be beneficial.

Effects of the Alternative on Climate Change

Vehicle exhaust from construction of fish passage could increase GHG emissions in the short term to levels that could exceed the significance criteria. This alternative does not result in the removal of any excavated material from the sites, and instead only includes a reduced amount of material being hauled to the sites. Table 3.10-10 summarizes uncontrolled annual emissions inventories for the Fish Passage at Four Dams Alternative. Detailed calculations are provided in Appendix N.

Table 3.10-10. Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Four Dams

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
Iron Gate (2023)	1,599	1	n/a	1,600
Copco 1 (2025)	1,307	1	n/a	1,308
Copco 2 (2024)	302	<1	n/a	302
J.C. Boyle (2022)	820	<1	n/a	820
Maximum Annual Emissions[3]	1,599	1	n/a	1,600

Notes:

[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

[2] Nitrous oxide (N_2O) emissions are not directly estimated from the various emission calculation models; therefore, emissions are estimated as zero for most equipment.

[3] Construction of the fish ladders occur during different years and activities for each dam site do not overlap; therefore, the maximum emissions are shown to evaluate significance.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

As Table 3.10-10 shows, there would be a net increase in GHG emissions from construction of fish passages; however, these emissions would be temporary and would not contribute to long-term emissions. Constructing fish passage would contribute a maximum of 1,600 $MTCO_2e$ to California's GHG emissions for 1 year. Amortizing these construction emissions over 30 years results in approximately 53 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over 30 years such emissions are 8,400 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions constructing fish passage would be 0.0009 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, Alternative 4 would equal less than 1 percent of allowable construction emissions. **The 1-year construction emissions for fish passage would not exceed the established significance thresholds for ongoing industrial emissions. Therefore, the GHG emissions related to fish passage construction would be less than significant.**

Reducing a renewable source of power by developing fish passage could result in increased GHG emissions from possible non-renewable alternate sources of power. GHG emission effects could also occur following replacement of a renewable source of electricity with other, emission-generating sources of electric power. Although the dams would not be removed, there would be a decrease in power generation, which is necessary for successful operation of the fish passage. The FERC Final EIS (2007) states that the installation of fish passage would allow the Klamath Hydroelectric Project to generate an average of 533,879 MWh of electricity annually. Since the baseline generation (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) is 686,000 MWh, the amount of power that may need to be replaced would equal 152,121 MWh per year. Table 3.10-11 summarizes replacement power emissions that would be associated with the replacement power needed after fish passage construction assuming that the current power resource mix was used. Table 3.10-12 summarizes replacement power emissions that would be needed after fish passage construction assuming that PacifiCorp's RPS obligations were met.

Table 3.10-11. Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (Current Resource Mix)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	97,792	41,858	2	<1	41,858	36	56	41,951
Off-Peak	54,329	45,332	<1	<1	45,332	14	229	45,575
Total	152,121	87,190	2	1	87,190	50	286	87,525

Notes:

[1] Generation based on FERC Final EIS (2007). The Fish Passage generation is based on the FERC Final EIS for the Staff Alternative with Mandatory Conditions (533,879 MWh).

[2] Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b).

[3] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide	lb/MWh = pounds per megawatt-hour
CH_4 = methane	lb/GWh = pounds per gigawatt-hour
N_2O = nitrous oxide	GWP = global warming potential
MWh = megawatt hour	$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Table 3.10-12. Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (33 Percent RPS)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	97,792	41,858	2	<1	41,858	36	56	41,951
Off-Peak	54,329	33,302	1	1	33,302	10	168	33,481
Total	152,121	75,161	2	1	75,161	46	225	75,431

Notes:

[1] Generation based on FERC Final EIS (2007). The Fish Passage generation is based on the FERC Final EIS for the Staff Alternative with Mandatory Conditions (533,879 MWh).

[2] Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Off-peak emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b) except for the dams proposed to be removed. It was also assumed that PacifiCorp would meet its RPS obligation.

[3] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide
CO_2e = carbon dioxide equivalent
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds
lb/GWh = pounds per gigawatt-hour
GWP = global warming potential
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

As previously described for the No Action/No Project Alternative, CH_4 would be released from the reservoirs because of poor water quality conditions. Since the dams would remain in place under this alternative, CH_4 from the impounded water would continue to be emitted. CH_4 emissions from the reservoirs would range from 4,000 to 14,000 $MTCO_2e$ per year. Table 3.10-13 summarizes the expected range in emissions that could occur from power replacement and CH_4 released from the reservoirs.

Table 3.10-13. Adjusted Power Replacement Emissions With Methane Emissions from Reservoirs

Scenario	Annual CO_2e Emissions ($MTCO_2e$/year)	CH_4 Emissions from Reservoirs ($MTCO_2e$/year)		Adjusted Emissions ($MTCO_2e$/year)[1]	
		Low	High	Low	High
Current Grid Mix	87,525	4,000	14,000	91,525	101,525
33 Percent RPS	75,431	4,000	14,000	79,431	89,431

Notes:

[1] Adjusted emissions reflect the difference between each scenario and the estimated CH_4 emissions from the reservoirs.

Key:

CO_2e = carbon dioxide equivalent
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

In the long term, it is expected that PacifiCorp would be able to eventually replace the lost energy from the dams with other sources of renewable energy.

CARB expects that implementation of its Scoping Plan (2008) would reduce 21.3 $MMTCO_2e$ by 2020 (from 2005 baseline) from California's RPS; therefore, the possible increase in emissions from the replacement power generation allowing decreased electricity produced by the dams would account for one percent of the expected emissions reduction. Under a business-as-usual scenario, which assumes that the Scoping Plan would not be implemented, this would impede California's ability to meet its emission reduction goal. **Emissions from power replacement would therefore be a significant impact**. **Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

Trap and Haul – Programmatic Measures

Implementation of trap and haul measures could result in temporary increases in GHG 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 to Upper Klamath Lake or its tributaries. Downstream-migrating fish would be collected at Link River Dam (and the East Side and West Side canals) and relocated downstream from Keno Dam. Operational emissions are not expected to exceed the SCAQMD's threshold of significance, especially when amortized over 30 years, because of the limited amount of haul trucks that would be expected to be used. **The impact on GHG emissions and climate change from operational emissions associated with trap and haul measures would be less than significant.**

3.10.4.4.7 Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

Effects of Climate Change on the Alternative

The Fish Passage at Two Dams Alternative would result in the removal of two dams and the retention of two dams; the types of climate change effects from this alternative would be within the range of those described for the Proposed Action and the Fish Passage at Four Dams Alternatives. Temperature effects would likely be more similar to the Proposed Action than the Fish Passage at Four Dams Alternative because the Fish Passage at Two Dams Alternative would result in the removal of the two largest dams, which would have a greater role in warming the river water than the smaller dams.

Effects of the Alternative on Climate Change

Vehicle exhaust from dam removal activities or construction of fish passage could increase GHG emissions in the short term to levels that could exceed the significance criteria. This alternative would essentially be a combination of the Proposed Action and the Fish Passage at Four Dams Alternative, and would have similar effects. Table 3.10-14 summarizes uncontrolled annual emissions inventories for the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative. Appendix N provides detailed calculations.

As Table 3.10-14 shows, there would be a net increase in GHG emissions from deconstruction of the dams; however, these emissions would be temporary and would not contribute to long-term emissions. The decommissioning of the dams would contribute 6,445 $MTCO_2e$ to California's GHG emission for 1 year.[13] Amortizing these construction emissions over 30 years results in approximately 215 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over 30 years such emissions are 3,555 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions from dam removal would be 0.002 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, the Proposed Action would equal approximately 1 percent of allowable construction emissions. **The 1-year construction emissions would not exceed the established significance threshold for ongoing industrial emissions. Therefore, the GHG emissions related to construction would be less than significant.**

Table 3.10-14. Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
	2020			
Iron Gate	3,944	4	n/a	3,949
Copco 1	1,474	1	n/a	1,475
Copco 2	269	1	n/a	269
J.C. Boyle	752	<1	n/a	752
Total Emissions (2020)	6,439	6	n/a	6,445
California Total	5,687	6	n/a	5,693
Oregon Total	752	n/a	n/a	752

Notes:

1 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

2 Nitrous oxide (N_2O) emissions are not directly estimated from the various emission calculation models; therefore, emissions are estimated as zero for most equipment.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Construction of a new, elevated City of Yreka Water Supply Pipeline and steel pipeline bridge to support the pipe above the river would result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated

[13] The value of 6,445 $MTCO_2e$ includes emissions from the J.C. Boyle Dam. Although J.C. Boyle Dam is located in Oregon, CEQA requires GHG emissions related to J.C. Boyle Dam could affect California because climate change is a global phenomenon. Therefore, and for purposes of full disclosure, emissions related to JC Boyle Dam are being analyzed under CEQA.

with the City of Yreka water supply pipeline would be the same as those described for the Proposed Action. **The impact on GHG emissions and climate change from the construction of the City of Yreka Water Supply Pipeline would be less than significant.**

Restoration actions would result in short-term and temporary increases in GHG emissions from the use of helicopters, trucks, and barges. GHG emission 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. Table 3.10-15 summarizes emissions from reservoir restoration.

As shown in Table 3.10-15, total GHG emissions would not exceed 685 $MTCO_2e$ per year. The impact on GHG emissions and climate change from revegetation would be less than significant.

Table 3.10-15. Uncontrolled Direct GHG Emissions Inventories for Reservoir Restoration (Reseeding)

Location	Project Emissions ($MTCO_2e$/year)[1]			
	Ground Equipment	Barges	Aerial	Total
Iron Gate	29	88	149	266
Copco	32	88	298	419
J.C. Boyle	n/a	n/a	n/a	n/a
Total Emissions	61	177	447	685

Notes:
[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
Key:
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Relocation and demolition of various recreation facilities would result in short-term and temporary increases in GHG emissions from vehicle exhaust. 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. Annual GHG emissions were estimated using information provided in the Detailed Plan for Dam Removal – Klamath River Dams (Reclamation 2012a) and CalEEMod, Version 2011.1.1. Approximately 154 $MTCO_2e$ would be emitted during relocation and demolition of the recreation facilities. **The impact on GHG emissions and climate change from the relocation and demolition of recreation facilities would be less than significant.**

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. It is expected that removing the existing hydropower capability from the two dams (Copco 1 and Iron Gate) would reduce power generation. Replacement power generation may result in changes in emissions. Although J.C. Boyle and Copco 2 Dams would not be removed, there would be a decrease in power generation, which is necessary for successful operation of the fish passage. The FERC Final EIS (2007) states that after retiring Copco 1 and Iron Gate the Klamath Hydroelectric Project would generate an average of 443,694 MWh of electricity annually. Since the baseline generation (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) is 686,000 MWh, the amount of power that may need to be replaced would equal 242,306 MWh per year. Table 3.10-16 summarizes replacement emissions that would be associated with the replacement power needed after construction of this alternative.

Electricity that was originally produced from these dams would likely be replaced using another source within the PacifiCorp PCA; therefore, emission rates from the grid were estimated assuming that all power sources within the PCA would remain except for Copco 1 and Iron Gate Dams. Data from eGRID was used to estimate GHG emissions from the use of different energy resources (USEPA 2010b). The Lead Agencies acquired data for all of the plants within the PacifiCorp PCA and derived emission factors were derived from this source with the applicable dams removed from the mix. Table 3.10-16 summarizes the increase in emissions that could result from the use of replacement power from other sources assuming that the current power resource mix was used. Table 3.10-17 summarizes the increase in emissions that could result from the use of replacement power from other sources assuming that PacifiCorp met is RPS obligations.

Table 3.10-16. Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (Current Resource Mix)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2$e/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	155,768	66,674	3	<1	66,674	57	90	66,821
Two Dams	86,538	72,435	1	1	72,435	22	366	72,824
Total	242,306	139,109	4	1	139,109	79	456	139,644

Notes:
1 Generation based on FERC Final EIS (2007). The Two Dams Removed generation is based on the FERC Final EIS for the alternative that would retire Copco 1 and Iron Gate (443,694 MWh).
2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA except for the dams proposed to be removed.
3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds per megawatt-hour
lb/GWh =pounds per gigawatt-hour.
eGRID = Emissions & Generation Resource Integrated Database
$MTCO_2$e/year = metric tons carbon dioxide equivalent per year

Table 3.10-17. Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (33 Percent RPS)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	155,768	66,674	3	<1	66,674	57	90	66,821
Two Dams	86,538	53,213	1	1	53,213	16	269	53,499
Total	242,306	119,888	4	1	119,888	73	359	120,320

Notes:

1 Generation based on FERC Final EIS (2007). The Two Dams Removed generation is based on the FERC Final EIS for the alternative that would retire Copco 1 and Iron Gate (443,694 MWh).

2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA except for the dams proposed to be removed. It was also assumed that PacifiCorp would meet its RPS obligation.

3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds per megawatt-hour
lb/GWh =pounds per gigawatt-hour.
eGRID = Emissions & Generation Resource Integrated Database
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

CH_4 emissions would occur from water impounded in the reservoirs. Since Iron Gate and Copco 1 Dams would be removed under this alternative, the only remaining reservoir that would contribute to CH_4 emissions from impounded water would be at J.C. Boyle Dam. Assuming that this would be the only source of emissions, CH_4 emissions would range from 700 to 3,000 $MTCO_2e$ per year for the J.C. Boyle Reservoir, equivalent to approximately 0.5 to 2 percent of replacement power emission.[14] See Appendix N for detailed calculations. Table 3.10-18 summarizes the adjusted power replacement emissions that could occur when CH4 emissions from impounded water at J.C. Boyle Reservoir is considered.

In addition to the emissions from possible natural gas combustion, there could also be emissions associated with SF_6 leaks. Although there would be a decrease in SF_6 associated with the removal of transmission lines under this alternative, these emissions could be counteracted by increases from new power supplies that would be used to replace the existing power. As a result, determining the net SF_6 emissions is not possible. **Emissions from power replacement would be significant and unavoidable. Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

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[14] Emissions range is valid for both renewable portfolio standard assumptions (i.e., current grid mix or 33 percent renewable power).

Table 3.10-18. Adjusted Power Replacement Emissions With Methane Emissions from Reservoirs

Scenario	Annual CO_2e Emissions ($MTCO_2$e/year)	CH_4 Emissions from Reservoirs ($MTCO_2$e/year)		Adjusted Emissions ($MTCO_2$e/year)[1]	
		Low	High	Low	High
Current Grid Mix	139,644	700	3,000	140,344	142,644
33 Percent RPS	120,320	700	3,000	121,020	123,320

Notes:
[1] Adjusted emissions reflect the difference between each scenario and the estimated CH_4 emissions from the reservoirs.
Key:
CO_2e = carbon dioxide equivalent
$MTCO_2$e/year = metric tons carbon dioxide equivalent per year

City of Yreka Water Supply Pipeline Relocation - Programmatic Measures

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 GHG emissions from vehicle exhaust. The effects of the City of Yreka Water Supply Pipeline relocation would be the same as those described for the Proposed Action. **The impact on GHG emissions and climate change from the construction of the City of 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 GHG emissions from vehicle exhaust. The trap and haul measures around Keno Impoundment 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. **The impact on GHG emissions and climate change from operational emissions associated with trap and haul measures would be less than significant.**

3.10.4.5 Mitigation Measures

As required by the KHSA, PacifiCorp would cooperate in the investigation or consideration of joint development and ownership of renewable generation resources, and purchase by PacifiCorp of power from renewable energy projects developed by Klamath Water and Power Authority or other parties. Although this effect cannot be quantified, the development of this power would help offset the significant impacts expected from any use of replacement power following removal of the dams.

3.10.4.5.1 Mitigation Measure by Consequence Summary

CC-1 – Use the market mechanism under development as part of AB 32 development when feasible to mitigate GHG emissions impacts. The market mechanism program under AB 32 is targeted for implementation in 2012.

CC-2 – Establish an energy audit program to enable local residences and business to determine how much energy they currently consume and to identify measures that would reduce energy consumption.

CC-3 – Establish an energy conservation plan to reduce the region's reliance on purchased electricity.

3.10.4.5.2 Effectiveness of Mitigation in Reducing Consequence

The effectiveness of the various mitigation measures would vary based on the type of measures that would be implemented. Market-based measures could potentially be 100 percent effective at offsetting the significant emissions, but may not be cost-effective depending on the availability of carbon credits. Plus, this measure would be contingent on the availability of carbon credits on the open market. If credits are scarce when they need to be purchased, then it may be difficult to offset the entire amount.

The effectiveness of the energy audits and conservation programs would vary based on the improvements that would be made following the audit. While the audits can identify deficiencies in the energy efficiency of a residential or commercial source, there is no guarantee that the identified improvements would be made. The California Air Pollution Control Officers Association published a resource called *Quantifying Greenhouse Gas Mitigation Measures* (2010) that quantifies the effectiveness of various GHG emission reduction measures. For example, if a non-residential building is constructed to be more energy efficient than the 2008 Title 24 standards, the GHG emissions from electricity can be reduced up to 0.40 percent for every 1 percent improvement over 2008 Title 24. Installing energy efficient appliances could reduce GHG emissions up to 2.59 percent.

Table 3.10-19 summarizes the GHG emissions that would be expected from power replacement activities following dam removal. All alternatives would result in significant impacts from use of replacement power following removal of the dams or reductions necessary to properly maintain fish passage. The construction and demolition emissions represent a worst-case scenario that illustrates the maximum emissions that could occur if reservoir restoration, recreation facility removal, and construction of the City of Yreka pipeline occurred in the same year as any construction or demolition activities. It is expected that certain components, such as construction of the City of Yreka pipeline, would occur in a year other than 2020; and cumulative annual emissions would be less than those shown in Table 3.10-19.

Table 3.10-19. Impact Summary Table (Without Methane Generation from Reservoirs)

Alternative	Emissions		
	Construction and Demolition (metric tons CO_2e/project)[1,2]	Power Replacement (metric tons CO_2e/year)[3]	
		(Current Resource Mix)	(33% RPS)
2	9,454	396,575	341,539
3	8,645	396,575	341,539
4	1,600	87,525	75,431
5	7,316	139,644	120,320

Notes:
[1] Construction and demolition values represent a cumulative impact from construction or demolition impacts at the Four Facilities, reservoir restoration (reseeding), recreation facility removal, and construction of the City of Yreka Water Supply Pipeline.
[2] Emissions summarized for construction and demolition activities represent the worst-case year of analysis (2020) and would only occur once.
[3] Emissions from power replacement represent an annual average value that would occur until electricity from the Four Facilities is replaced with other renewable power sources.
Key:
CO_2e = carbon dioxide equivalent
RPS = Renewable Portfolio Standard

Table 3.10-20 summarizes GHG emissions that would be projected to occur from power replacement activities with CH_4 that would be produced from impounded water.

Table 3.10-20. Impact Summary Table (With Methane Generation from Reservoirs)

Alternative	Power Replacement and CH_4 from Impounded Reservoirs Emissions (metric tons CO_2e/year)			
	(Current Resource Mix)		(33% RPS)	
	Low[1]	High[2]	Low[1]	High[2]
2	392,575	382,575	337,539	327,539
3	392,575	382,575	337,539	327,539
4	91,525	101,525	79,431	89,431
5	140,344	142,644	121,020	123,320

Notes:
[1] Low power replacement refers to minimum CH_4 emissions projected to be emitted by the reservoirs.
[2] High power replacement refers to maximum CH_4 emissions projected to be emitted by the reservoirs.
Key:
CH_4 = methane
CO_2e = carbon dioxide equivalent
RPS = Renewable Portfolio Standard

3.10.4.5.3 Agency Responsible for Mitigation Implementation

The Dam Removal Entity (DRE) would be responsible for implementing mitigation measures CC-1, CC-2, and CC-3.

3.10.4.5.4 Remaining Significant Impacts

Following implementation of the mitigation measures specified for a given alternative, GHG emissions would remain significant and unavoidable for all four action alternatives for power replacement.

3.10.4.5.6 Mitigation Measures Associated with Other Resource Areas

Mitigation Measures AR-1, 2, 5-7 would cause temporary increases in GHG emissions. 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 from Iron Gate Dam to the confluence of the Klamath and Trinity Rivers between February and April 2020. The increase in daily truck trips is expected to be minor (approximately 2 trips per day) and would not contribute substantially to the existing emissions. **The impacts associated with increases in GHG emissions from these mitigation measures would be less than significant.**

Mitigation Measure TR-1 could cause a temporary increase in GHG 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. **The impacts associated with increases in GHG emissions from Mitigation Measure TR-1 would be less than significant.**

Mitigation Measure REC-1 could cause a temporary increase in GHG emissions. REC-1 calls for the preparation of a plan to develop new recreational facilities along the new river channel once the reservoirs are removed. On- and off-road construction equipment would be used to complete the necessary construction, but would be minor compared to the dam demolition emissions, and would occur after the demolition was complete. **The impacts associated with increases in GHG emissions from Mitigation Measure REC-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), and WRWS-1 (modify water intakes). These measures could produce temporary impacts on GHG emissions 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 wildlife and plants, including special-status species, and sensitive habitats. **Impacts on GHG emissions from the implementation of H-2, GW-1, and WRWS-1 would be less than significant.**

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<http://nationalatlas.gov/atlasftp.html?openChapters=chpclim#chpclim> and
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